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FIRST IN CHANGE **UNIST UCRF**

UNIST Central Research Facilities

UNIST
ULSAN NATIONAL INSTITUTE OF SCIENCE AND TECHNOLOGY

Research Facilities *Enabling Exceptional Achievement!*

Contents

About UCRF

UNIST Central Research Facilities (UCRF) was established in 2009 for the purpose of enhancing the research abilities of UNIST through the sharing of expensive equipment, the promoting of interdisciplinary studies and the establishing networks of professionals specialized in analysis and instrumentation. In addition to serving the faculty, students and staff who conduct cutting-edge research at UNIST, the UCRF also provides services to regional industries, institutes and universities. The UCRF is equipped with Analysis lab, Nano Fabrication Cleanroom, Machine Shop, Environmetal Analysis Center, Biomed Imaging Center, *In Vivo* Research Center, Radiation Safety Lab, Synchrotron Radiation Center. Furthemore, the UCRF offers the advanced training courses and seminars to help the users learn the skills and analytical methods required for the effective and efficient utilization of this equipment. From this day forward, we will do our best to serve researchers who need our facilities for characterization, analysis and micro/nano fabrication and to continuously procure expensive and state-of-the-art equipment. Thank you.

Mission of UCRF

Providing services for researchers in universities, institutes and industries

- Continuous procurement maintenance of expensive equipment
- Maintenance of state-of-the-art equipment

Collaborative framework

- Interdisciplinary studies of science and technology
- Industry-academic cooperation for development of advanced technologies

Training courses and workshops

- Training courses for self-users
- Workshops to develop the skills and analytical methods required for the effective and efficient utilization of the equipment

Organization of UCRF

President

Director

Steering Comittee

UNIST Mechanical Analysis Lab (UMAL)
- Electron Microscopy
- X-ray Analysis
- Spectroscopic Analysis
- Surface Analysis
- Mass Analysis
- Thermal & Physical Analysis

UNIST Nano Fabrication Center (UNFC)
- Photolithography
- Thin Film
- Etch Process
- Measurement
- Packing

UNIST Design & Manufacturing Center (UDMC)
- CNC Workshop
- Shape Manufacturing
- 3D Measurement
- Material Test
- Welding
- CAD/CAM/CAE

UNIST Environmental Analysis Center (UEAC)
- Environmental Analysis
- Pre-treatment Sampling
- Preparation

UNIST Olympus Biomed Imaging Center (UOBC)
- Multi-photon
- Zero drift microsopy
- Virtual microscopy
- LSCM with SIM & live
- TIPF microscopy
- All-in-one confocal system
- Bio imaging navigator
- Macro view Imaging system
- In vivo imaging system

***In Vivo* Research Center (IVRC)**
- Strain Preservation Zone
- Small Animal Zone
- Return Animal Zone
- BSL-2 Zone
- *In Vivo* Imaging
- Behavior Study
- Histopathology
- Autopsy

UNIST Radiation Safety Lab (URSL)
- Radioisotope lab.
- Radioactive waste

UNIST Synchrotron Radiation Center (USRC)
- XAS
- SAXS
- Crystallography

Method on Reservation and Analysis

Request of Analysis

1. To request analysis
2. Contact UCRF & discuss
3. Visit UCRF homepage for reservation
4. Staff measurement
5. Review the result with user and inform
6. Inform the cost to the requester in the following month

For Self-users

1. Self-user
2. Training & test for self-user
3. Visit UCRF homepage for reservation
4. Self-user measurement
5. Fill in logbook & examine equipment
6. Inform the cost to the user in the following month

UNIST Mechanical Analysis Lab (UMAL)

The UNIST Mechanical Analysis Lab (UMAL) was established in 2009 for the purpose of enhancing the ability to do better research at UNIST through the sharing expensive equipment including advanced TEM, TOF-SIMS, FT-NMR, etc. The lab possesses more than 50 different types of state-of-the-art research equipment, including Electron Microscopy Analysis, X-ray Analysis, Spectroscopic Analysis, Surface Analysis, Mass Analysis and a room for Thermal & Analysis, all of which are equivalent to approximately 25 million U. S. dollars.

List of Instruments

Lab	No.	Equipment	Model	Maker	Page
Electron Microscopy	1	Advanced Transmission Electron Microscope	Titan3 G2 60-300	FEI, USA	7
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		Normal Transmission Electron Microscope	JEM-2100	JEOL, Japan	8
		Bio-Transmission Electron Microscope	JEM-1400	JEOL, Japan	8
	3	Field Emission-Scanning Electron Microscope	Quanta 200	FEI, USA	9
			NanoSem 230	FEI, USA	9
			S-4800	Hitachi, Japan	9
	4	Dual-Beam Focused Ion Beam	Helios 450HP	FEI, USA	10
			Quanta 3D FEG	FEI, USA	10
TEM/SEM sample prep.	5	Ultramicrotome	CR-X	RMC, USA	11
	6	Ion Milling System	IM4000	Hitachi, Japan	11
			NanoMill	Fischione, USA	11
	7	Sample Preparation(1)	TechPress2	Allied, USA	12
			MetPrep4	Allied, USA	12
			MultiPrep	Allied, USA	12
			Disc Punch	Gatan, USA	12
			Dimple Grinder	Gatan, USA	12
		Sample Preparation(2)	Precision Ion Polishing System	Gatan, USA	12
			Precision Etching Coating System	Gatan, USA	12
X-ray Analysis	8	High Power X-ray Diffractometer	D/MAX 2500V/PC	Rigaku, Japan	13
		High Resolution X-ray Diffractometer	D8 Discover	Bruker, Germany	13
	9	Normal X-ray Diffractometer	D8 Advance	Bruker, Germany	14
		Single Crystal X-ray Diffractometer	R-AXIS RAPID II	Rigaku, Japan	14
	10	Wavelength Dispersive X-ray Fluorescence Spectrometer	T8 Tiger	Bruker, Germany	15
Spectro scopic Analysis	11	600 MHz FT-NMR	VNMRS 600	Agilent, USA	16
		400 MHz FT-NMR	400-MR DD2	Agilent, USA	16
	12	UV-Vis-NIR	Cary 5000	Agilent, USA	17
		UV-Vis Microspectrometer	20/20 PV	CRAIC, USA	17
	13	Fluorometer	Cary Eclipse	Agilent, USA	18
		Spectrofluorometer (Solid, Quantum Yield)	FP-8500	Jasco, Japan	18
		Fluorescence Spectrometer	NF900 (FLS920)	Edinburgh Instrument, UK	18
	14	FT-IR	670-IR / 620-IR Imaging Model	Agilent, USA	19
	15	Micro Confocal Raman	Alpha300R	WITec, Germany	20
		Combined AFM & Confocal Raman Microscope	Alpha300S	WITec, Germany	20
	16	Confocal Laser Scanning Microscope	OLS 3100	Olympus, Japan	21
		Sub-micron Size & Zeta Potential Measuring System	Nano ZS	Malvern, UK	21
Surface Analysis	17	Time-of-Flight Secondary Ion Mass Spectrometer	TOF SIMS 5	ION TOF, Germany	22
	18	X-ray Photoelectron Spectroscope	K-alpha	ThermoFisher, UK	23
			Escalab 250Xi	ThermoFisher, UK	23
	19	Atomic Force Microscope	Multimode V	Veeco, USA	24
			Dimension 3100	Veeco, USA	24
	20	Physisorption Analyzer	ASAP 2420	Micromeritics, USA	25
			ASAP 2020	Micromeritics, USA	25
Mass Analysis	21	MALDI-TOF/TOF	Ultraflex III	Bruker, Germany	26
	22	Liquid Chromatography Mass Spectrometer	HCT Basic System	Bruker, Germany	27
		Gas Chromatography Mass Spectrometer	450-GC & 320-MS	Bruker, Germany	27
		GPC/MALS	Agilent 1200 series, miniDAWN	Agilent, USA / Wyatt, USA	27
	23	Element Analyzer	TrueSpec Micro CHNS	LECO Corporation, USA	28
			Flash 2000	Thermo Scientific, Netherlands	28
Thermal & Physical Analysis	24	Thermogravimetric Analyzer	Q500	TA Instrument, USA	29
		Differential Scanning Calorimeter	Q200	TA Instrument, USA	29
	25	Simultaneous TGA/DSC	Q600	TA Instrument, USA	30
		Dynamic Mechanical Analyzer	Q800	TA Instrument, USA	30
	26	Cryogenic Probe Station	CRX-4K	Lake Shore, USA	31
		Rheometer	Haake MARS3	Thermo Electron (Karlsruhe) GmbH, Germany	31

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Office Email : analysis-lab@unist.ac.kr

Electron Microscopy

1 Advanced Transmission Electron Microscope

Model ● Titan3 G2 60-300 *[Image Corrector]* [FEI, USA]

Principle

TEM is used to analyze micro-structures of materials with high spatial resolution. The high voltage electron beam generated from electron gun is illuminated on thin film specimen. The beam penetrating the specimen passes through an array of magnetic lenses and forms a high resolution electron image of the electron diffraction pattern.

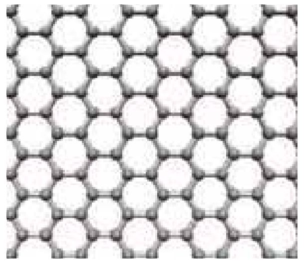
Room #B112

Specifications

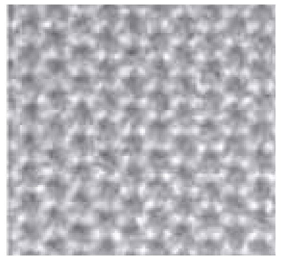
- Acceleration voltage : 60 - 300 kV
- Lattice resolution : 0.065 nm
- BF-STEM resolution : 0.14 nm
- HAADF-STEM resolution : 0.12 nm
- Probe stability : 1 nm/min or less
- Stage stability : 1 nm/min or less
- EDS resolution : 128 eV
- EELS resolution : 0.16 eV
- Contamination : 1 nm/min or less

Applications

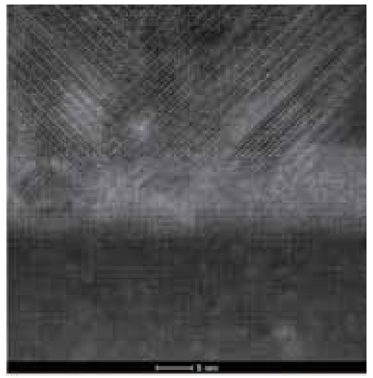
- Sub angstrom spatial resolution TEM
- Atomic resolution at low kV
- Imaging and spectroscopy of soft matters
- Dynamics of individual atoms
- High energy resolution EELS and EDS
- Energy-filtered imaging and diffraction

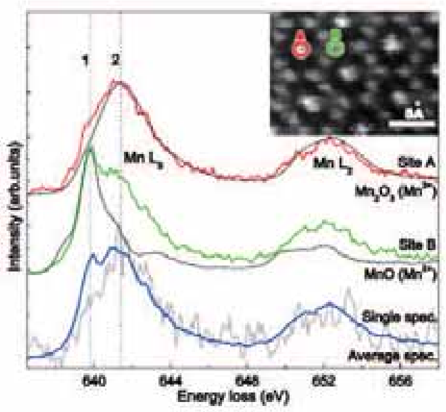


Atomic image



Single raw image at 80 kV





[Optics of Cs-corrector for TEM]

2 [High Resolution | Normal | Bio-] Transmission Electron Microscope

Model ● JEM-2100F *[Cs Corrector]* ; JEM-2100 ; JEM-1400 [JEOL, Japan]

Principle

TEM is used to analyze micro-structures of materials with high spatial resolution. The high voltage electron beam generated from electron gun is illuminated on thin film specimen. The beam penetrating the specimen passes through an array of magnetic lenses and forms a high resolution electron image of the electron diffraction pattern.

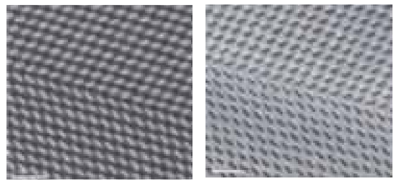
Room #B106

Specifications

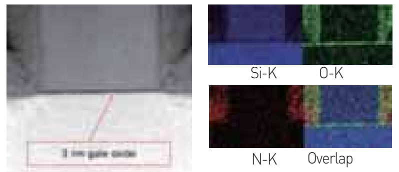
- Acceleration voltage : 200 kV
- Lattice resolution : 0.102 nm
- BF-STEM resolution : 0.14 nm
- HAADF-STEM resolution : 0.096 nm
- Probe stability : 1 nm/min or less
- Stage stability : 1 nm/min or less
- EDS resolution : 128 eV
- EELS resolution : 0.8 eV
- Contamination : 1 nm/min or less

Applications

- Ultra high resolution electron imaging
- Diffraction pattern
- STEM imaging (BF, HAADF)
- Energy dispersive spectroscopy (EDS)
- Electron energy loss spectroscopy (EELS)



STEM HAADF Image STEM BF Image
[Si (110) Twin Crystal]



Si-K O-K N-K Overlap

STEM HAADF Image [EDS Mapping of Gate]

Room #B104

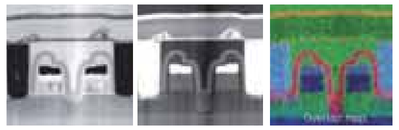
Specifications

- Acceleration voltage : 200 kV
- Lattice resolution : 0.23 nm
- Point resolution : 0.14 nm
- Specimen tilting : X = ± 35 °, Y = ± 30 °
- Image recording system : CCD
- EDS resolution : 132 eV

Applications

- High resolution electron imaging
- Diffraction pattern
- STEM imaging (BF, HAADF)
- Energy dispersive spectroscopy (EDS)

HR EM Image/DP
[SiC Nanowire]



STEM HAADF Image STEM BF Image EDS Mapping
[Semiconductor device]

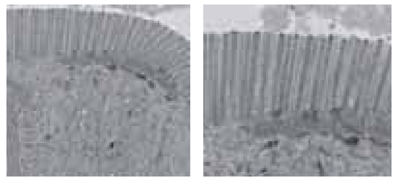
Room #B105

Specifications

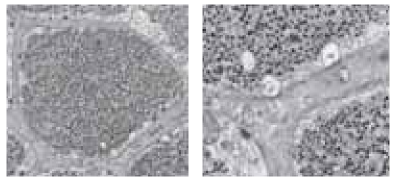
- Acceleration voltage : 120 kV
- Lattice resolution : 0.38 nm
- Point resolution : 0.20 nm
- Specimen tilting : X = ± 25 °, Y = ± 70 °
- Image recording system : CCD

Applications

- High resolution electron imaging
- Diffraction pattern



Small intestine of mouse



Mytilus edulis
Anterior Byssus Retractor Muscle

3 Field Emission-Scanning Electron Microscope

Model ● Quanta 200 ; NanoSem 230 [FEI, USA] | S-4800 [Hitachi, Japan]

Principle

SEM is a microscope that uses electrons instead of light to form an image. The SEM uses electromagnets rather than lenses, the researcher has much more control in the degree of magnification. Field-emission scanning electron microscope provides ultra high resolution image down to 1 nm resolution thanks to the inherent brightness of field-emission electron gun.

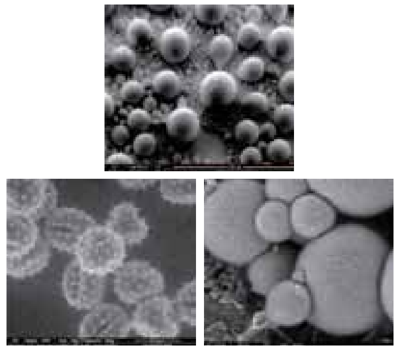
Room #B110

Specifications

- Electron gun
  : Schottky type thermal FE gun
- Resolution
  - < 1.2 nm @ 30 kV high vacuum mode
  - < 1.5 nm @ 30 kV low vacuum mode
  - < 1.5 nm @ 30 kV ESEM mode
- Beam current : > 100 nA
- Heating stage (1,500 °C)
- Cooling stage (-20 °C)

Applications

- High vacuum mode
- Low vacuum mode (10 to 130 Pa)
- ESEM mode (10 to 4,000 Pa)



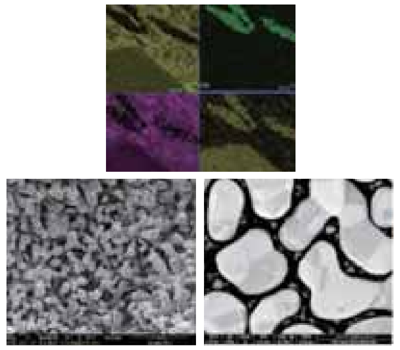
Room #B109

Specifications

- Electron gun
  : Schottky type thermal FE gun
- Resolution
  - < 1.0 nm @ 15 kV
  - < 1.6 nm @ 1 kV
- Probe current : 0.6 pA ~ 100 nA
- Reduced charge & contamination operation

Applications

- Secondary electron image
- Backscattered electron image
- Energy dispersive X-ray analysis EDS
- X-ray elemental mapping
- Nano-particles characterization
- Magnetic materials characterization



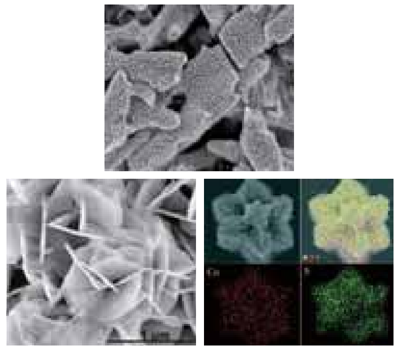
Room #B110

Specifications

- Electron gun
  : cold cathode field emission • electron source
- Resolution
- < 1.0 nm @ 15 kV
- Magnification
  - LM 20 ~ 2,000 x, HM 100 ~ 800,000 x
- Accelerate voltage : 0.1 ~ 30 kV (0.1 kV/step)
- Electrical image shift : ± 12 μm (WD = 8 mm)

Applications

- Secondary electron image
- Energy dispersive spectroscopy (EDS)



4 Dual-Beam Focused Ion Beam

Model ● Helios 450HP ; Quanta 3D FEG [FEI, USA]

Principle

Dual-beam FIB has a multitude of capabilities including high resolution electron imaging, ion imaging, nano device fabrication, and material deposition. Simultaneous patterning and imaging are possible to nm resolution for both imaging and machining. FIB with both ion and electron beams enables high-precision cross-section processing and TEM/3DAP sample preparation.

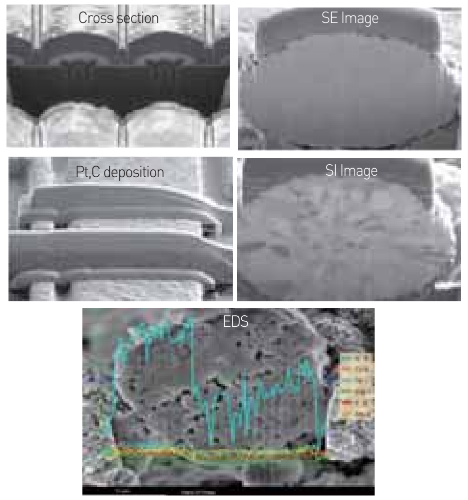
Room #B108

Specifications

- Electron optics - Resolution
  - HV : 0.9 nm @ 15 kV, 1.4 nm @ 1 kV
  - Accelerating voltage : 1 kV ~ 30 kV
  - Probe current : up to 200 nA
  - Magnification : 30 x ~ 1,280 kx
- Ion optics
  - Resolution : 5 nm @ 30 kV
  - Beam voltage : 500 V - 30 kV
- Multi chem gas injection systems (C, Pt, W, H_2O)

Applications

- Ultra high resolution electron, ion imaging
- TEM sample preparation
- Energy dispersive spectroscopy (EDS)
- SE, BSE imaging



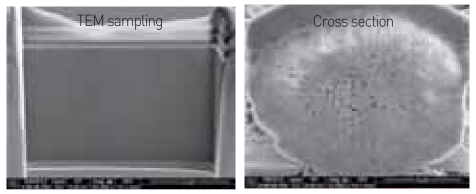
Room #B108

Specifications

- Electron optics - Resolution
  - HV : 1.2 nm @ 30 kV
  - Accelerating voltage : 1 kV ~ 30 kV
  - Probe current : up to 200 nA
  - Magnification : 30 x ~ 1,280 kx
- Ion optics
  - Resolution : 7 nm @ 30 kV
  - Accelerating voltage : 2 ~ 30 kV
  - Probe current : 1 pA ~ 65 nA
  - Magnification : 40 x ~ 1,280 kx

Applications

- Ultra high resolution electron, ion imaging
- TEM sample preparation
- Energy dispersive spectroscopy (EDS)
- EBSD image



5 Ultramicrotome

Model ● CR-X [RMC,USA]

Principle

Ultramicrotomes are precision mechanical instruments designed to cut uniformly thin sections of materials for detailed microscopic examination. The quality of a section is dependent on the sample material, cleanliness, sample prep, and cutting parameters. Section thickness is controlled by precise advancement of the sample towards a knife held rigidly in place.

Room#B109

Specifications

- Auto thin sectioning from 5 nm
- Auto thick sectioning to 15 µm
- Cutting speed range from 0.1 ~ 49.9 mm/sec
- Specimen auto feed 200 µm
- Variable return speed over entire cutting speed range

Applications

- Optical, SEM, TEM sample prep

6 Ion Milling System

Model ● IM4000 [Hitachi, Japan] | NanoMill [Fischione, USA]

Principle

The new Hitachi IM4000 Ar ion cross section and sample surface polisher makes two milling configurations available in a single instrument.

Room#B109

Room#B105

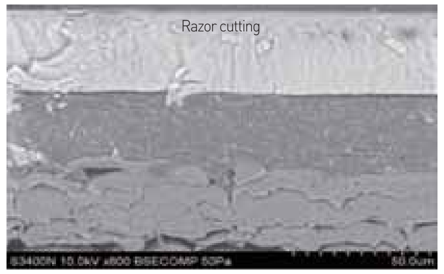
Specifications

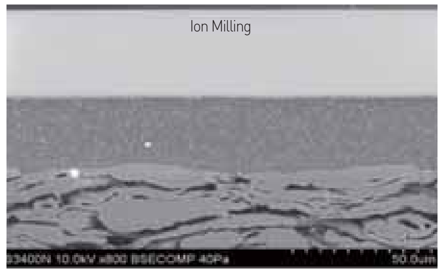
Ion gun

- Type : penning type or saddle field type Ar gun
- Discharge voltage : 0 to 1.5 kV or wider
- Discharge current : 0 to 560 µA or wider
- Accelerating voltage : 0 to 6 kV or wider
- Ion beam diameter : Max. 500 µm or better
- Milling rate : cross-section - 300 µm/hr (sample Si, 6 kV) or better
- Ar gas flow control : high accuracy mass flow control

Applications

- High-quality sectioning (paper, polymers, powders)
- TEM sample prep.





7 Sample Preparation (1)

Model ● Polishing, Grinding System

Principle

The MultiPrep System enables precise semi-automatic sample preparation of a wide range of materials for microscopic (optical, SEM, EBSD, FIB, TEM, AFM, etc.) evaluation. Capabilities include parallel polishing, angle polishing, site-specific polishing or any combination thereof. It provides reproducible sample results by eliminating inconsistencies between users, regardless of their skills.

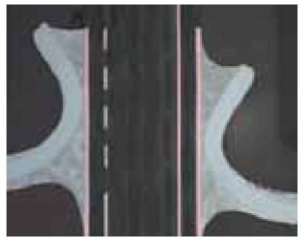
Room #B111

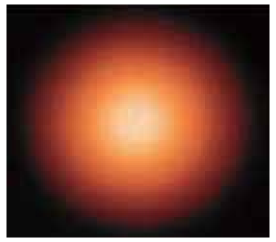
Specifications

- Size : 300 mmW x 200 mmD x 125 mmH
- Shipping weight : 10 kg (22 lbs)
- Power requirement : 100 VAC - 240 VAC, 50/60 Hz
- Control : table rotation, grinding wheel rotation, transmitter light, grinding wheel speed

Applications

- Cross-sectioning
- Serial/3-D preparation
- Wedge polishing, EBSD polishing
- SIMS sample preparation





Sample Preparation (2)

Model ● Polishing, Etching, Coating System

Principle

The PIPS ion mill is a user-friendly, tabletop Precision Ion Polisher System designed to produce high quality, TEM specimens with large electron transparent areas.

Room #B111

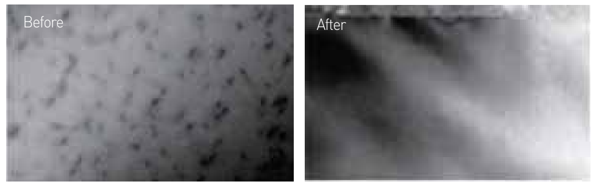
Specifications

- Base vacuum reading : 2.5 x 10^{-6} or lower
- Argon gas pressure at the connection point : 50 +/-5 psi.
- Coating & etching
  - Coating rate : approximately 0.5 Å/sec for Carbon and 1.5 Å/sec for chromium at 10 kV
  - Etching rate : approximately 3 µm/hr for tungsten at 10 kV

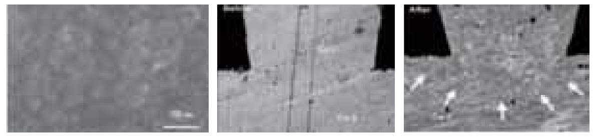
Applications

- TEM sample prep
- EBSD polishing
- Material coating, etching

PIPS



PECS



Coating　Etching

X-ray Analysis

8 High Power X-ray Diffractometer | High Resolution X-ray Diffractometer

Model ● D/MAX 2500V/PC [Rigaku, Japan] | D8 Discover [Bruker, Germany]

Principle

X-ray diffraction is a non-destructive analytical technique which reveals information about the crystallographic structure, chemical composition, and physical properties of powder and thin films.

Room #B115

Specifications

- X-ray source : Cu-rotating anode x-ray
- Focus : line focus
- X-ray generator : 3 phase, 380 V, 18 kW
- Goniometer (angular range) : - 60 ° ~ 128 °
  - horizontal goniometer (SAXS)
  - vertical goniometer (WAXS)
- Attachment
  - high temperature (RT ~ 1,500 °C)
  - battery cell for charging & discharging

Applications

- Characterization of materials with temperature variation
- Characterization of Li battery material for charging & discharging

SAXS

WAXS

Room #B115

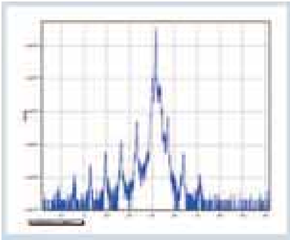
Specifications

- X-ray source : Cu-closed x-ray tube
- Focus : line focus
- X-ray generator : single, 220 V, 3 kW
- θ -2θ based goniometer
- Angular range
  - θ : 0 ~ 360 °
  - 2θ : - 110 ° ~ 168 ° more

Applications

- Determination of lattice mismatch between film & substrate
- Assumption of stress and strain
- Determination of dislocation density and characterization of the film
- Measurement of super-lattices in multilayered epitaxial structures
- Determination of the thickness, roughness, and density of the film (XRR)

High Intensity with Slit



High Resolution with analyzer

9 Normal X-Ray Diffractometer | Single Crystal X-ray Diffractometer

Model ● D8 Advance [Bruker, Germany] | R-AXIS RAPID II [Rigaku, Japan]

Principle

X-ray diffraction is a non-destructive analytical technique which reveals information about the crystallographic structure, chemical composition, and physical properties of materials and thin films. X-ray diffraction is based on constructive interference of monochromatic X-rays and a crystalline sample.

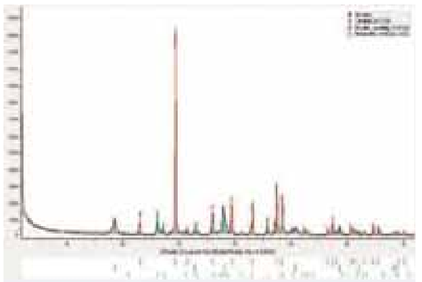
Room #B115

Specifications

- X-ray source : Cu-closed x-ray tube
- Focus : line focus
- X-ray generator : 3 kW
- θ - θ based goniometer
- Angular range
  - θ : 0 ° ~ 360 °
  - 2θ : - 110 ° ~ 168 ° more

Applications

- Material characterization
  - liquid samples
  - airproof samples



Phase ID from peak position

Principle

R-AXIS RAPID II is 2D XRD which has curved imaging plate. It can measure rapidly a variety of samples such as small parts of bulk, normal powder, film, and fiber samples. It also can distinguish single crystal from multi crystal indicating the difference of particle size and alignment through the 2D image patterns. 2D image X-ray Patterns from 2D detector can tell us the information of samples' alignments or crystal structures.

Room #B115

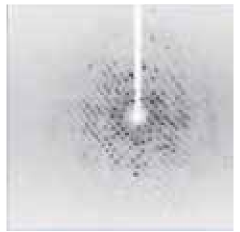
Specifications

- X-ray tube : Mo source
- X-ray generator with high stability : 3 kW (max : 60 kV/ 60 mA)
- Goniometer : decoupled θ and 2θ
- Analyzing crystal
- Optics and chamber
- Imaging Plate (IP) detector : + 5 ~ + 35 °C

Applications

- Measurement of small area and mapping by X-Y stage and collimator
- Measurement of normal powder, residual stress of small area, pole figure, and high temperature
- Trace analysis of small crystallinity

Optical microscopic photograph



Diffraction pattern

10 Wavelength Dispersive X-ray Fluorescence Spectrometer

Model ● T8 Tiger [Bruker, Germany]

Principle

X-ray fluorescence is the emission of characteristic secondary X-rays from a material that has been excited by bombarding with high-energy X-rays or gamma rays. XRF is able to analyze quality and quantity of various elements of solid materials such as geological specimens, slugs, soils, and ceramics very quickly as well as simultaneously. Qualitative analysis of elements ranging from ^{4}Be to ^{92}U is made in concentration of 100 ppm ~ 100 %. With the advantage of non-destructive analysis, precision, and accuracy by repetitive measurements is certified. Moreover, sample preparation is simple.

Room #B115

Specifications

- X-ray generator with high stability : 4 kW (max. : 60 kV/ 170 mA)
- X-ray tube : Rh-anode source
- Goniometer : decoupled θ and 2
- Analyzing crystal
- Analysis elements : ^{4}Be ~ ^{92}U
- Concentration : 100 ppm ~ 100 %
- External cooling system : + 5 ~ + 35 °C
- Sample preparation equipment
  - Ball mill (8000D)
  - pressor (X-Press)
  - Bead machine (k2)
  - Freezer mill (6770)

Applications

- Element analysis
- Semi-quantative analysis

Ball mill

Pressor

Bead machine

Freezer mill

Spectroscopic Analysis

11 [600 MHz | 400 MHz] FT-NMR

Model ● VNMRS 600 ; 400-MR DD2 [Agilent, USA]

Principle

NMR is a technique for determining the structure of most organic and some inorganic molecules. NMR studies a magnetic nucleus by aligning it with a very powerful external magnetic field and disturbing this alignment using an electromagnetic field. Different atoms within a molecule resonate at different frequencies at a given field strength.

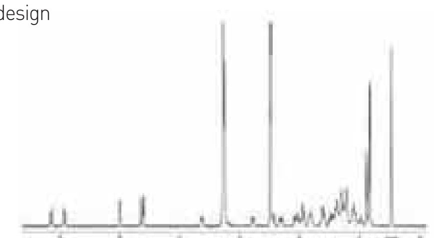
Room #B119

Specifications

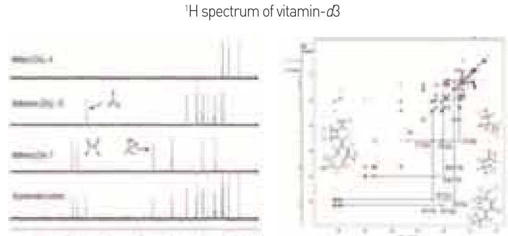
- Premium shielded 14.09 T MHz magnet
- 3 channel console
- Available probes
  - dual broad band auto X probe
  - 5 mm double resonance MAS solid probe
  - 1.6 mm HXY fast MAS triple resonance probe
  - nano TM probe
  - automated triple resonance probe

Applications

- Structural elucidation of chemicals
- Structural determination of biomolecules (DNA, RNA, proteins, peptides, etc.)
- Study of dynamic process
- Drug design



^{1}H spectrum of vitamin-d3



DEPT, gCOSY spectrum of vitamin-d3

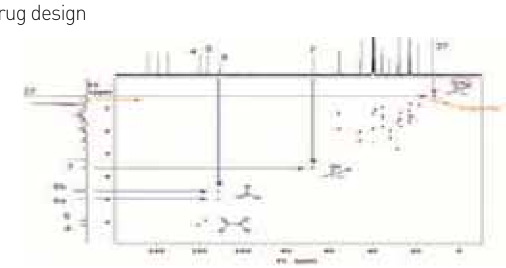
Room #B119

Specifications

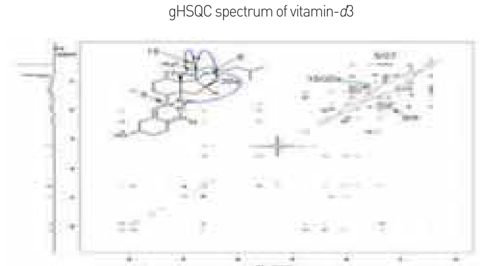
- 9.4 T magnet
- 2 channel console
  - Channel 1 : high band with 1H/19F observe
  - Channel 2 : broadband observe
- 5 mm PFG One NMR Probe
- 12 Auto-sampler

Applications

- Structural elucidation of chemicals
- Structural determination of biomolecules (DNA, RNA, proteins, peptides, etc.)
- Study of dynamic process
- Drug design



gHSQC spectrum of vitamin-d3



ROESY spectrum of vitamin-d3

12 UV-Vis-NIR | UV-Vis Microspectrometer

Model ● Cary 5000 [Agilent, USA] | 20/20 PV [CRAIC, USA]

Principle

UV-Vis-NIR is used for optical absorbance, transmittance, and reflectance measurement in the wavelength range (200 ~ 3,300 nm). When a sample of an unknown compound is exposed to light, certain functional groups within the molecule absorb light of different wavelength. It is used for qualitative and quantitative analysis of materials.

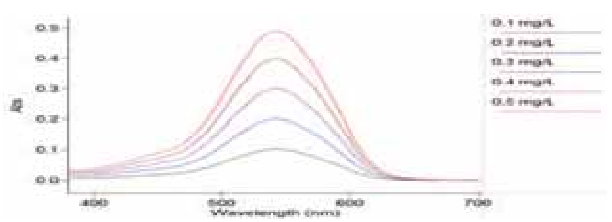
Room #B111

Specifications

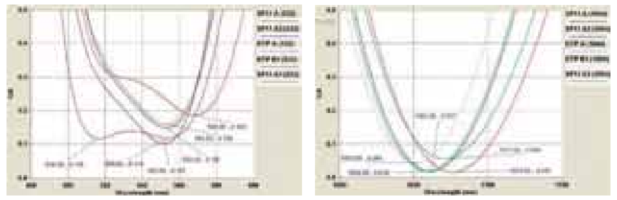
- Wavelength range : 200 ~ 3,300 nm
- Limiting resolution : UV-Vis < 0.048 nm
  NIR < 0.2 nm
- Monochromator : double out-of-plane littrow
- Source - UV : D2 lamp
  Vis-NIR : tungsten halogen lamp
- Detector - UV-Vis : PMT
  - NIR : Pbs

Applications

- Measurement of absorbance and transmittance
- Measurement of reflectance
- Film/coating thickness



Absorbance spectra of chromium solution



Absolute specular reflectance spectra of low-R samples

Principle

UV-visible-NIR microspectrometer measure the transmission and reflectance spectrum of sample areas smaller than a micron from UV, Vis regions. And while microspectrum is being acquired, the sample may be viewed with high-resolution digital image.

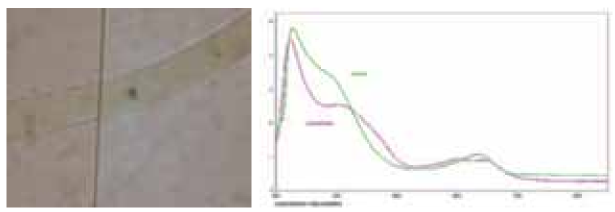
Room #B111

Specifications

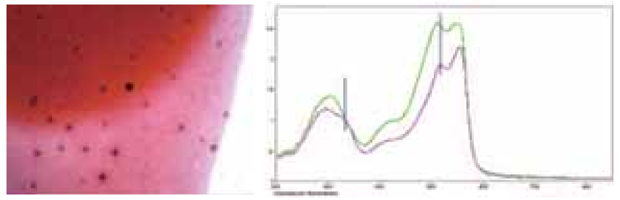
- Spectral rage : 200 ~ 800 nm
- Spectrum bandwidth : 0.32 nm
- Full range single scan time : 7 msec
- Image resolution : more than 1 Mpixel
- Mode : absorbance, transmittance, reflectance

Applications

- Microscale characterization
- Micro-contaminant identification
- Identifying protein, DNA, RNA crystals



Spectrum comparison of two green wool fibers



Microspectrometer and image of red pigment

13 Fluorometer | Spectrofluorometer (Solid, Quantum Yield) | Fluorescence Spectrometer

Model Cary Eclipse [Agilent, USA] | FP-8500 [Jasco, Japan] | NF900(FLS920) [Edinburgh Instrument, UK]

Principle

Fluorescence occurs when the molecule returns to the electronic ground state from the excited state. It is capable of measuring excitation and emission spectra in UV, and Visible regions.

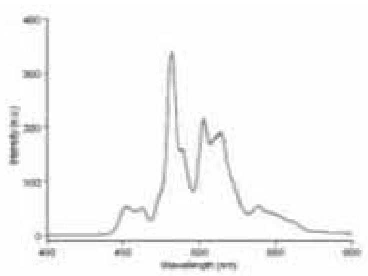
Room #B111

Specifications

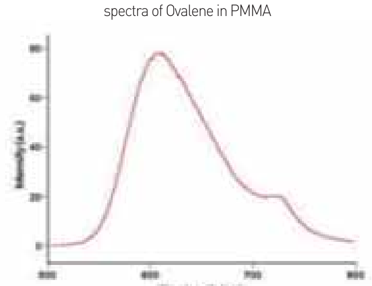
- Light source : Xe lamp
- Wavelength range : 200 ~ 900 nm
- Wavelength accuracy : < 1.5 nm
- Limiting resolution : 1.5 nm
- Detector : photomultiplier tube

Applications

- Qualitative and quantitative analysis of fluorescence for organic and inorganic compounds
- Study of kinetic
- Temperature control measurement
- Multi-cell measurement.



Fluorescence emission spectra of Ovalene in PMMA



Chemiluminescence of Tris (2,2' - bipyridyl) Ruthenium(II) complex

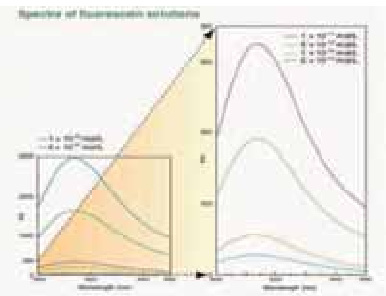
Room #B111

Specifications

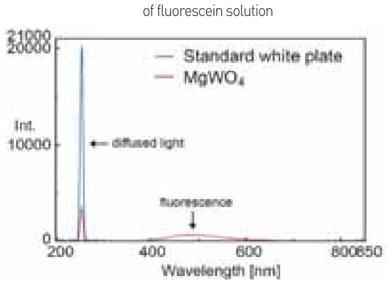
- Light source : Xe lamp (150 W)
- Wavelength range : 200 - 850 nm
- Wavelength accuracy : < 1.0 nm
- Limiting resolution : 1.0 nm
- Detector : photomultiplier tube

Applications

- Qualitative and quantitative analysis of fluorescence for organic and inorganic compounds
- Study of kinetic
- Measurement of quantum yield



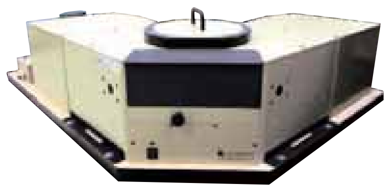
Highest S/N performance spectra of fluorescein solution



Quantum yield calculation (80.8 %) of $MgWO_4$

Principle

Fluorescence occurs when the molecule returns to the electronic ground state from the excited state. It is capable of measuring excitation and emission spectra in UV, Visible and NIR regions



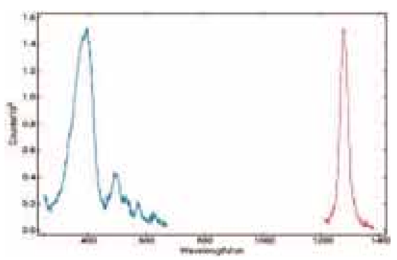
Room #B111

Specifications

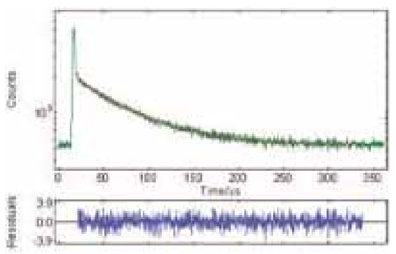
- Light source
  - Xe lamp (450 W)
  - Microsecond Flash Lamp (MCS)
- Wavelength range
  - MCT PMT : 200 - 850 nm
  - NIR PMT : 300 - 1400 nm
- Wavelength accuracy : < 0.2 nm
- Limiting resolution : 0.05 nm
- Detector : photomultiplier tube

Applications

- Qualitative and quantitative analysis of fluorescence for organic and inorganic compounds
- Study of kinetic



Emission spectrum of hematoporphyrin in ethanol, λ_{ex} = 380 nm, λ_{em} = 1270 nm



Time Resolved Singlet Oxygen Measurements μF900 H rate 100 Hz, NIR-PMT, Fit Result : t = 58.5 μs

14 FT-IR

Model 670-IR ; 620-IR Imaging Model [Agilent, USA]

Principle

Fluorescence occurs when the molecule returns to the electronic ground state from the excited state. It is capable of measuring excitation and emission spectra in UV, Visible and NIR regions

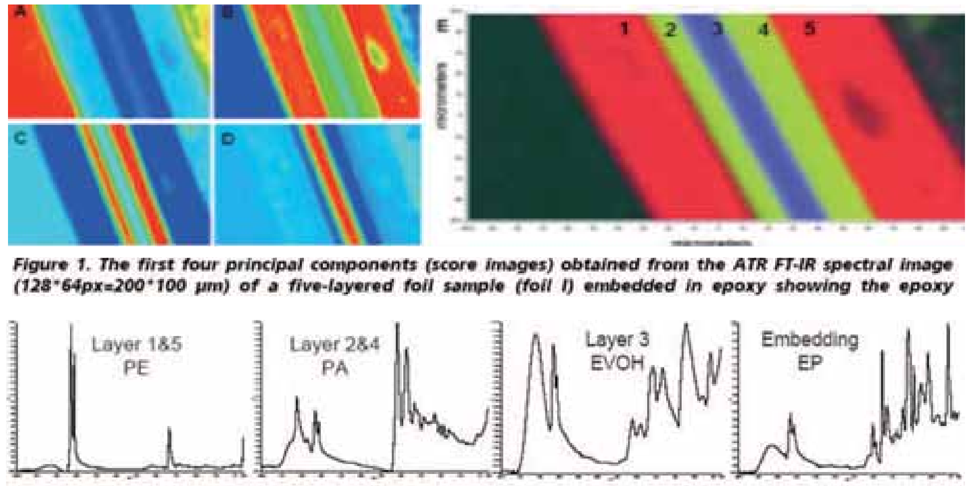
Room #B111

Specifications

- Spectral range : 4000 ~ 50 cm^{-1}
- Spectral resolution : 0.075 cm^{-1}
- Detector - MCT (10000 ~ 450 cm^{-1})
  - DLaTGS (10000 ~ 150 cm^{-1})
  - Far-IR DLaTGS (600 ~ 50 cm^{-1})
- Signal to noise ratio (5 sec) : 12,000 : 1 with 25 % source power
- ATR imaging : 1.4 μm per 1 pixel

Applications

- Qualitative analysis of samples
- Quantitative analysis of samples
- Defect analysis
- Analysis of molecular structure



ATR FT-IR spectra and spectral image of a five-layered foil sample

15 Micro Confocal Raman | Combined AFM & Confocal Raman Microscope

Model ● Alpha300R ; Alpha300S [WITec, Germany]

Principle

Raman information present to characterization of the molecular structure by scattered radiation of different wavelengths. The energy change (either lost or gained) of Raman depends on the symmetry of the molecule.

Room #B107

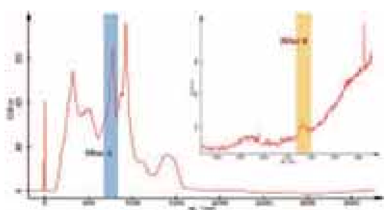
Specifications

- Laser wavelength : 532 nm
- Lens magnification : 50 x, 10 x
- Confocal raman (single, line, and image scan)
- Heating cryostat temperature range : ~ 600 °C
- Freezing cryostat temperature range : 77 ~ 300 K

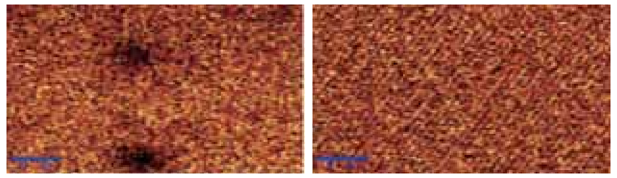
Applications

- Measurement of raman image & single spectrum with temperature variation

Confocal Image



Single Spectrum



Scan Image

Principle

Raman information present to characterization of the molecular structure by scattered radiation of different wavelengths. The energy change (either lost or gained) of Raman depends on the symmetry of the molecule. It is possible to obtain confocal Raman microscopy combined AFM.

Room #B107

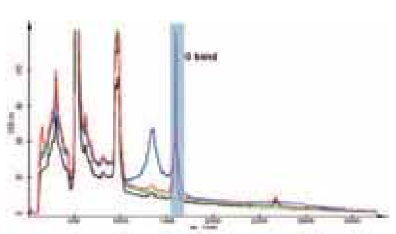
Specifications

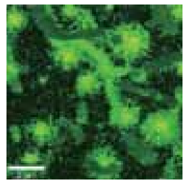
- Laser wavelength : 532 nm/ 633 nm/ 785 nm
- Lens magnification : 100 x, 50 x, 20 x
- Confocal raman (single, line, and image scan)
- Scanning near-field optical microscope (SNOM)
- AFM mode (Acoustic AC and contact mode)

Applications

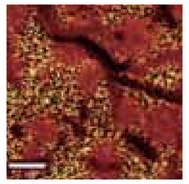
- Measurement of surface topography (AFM mode)
- Measurement of raman image & single spectrum (Raman mode)

Confocal Raman AFM imaging of SWCNT





width analysis of G band



center of mass of G band

16 Confocal Laser Scanning Microscope | Sub-micron Size & Zeta Potential Measuring System

Model ● OLS 3100 [Olympus, Japan] | Nano ZS [Malvern, UK]

Principle

Confocal laser scanning microscopy (CLSM or LSCM) is a technique for obtaining high-resolution optical images with depth selectivity. Images are acquired point-by-point and reconstructed with a computer, allowing three-dimensional reconstructions of topologically complex objects.

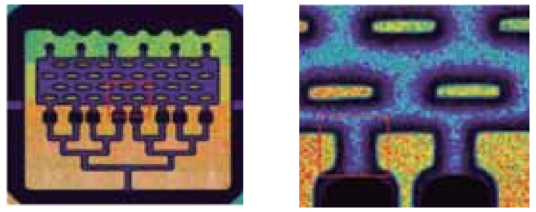
Room #B107

Specifications

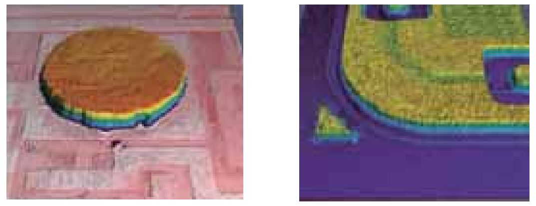
- Laser : 310 nm
- Microscopy : conventional/ laser mode
- Detector
  - 2 PMT fluorescence detectors
  - 2 individual channels simultaneously

Applications

- Observation of 3D image
- Roughness measurement of sample surface
- Depth measurement



Non-confocal measurement & enlargement



Measurement of height, width & roughness

Principle

Particles, emulsions, and molecules in suspension undergo Brownian motion. If the particles or molecules are illuminated with a laser, the intensity of the scattered light fluctuates at a rate that is dependent upon the size of the particles as smaller particles are kicked further by the solvent molecules and move more rapidly. Analysis of these intensity fluctuations yields the velocity of the Brownian motion and hence the particle size using the Stokes-Einstein relationship.

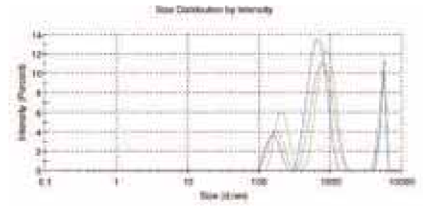
Room #B111

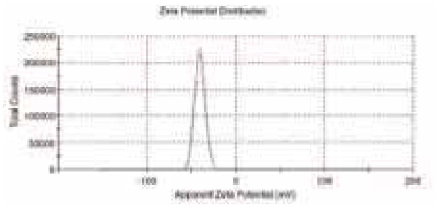
Specifications

- Particle measurement
  - volume range of 12 μL ~ 1.0 mL
  - sample concentration : > 40 % by weight
- Zeta potential measurement
  - principle : laser doppler velocimetry
  - range : - 150 mV ~ + 150 Mv
- Attachment : Multi Purpose Titorator (MPT)

Applications

- Size measurement
- Zeta-potential measurement





Surface Analysis

17 Time-of-Flight Secondary Ion Mass Spectrometer

Model ● TOF SIMS 5 [ION TOF, Germany]

Principle

Secondary ion mass spectrometry (SIMS) is a technique to analyze the composition of solid surfaces and thin films by sputtering the surface of the specimen with a focused primary ion beam and collecting and analyzing ejected secondary ions. Time-of-flight (TOF) is a method of mass spectrometry in which ions are accelerated by an electric field of known strength. The velocity of the ion depends on the mass-to-charge ratio. The time that it subsequently takes for the particle to reach a detector at a known distance is measured. This time will depend on the mass-to-charge ratio of the particle (heavier particles reach lower speeds).

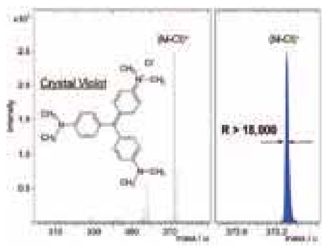
Room #B118

Specifications

- Mass resolution (@ 29 amu) : > 10,000 (for Bi^+)
- Sensitivity (@ 29 amu) : > 3 x 10 - 8 Al^+/nC
- Mass range : > 9,000 amu
- Base pressure : < 5.0×10^{-10} torr
- A self-adjusting charge compensation system
- Primary source : pulsed Bi cluster ion source
- O_2 and Cs dual sources for depth profiling
- A motorized five-axes UHV sample stage
- Two CCD high resolution video cameras

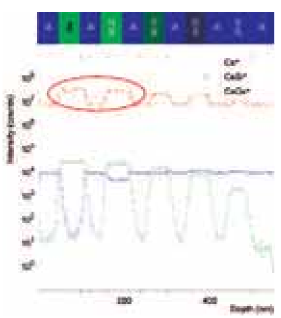
Applications

- Analysis of molecular structrue
- Analysis of trace elements (including H, He)
- Chemical mapping (SIMS imaging)
- Depth profiling and 3D analysis



Positive Surface Spectrum of Crystal Violet on a Silicon Wafer

Chemically Treated Woven Fibres



Depth Profiling of Multilayer

18 X-ray Photoelectron Spectroscope

Model ● K-alpha ; Escalab 250Xi [ThermoFisher, UK]

Principle

X-ray photoelectron spectroscopy (XPS) is a quantitative spectroscopic technique that measures the elemental composition, empirical formula, chemical state and electronic state of the elements that exist within a material. XPS spectra are obtained by irradiating a material with a beam of aluminum or magnesium X-rays while simultaneously measuring the kinetic energy (KE) and number of electrons that escape from the top 1 to 10 nm of the material being analyzed.

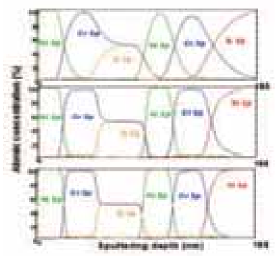
Room #B117

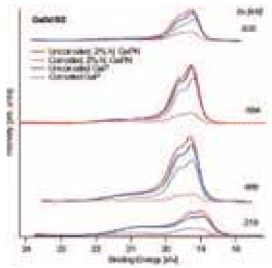
Specifications

- Double-focusing hemispherical analyzer
- Multi-element, high-transmission spectrometer input lens
- 128-channel detector for high quality
- Energy range : 200 eV to 3 keV
- High flux even at low beam energy
- 250 mm Rowland circle monochromator

Applications

- Analysis of organic compound
- Analysis of thin film
- Depth profile





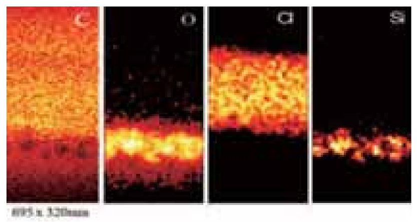
Room #B116

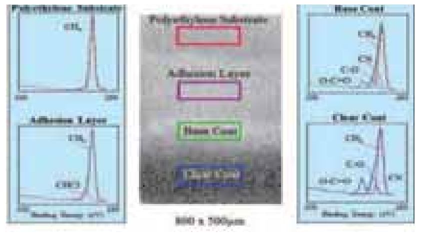
Specifications

- Ultra high vacuum : 1 x 10-10 torr, metal chamber
- Hemispherical energy analyzer (High Resolution 0.45eV)
- Energy source : monochromated Al-Kα, ultraviolet He1, He2
- charge compensation
- XPS imaging : Resolution 3μm
- UPS (ultraviolet source)

Applications

- Analysis of organic compound
- Analysis of thin film
- Depth profile
- Work function





19 Atomic Force Microscope

Model Multimode V ; Dimension 3100 [Veeco, USA]

Principle

AFM or SPM is a branch of microscopy that forms images of surfaces using a physical probe that scans the specimen. An image of the surface is obtained by mechanically moving the probe in a raster scan of the specimen line by line and recording the probe-surface interaction as a function of position.

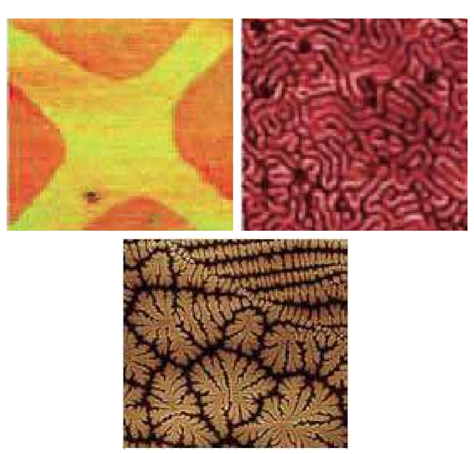
Room #B113

Specifications

- Resolution
  - Noise level RMS : < 0.3 Å RMS
  - Vertical resolution : 0.1 Å
  - Lateral resolution : 1 Å
- Controller
  - X,Y,Z axis : 16 bit, Total : 48 bit
  - High-speed DSP/ADC
  - 2 high-speed ADCs (50 MHz 14 bit)

Applications

- Surface morphology
- Conductive AFM
- Nano indentor



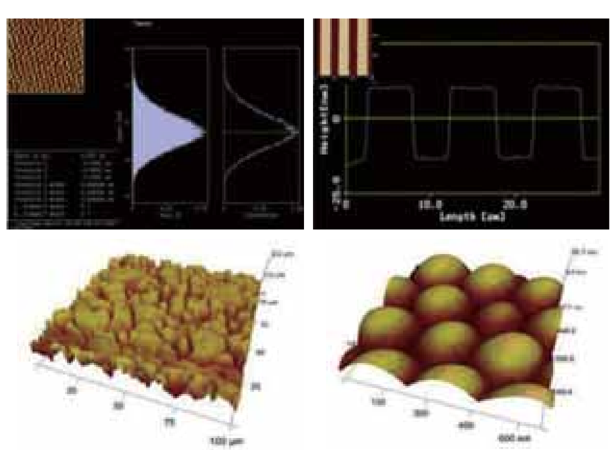
Room #B113

Specifications

- Resolution
  - Noise level RMS : < 0.5 Å RMS
  - Vertical resolution : 0.1 Å
  - Lateral resolution : 1 Å

Applications

- Surface morphology
- Conductive AFM
- Nano indentor



20 Physisorption Analyzer

Model ASAP 2420 ; ASAP 2020 [Micromeritics, USA]

Principle

Accurate and precise surface area and porosimetry measurements are essential to the determination of the effectiveness and quality of a wide variety of materials. Surface Area and Porosimetry system integrates multiple gas sorption techniques into a single, convenient tabletop instrument.

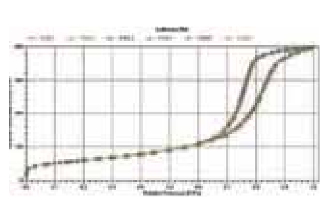
Room #B111

Specifications

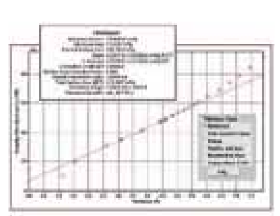
- Operating specifications
  - Surface area range : 0.0005 m^2/g and up
  - Pore diameter range : 3.5 ~ 5000 Å
  - Micro volume : detectable within 0.0001 cc/g
- Pressure measurement Resolution
  - 0 to 1 mmHg Transducer : 0.0000001 mmHg
  - 0 to 10 mmHg Transducer : 0.00001 mmHg
  - 0 to 1000 mmHg Transducer : 0.001 mmHg
- Typical relative pressures
  - N_2/Liquid N_2 : 10^{-7}
  - Ar/Liquid Ar : 10^{-7}

Applications

- BET, langmuir surface.
- BJH, t-Plot, MP, αs-plot, D-A, H-K, DFT Plus (Micro/Mesopore)
- Pore size distribution, volume.



Overlaid results from six samples of high surface area silica alumina



Both mesoporous and microporous sample

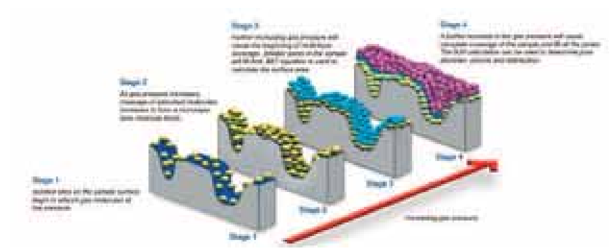
Room #B111

Specifications

- Operating specifications
  - Surface area range : 0.0005 m^2/g and up
  - Pore diameter range : 3.5 ~ 5000 Å
  - Micro volume : Detectable within 0.0001 cc/g
- Pressure measurement resolution
  - 0 to 1 mmHg Transducer : 0.0000001 mmHg
  - 0 to 10 mmHg Transducer : 0.00001 mmHg
  - 0 to 1000 mmHg Transducer : 0.001 mmHg
- Typical relative pressures
  - N_2/Liquid N_2 : 10^{-7}
  - Ar/Liquid Ar : 10^{-7}

Applications

- BET, langmuir surface area.
- BJH, t-plot, MP, αs-Plot, D-A, H-K, DFT Plus.
- Rate of adsorption
- Heat of adsorption
- Meso/micro-pores pore size distribution, volume.



21 Matrix Assisted Laser Desorption Ionization Time-of-Flight Mass Spectrometer

Model ● Ultraflex III [Bruker, Germany]

Principle

Matrix-assisted laser desorption/ionization (MALDI) is a soft ionization technique used in mass spectrometry, allowing the analysis of biomolecules and large organic molecules which tend to be fragile and fragment when ionized by more conventional ionization methods. TOF/TOF is a tandem mass spectrometry method where two time-of-flight mass spectrometers are used consecutively. The first TOF-MS is used to separate the precursor ions, and the second TOF-MS analyzes the product ions. An ion gate for selecting the precursor ion, an ion fragmentation region (e. g. a collision cell) and an ion accelerator may be provided between the first and second TOF-MS.

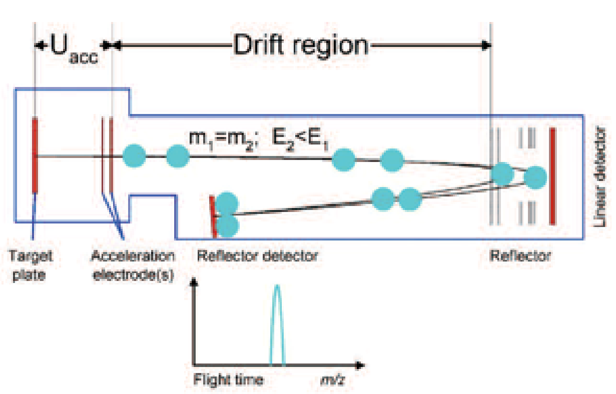
Room #B111

Specifications

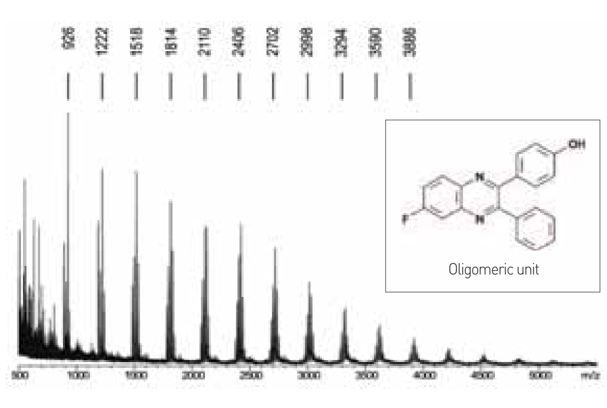
- High mass resolution at every mass from 700 ~ 6,000 Da
- Resolution ≥ 1,100 & mass accuracy of ≤ 80 ppm in linear mode for protein
- Mass accuracy of ≤ 3 ppm for peptide mass range in reflectron mode
- Sensitivity in low attomole range with high S/N ratio in TOF/TOF mode

Applications

- Analysis of biomolecules (protein, peptide, sugar, etc)
- Analysis of large organic molecules (synthetic polymer, dendrimer, etc)



Reflector Flight Tube



Full scale spectrum of copolymer. (Oligomeric unit : 296 Da)

22 Liquid Chromatography Mass Spectrometer, Gas Chromatography Mass Spectrometer, GPC/MALS

Model ● HCT Basic System ; 450-GC & 320-MS [Bruker, Germany] | Agilent 1200 series [Agilent, USA], miniDAWN [Wyatt, USA]

Principle

LC/MS/MS is a powerful and widely used tool in qualitative and quantitative residue and contaminant analysis. The mixture is separated with HPLC preferably using a reversed-phase column. The analytes can be ionized with a suitable ion source by various methods, followed by partial fragmentation. After acceleration, they are deflected by a magnetic field which resolves them according to their mass.

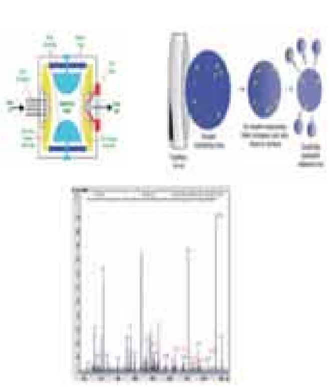
Room #B111

Specifications

- Ion source : ESI, APCI
- Mass range : 50 ~ 3,000 (m/z)
- Resolution : 0.6 unit
- Accuracy : 0.1 ~ 0.3 % absolute
- Scan speed : 26,000 amu/sec
- Mass accuracy : ± 0.15 unit
- Electro sensitivity
  - MS : reserpine 5 pg S/N 10 : 1
  - MS/MS : reserpine 1 pg S/N 50 : 1

Applications

- Analysis of organic composition
- Identification of molecular weight
- Analysis of DNA, RNA, proteins
- Analysis of environmental samples (water, waste, soil)



Principle

GC/MS/MS makes an effective combination for chemical analysis. Mixture of volatile substances is separated by gas chromatography. Via a transfer line the fractions of each peak are transferred into the ion source where the ionization takes place. After acceleration, the ions pass through a magnetic field which causes deviation of their linear flight curve according to their respective mass. After this magnetic field the detector counts the ions.

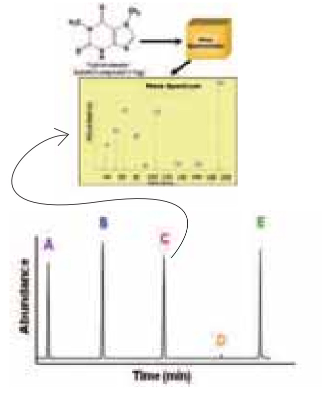
Room #B111

Specifications

- Ionization mode
  - electron ionization
  - positive/negative chemical ionization
- Mass range : 10 ~ 2,000 amu
- Mass axis stability : ± 0.1 unit over 24 hrs
- Resolution : 0.7 amu at 1,250 amu/sec, 0.6 amu at 500 amu/sec
- Mass type : tandem triple quadrupole
- Library : NIST library

Applications

- Confirmation of organic compounds structure
- Confirmation of molecular weight
- Identification of impurities and by-products



Principle

Gel permeation chromatography (GPC) is a termused for when the separation technique size exclusion chromatography (SEC). GPC is often used to determined the relative molecular weight of polymer. Multiangle light scattering (MALS) is a technique for determining, independently, the absolute molar mass and the average size of particles in solution, by detecting how they scatter light.

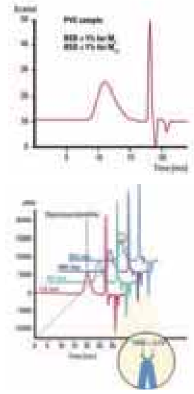
Room #B111

Specifications

- GPC - flow precision : < 0.07 % RSD
  - pressure : 0 ~ 400 bar
  - detector type : double-beam photometer
  - wavelength range : 190 ~ 600 nm
- MALS - light source : 60 mW GaAs linearly polarized laser
  - laser wavelength : 658 nm
  - laser life time : >10,000 hours
  - detectors : 3 angles
- Molecular weight range : 10^3 ~ 10^6 g/mole
- Molecular size range : 10 ~ 50 nm^4

Applications

- Analysis of synthetic polymer
- Analysis of biopolymer



23 Element Analyzer

Model ● TrueSpec Micro CHNS [LECO Corporation, USA] | Flash 2000 [Thermo Scientific, Netherlands]

Principle

Element analyzer determinates the percentage eights of carbon, hydrogen, nitrogen, sulfur and oxygen of a sample. This information is important to help determine the structure of an unknown compound, as well as to help prove the structure and purity of a synthesized compound. It is based on the dynamic flash combustion of the sample followed by reduction, trapping, complete GC Separation and detection of the products by thermal conductivity detector.

Room #B111

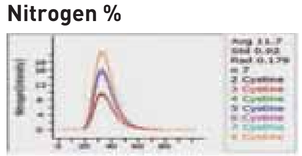
Specifications

- Measuring elements : C, H, N, S
- Measuring range : 0.01 % ~ 100 %
- Sample size : 0.01 ~ 2 mg
- Accuracy : 0.1 ~ 0.3 % absolute
- Detector : TCD, IR cell
- Furnace temperature : 1,100 °C
- Analysis time
  - C, H, N, S : 5 min

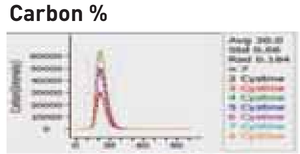
Applications

- Qualitative analysis of organic and inorganic compounds
- Qualitative analysis of environmental samples
- Qualitative analysis of geological samples
- Identification of empirical formula for organic compounds

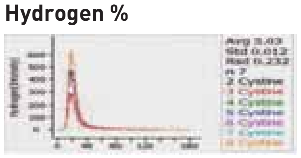
Nitrogen %



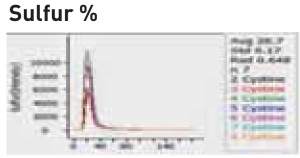
Carbon %



Hydrogen %



Sulfur %



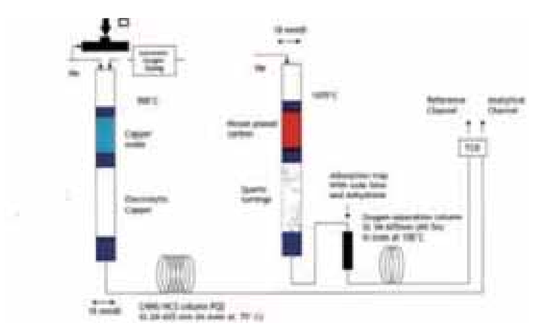
Room #B111

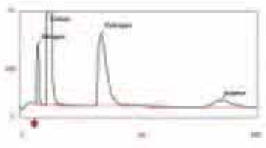
Specifications

- Measuring elements : C, H, N, S, O
- Measuring range : 0.01 % ~ 100 %
- Sample size : 0.01 ~ 500 mg
- Accuracy : 0.1 ~ 0.3 % absolute
- Detector : TCD
- Furnace temperature : 1,100 °C
- Analysis time
  - C, H, N, S : 10 min
  - oxygen : 5 min

Applications

- Qualitative analysis of organic and inorganic compounds
- Qualitative analysis of environmental samples
- Qualitative analysis of geological samples Identification of empirical formula for organic compounds





Thermal & Physical Analysis

24 Thermogravimetric Analyzer / Differential Scanning Calorimeter

Model ● Q500 ; Q200 [TA Instrument, USA]

Principle

Thermogravimetric Analysis (TGA) measures weight changes in a material as a function of temperature (or time) under a controlled atmosphere. Its principal uses include measurement of a material's thermal stability and composition.

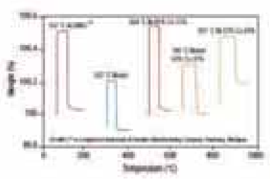
Room #B111

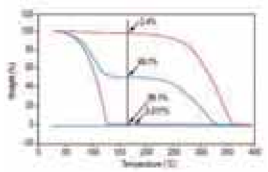
Specifications

- Maximum sample weight : 1 g
- Weight precision : ± 0.01 %
- Sensitivity : 0.1 micron
- Baseline dynamic drift : < 50 micron
- Temperature range : Ambient to 1000 °C
- Isothermal temp accuracy : ± 1 °C
- Isothermal heating rate : ± 0.1 °C
- Controlled heating rate : 0.01 to 100 °C/min
- Furnace cooling (forced air/N_2) : 1000 to 50 °C < 12 min

Applications

- Compositional analysis
- Volatiles analysis
- Effect of additives
- Verification of thermal events
- Quantification of filler content
- Moisture content
- Thermal stability





Principle

Differential scanning calorimetry (DSC) is a thermo analytical technique in which the difference in the amount of heat required to increase the temperature of a sample. Enthalpy of samples is measured as a function of temperature or time.

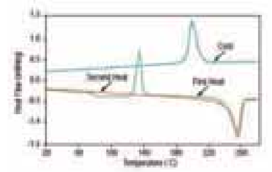
Room #B111

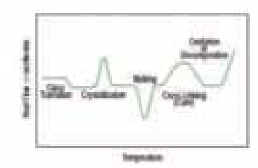
Specifications

- Temperature range : 725 °C
- Cooling accessories : - 180 ~ 725 °C
- Temperature accuracy : ± 0.1 °C
- Calorimetric reproducibility : ± 0.1 %
- Baseline curvature : 10 μW
- Sensitivity : 0.2 μW

Applications

- Glass transition temperature
- Crystallization time & temperature
- Percent crystallinity
- Heates of fusion and reaction
- Specific heat
- Rate of cure
- Degree of cure
- Reaction kinetics





25 Simultaneous TGA/DSC | Dynamic Mechanical Analyzer

Model Q600 ; Q800 [TA Instrument, USA]

Principle

Thermogravimetric analyzer (TGA) measures the amount of weight change of a material, either as a function of increasing temperature or as a function of time in an atmosphere of nitrogen and air.

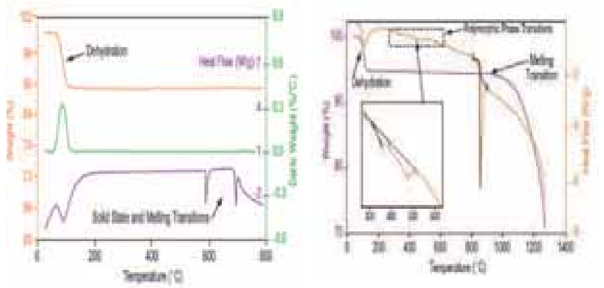
Room #B111

Specifications

- Sample capacity : 200 mg
- Balance sensitivity : 0.1 μg
- Temperature range : ambient ~ 1,500 °C
- Calorimetric accuracy/precision : ± 2 %
- DTA sensitivity : 0.001 °C

Applications

- Measurement of mass change
- Evaporation of water
- Thermal decomposition
- Thermal stability
- Compositional analysis : volatiles, polymers, glass fibers, carbon black, and fillers



DSC-TGA : Sodium tungstate

Principle

Dynamic mechanical analysis measures the mechanical modulus of the material as a function of temperature, time, and frequency by giving the external force which vibrates to the specimen as stress of sinusoidal wave.

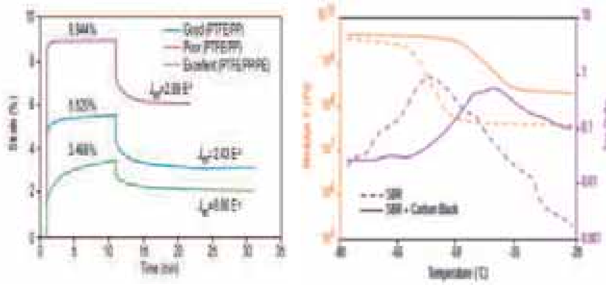
Room #B111

Specifications

- Force : 0.00001 N ~ 18 N
- Force resolution : 0.00001 N
- Strain resolution : 1 nm
- Modulus precision : ± 1 %
- Frequency range : 0.01 ~ 200 Hz
- Temperature range : - 150 ~ 600 °C
- Modulus precision : ± 1 %

Applications

- Viscoelastic behavior
- Relaxation behavior
- Glass transition
- Mechanical modulus
- Crystallization and melting
- Material faults



Effect of Carbon Black in Elastomers

26 Cryogenic Probe Station | Rheometer

Model CRX-4K [Lake Shore, USA] | Haake MARS3 [Thermo Electron(Karlsruhe) Gmbh, Germany]

Principle

A probe station is used to physically acquire signals from the internal nodes of a semiconductor device. If the device is being electrically stimulated, the signal is acquired by the mechanical probe and is displayed on an oscilloscope. This is a ver satile micro-manipulated probe station used for non-destructive testing of devices on full and partial wafers up to 2" in diameter.

Room #B116

Specifications

- Temperature : 1.5 K ~ 475 K
- 4 micro-manipulated probe arms
- 4" wafer probe capabilities
- Cryogen-free CCR (closed cycle refrigerator)
- Vertical or horizontal field magnets
- High vacuum to 10^{-7} torr
- Detector : KEITHLEY (4200-SCS)

Applications

- Characterization of semiconductor device
- Measurement of I-V curve in temperature variation (1.5 K ~ 475 K)
- Measurement of 4 probe resistivity in temperature variation (1.5 K ~ 475 K)

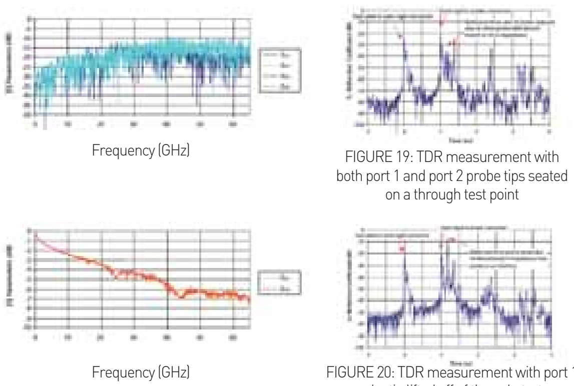


FIGURE 19: TDR measurement with both port 1 and port 2 probe tips seated on a through test point

Frequency (GHz)

FIGURE 17: Frequency Response at 4.3 K

FIGURE 20: TDR measurement with port 1 probe tip lifted off of the substrate; note the large reflection at ~1.2ns, which corresponds to the end of the tip

Principle

Rheometers measure the forces (like shear) associated with a flowing substance. Typically, the flowing substance is much thicker than a liquid (like concrete). A rheometer does not simply measure flow, but also measures the effects of flow at different pressures-especially key characteristics of the flow like shear (how difficult it is to change the flow) or how the flow of a substance tends to drag surrounding materials.

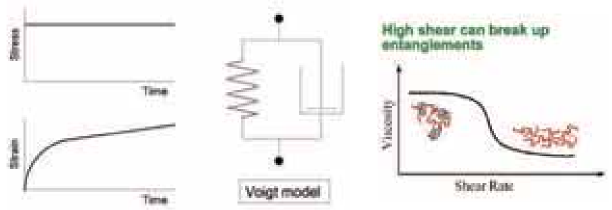
Machkine Shop Room #107

Specifications

- Speed : CR : 0.001 ~ 1500 min^{-1}
  CS : 10^{-7} ~ 1500 min^{-1}
- Angular resolution : 0.012 micro rad
- Temp. range : - 150 ~ 600 °C (Optional)
- Frequency : 10^{-5} up to 100Hz
- MultiWave : 0.01 ~ 20 Hz
- Bearing : air bearing with micro stress control
- Normal force : 0.01 ~ ± 50 N

Applications

- G' (storage modulus)
- G'' (loss modulus)
- tan delta
- η (Viscosity), Eta
- Thixotropic-loop



UNIST Nano Fabrication Center (UNFC)

UNIST Nano Fabrication Center (UNFC) was established to support various nano-fabrication related research areas such as Semiconductor, MEMS, Bio, LED, Solar Cell, Lab-on-a-chip and Packaging. Nano technology is an emerging technology that enables manipulation of materials and fabrication of structures at nm scale, which will take a crucial role in determining the fundamentals and quality of human life in future.

List of Instruments

Lab	No.	Equipment	Model	Maker	Page
Lithography	1	E-beam lithography	NB3	NBL, UK	33
	2	Mask aligner	MA6	SUSS MicroTec, Germany	34
		Mask contact aligner	MDA-400S	MIDAS, Korea	34
	3	Nanoimprint lithography system	ANT-6H	Elan & KIMM, Korea	35
	4	Spin coater	JSP6D	JD Tech, Korea	35
Etching	5	Deep RIE	TEGAL 200	TEGAL, France	36
		Dielectric RIE	Lab star-D	TTL, Korea	36
		Metal RIE	Lab star-M	TTL, Korea	36
	6	PR asher	V15-G	KAMI, Germany	37
	7	Wet station	Wet station	Donghoon tech, Korea	37
Thinfilm	8	Thermal atomic layer deposition	Lucida D100	NCD, Korea	38
		Cluster atomic layer deposition	Atomic premium	CN1, Korea	38
	9	Parylene coater	Parylene Coater	Alpha plus, Korea	39
		SAM (Self Assembly Mono-layer) coater	AVC-150M	SORONA, Korea	39
	10	UHV-CVD (Ultra High Vacuum Chemical Vapor Deposition)	UHV-CVD	Wooshin, Korea	40
		LP-CVD (Low Pressure Chemical Vapor Deposition)	KVL206	KSM, Korea	40
	11	PE-CVD (Plasma Enhanced Chemical Vapor Deposition)	PEH-600	SORONA, Korea	41
		SiC PE-CVD	FABStar-PECVD	TTL, Korea	41
	12	E-Beam evaporator (Temescal)	FC-2000	Temescal, USA	42
		E-Beam evaporator (Woosung)	WC-4000	WOOSUNG , Korea	42
	13	DC sputtering system	SRN-120M	SORONA, Korea	43
		RF sputtering system	SRN-120	SORONA, Korea	43
	14	Furnace system (Oxide & $POCl_3$)	KHD-306	KSM, Korea	44
	15	MO-CVD	MARVEL 260S	SYSNEX, Korea	44
Measurement	16	Normal scanning electron microscope	S-3400N	Hitachi, Japan	45
	17	Digital inspection microscopy system	DM4000M	Leica, Germany	46
		Measurement microscope	Axio scope A1	CarlZeiss, Germany	46
	18	Surface profiler	P-6	KLA Tencor, USA	47
		Thin film measurement	ST4000-DLX	K-MAC, Korea	47
	19	Full auto 4-Point probe system	CMT-SR2000N	AIT, Korea	48
		Contact angle	Phoenix 300	SEO, Korea	48
Packaging	20	Substrate sawing machine	AR06DM	Aaron, Korea	49
		Substrate bonder	SB-6L	SUSS MicroTec, USA	49

Office Phone Number : 4064, 4065
Office Email : u-nfc@unist.ac.kr

Lithography

1 E-Beam lithography

Model NB3 [NBL, UK]

Principle

As the primary electron beam penetrates the resist, elastic collisions spread the beam slightly. Backscattered electrons from the substrate may be spread over several microns. The secondary electrons generated in this process impart energy to resist through inelastic collisions. This causes the physical and chemical changes in the resist that renders in more soluble than the unexposed resist.

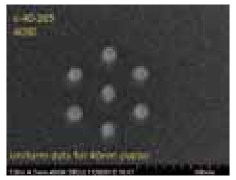
Room #B101

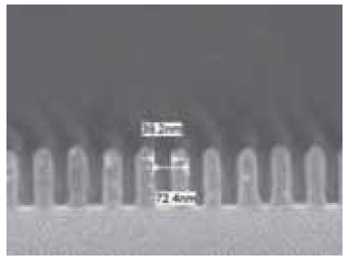
Specifications

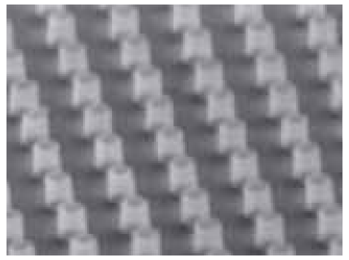
- Theoretical beam size : 2.1 nm @ 100 keV, 7 nA
- Line width : < 5 nm
- Deflection : vector scan, 55 MHz
- Address grid resolution : 1 nm, 1 mm main field
- Beam voltage : 30 ~ 100 keV
- Writing area : 195 mm × 195 mm
- Repeatable : 20 nm over wafer

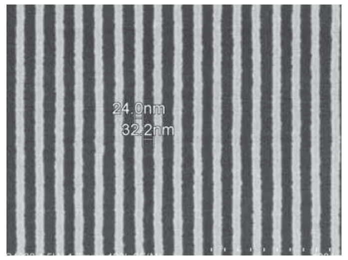
Applications

- nm level device fabrication
- Generating fine patterns
- Mask manufacture
- Optical device fabrication
- Contacts for Nanowires/rods









2 Mask aligner | Mask contact aligner

Model ● MA6 *[Image Corrector]* [SUSS MicroTec, Germany] | MDA-400S *[Image Corrector]* [MIDAS, Korea]

Principle

[MA6 | MDA-400S] performs alignment and exposures by UV lamp on the wafer and substrates coated by Photo-resist through mask with alignment keys

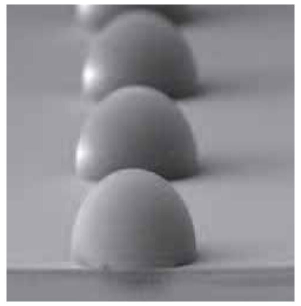
Room #B101

Specifications

- High efficiency & high accurate UV exposure system
- UV lamp : Hg 350 W
- UV 400 : 350 ~ 450 nm (I-, H-, G-line)
- Gap adjustment accuracy : 1 µm
- Methods : top & back side alignment
- Alignment accuracy : 1 µm
- Exposure type : vacuum, low vac., proximity, hard, soft, flood-exposure mode
- Semi automatic system

Applications

- Micro scale patterning for semiconductor process
- MEMS / Nano device fabrication



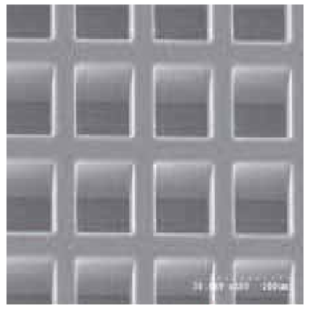
Room #B101

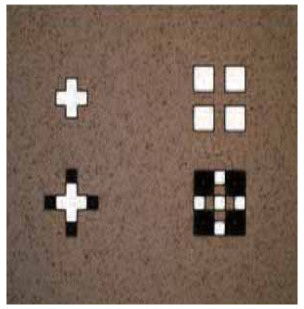
Specifications

- High efficiency & high accurate UV exposure system
- UV lamp : Hg 350 W
- UV 400 : 350 ~ 450 nm (I-, H-, G-line)
- Gap adjustment accuracy : 1 µm
- Methods : top side alignment only
- Alignment accuracy : 1 µm
- Microscope magnification : 90 x ~ 500 x
- Fully manual type system

Applications

- Micro scale patterning for semiconductor process
- MEMS / Nano device fabrication





3 Nanoimprint lithography system

Model ● ANT-6H *[Image Corrector]* [Elan & KIMM, Korea]

Principle

Nano-Imprint fundamental principle is to transfer the master patterns defined in the stamp to deformable materials such as Photo-resist spun on substrate by mechanical press.

Room #B101

Specifications

- Curing type : UV, thermal, UV & thermal
- Imprint area : ~ 6 inch
- Stamp : Quartz, Si, Ni, PDMS, PMMA, etc.
- Imprint Pressure : ≤ 2 bar (UV), ≤ 60 bar (Thermal)
- UV System : ~ 50 mw/cm², 2 Kw
- Temperature : RT ~ 250 °C

Applications

- Nanostructure device imprint fabrication
- Functional device chemical & bio sensor

4 Spin coater

Model ● JSP6D *[Image Corrector]* [JD Tech, Korea]

Principle

The device which deposits the uniformly thick & thin Photo-resists by high speed.

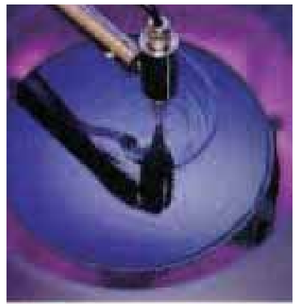
Room #B101

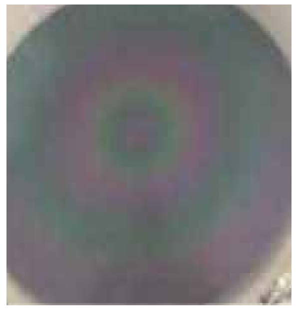
Specifications

- Wafer suitability loading size
- Chamber size : 300 mm diameter
- Sample size : piece ~ 6 inch
- Rotation speed : Max. 5,000 rpm
- Vacuum input : - 450 mmHg ~ - 750 mmHg

Applications

- Adhesion treatment on substrates
- Photo resist coating





Etching

5 [Deep | Dielectric | Metal] RIE

Model ● TEGAL 200 [TEGAL, France] | Lab star-D ; Lab star-M [TTL, Korea]

Principle

In current, micro electro mechanical systems (MEMS) fabrication, deep reactive ion etching (DRIE) is one of the most characteristic widely utilized techniques.

Room #B101

Specifications

- Source generator : 5500 W
- Chuck generator : 300 W
- E-chuck hellium cooling system
- SF_6 / C_4F_8 / O_2 bosch process
- Deep silicon etching
- Loadlock / process chamber transfer

Applications

- Deep etching process of Si / SiO_2 / Si_3N_4

Reactive ion etcher forms fine patterns by dry etching placing wafer inside the process mod ule and generating plasma.

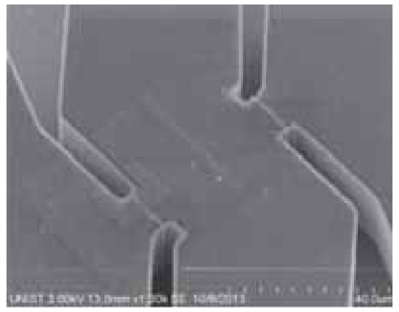
Room #B101

Specifications

- SiO_2 etch
  - process gases : CF_4, CHF_3, Ar, O_2
  - etch rate : > 35 nm/min
  - uniformity : ± 5 % (200 mm diameter)
  - selectivity : SiO_2 : resist = 3 ~ 5 : 1
- SiN etch
  - process gases : CF_4, Ar, O_2
  - etch rate : > 50 nm/min
  - uniformity : ± 5 % (200 mm diameter)
  - selectivity : 1.5 ~ 3 : 1

Applications

- Si / SiO_2 / Si_3N_4 dry etching



Metal RIE is an ion etching system for metal (Al, Ti, Cr, W, and Au) pattern formation.

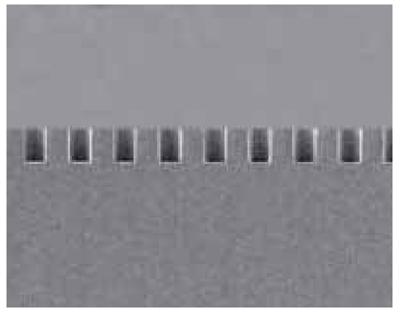
Room #B101

Specifications

- Reactor (process chamber) module
  - 200 mm electrode with water cooled by heat exchanger
  - 4 ~6 inch silicon wafer
- MFCs with bypass lines (BCl_3 / Cl_2 / Ar / O_2 / SF_6) installed
- RF generator & auto match network : 600 W, 13.56 MHz solid state
- RF generator with automatic match unit for bias (RIE) power

Applications

- Dry etching process for metal layer (Au, Al, Pt, W, Ti, and Cr)



6 PR asher

Model ● V15-G [KAMI, Germany]

Principle

The equipment removes selectively coated photoresist for the semi conductor process using gas plasma.

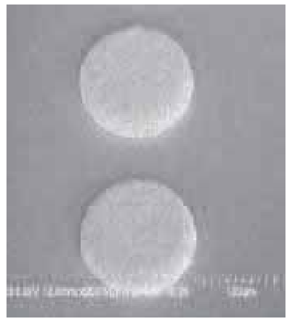
Room #B101

Specifications

- 250 x 250 x 250 mm, aluminum chamber
- Reactor with 250 mm water cooled chuck
- Microwave power generator : 2.45 GHz, from 100 up to max. 600 W
- Gas inlet : 2 gas inlet pipes (top side mounted)
- O_2, Ar gas control unit (MFC) : ≥ 200 ml/min
- Process storage capability of 10 main process with 16 sub-process, rotation table 19"

Applications

- Polymer elimination
- Photoresist residue elimination
- Polymer layer thickness control



7 Wet station

Model ● Wet station [Donghun tech, Korea]

Principle

This device allows 6" wafer to progress into photoresist development and wet etching process.

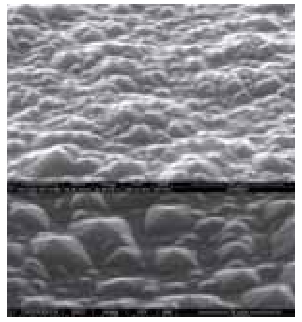
Room #B101

Specifications

- Chemical supply : manual
- Chemical temp. : 50 ~ 120
- Chemical drain : bottle drain (air valve)
- PR wet station (2 Set) : ultrasonic bath, develop bath, Q.D.R bath
- Acid wet station : SC-1, 2 bath, SPM bath, BOE bath, DHF bath, H_3PO_4 bath, Q.D.R bath
- Solvent wet station
- Etching wet station
- MEMS wet station
- CMOS wet station

Applications

- Photoresist developing
- Surface cleaning
- Wet etching (Si wafer/SiO_2 layer etc.)



8 (Thermal | Cluster) atomic layer deposition system

Model Lucida D100 [NCD, Korea] | Atomic premium (CN1, Korea)

Principle

ALD is a thin film deposition technique that is based on the sequential use of a gas phase chemical process. The majority of ALD reactions use two chemicals, typically called precursors. These precursors react with the surface of a material one at a time in a sequential, self-limiting, manner. Through the repeated exposure to separate precursors, a thin film is slowly deposited.

Room #B101

Room #B101

Specifications

- Substrate size : 4 ~ 8 inch silicon wafer
- Substrate temperature
  - 25 °C ~ 350 °C (± 0.2 °C) @ 1 Torr, in wafer
- Deposition uniformity : less than ± 2 % within wafer
- Precursor sources
  - 3, heated 2 sources and H_2O source

Applications

- High-k thin film (HfO_2, TiO_2, Al_2O_3) Depo.
- Applications of R&D

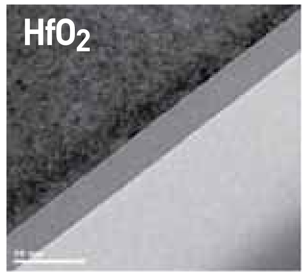
Specifications

- Substrate size : 4 ~ 8 inch silicon wafer
- Process temperature : 30 °C ~ 450 °C
- Deposition uniformity : less than ± 2 % within wafer
- Dual process mode : termal and plasma
- Shower head type multi-chamber cluster tool

Applications

- Dielectric thin films : Al_2O_3, HfO_2, etc
- Nitride & metal thin films : TaN, etc

Al_2O_3



HfO_2

Al_2O_3

TaN

9 [Parylene | SAM(Self Assembly Mono-layer)] Coater

Model Parylene Coater [Alpha plus, Korea] | AVC-150M [SORONA, Korea]

Principle

The Dimer is inserted into the vaporizer in the powder form and evaporated between 120 - 175 °C Furnace chamber heated to approximately 650 - 690 degrees through the monomer which is converted to the substrate. After the process, the temperature is recovered to room temperature, creating a Poly-para-Xylylene film coating.

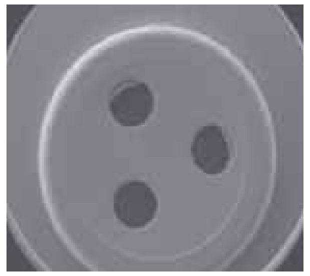
Room #B101

Specifications

- Dimer type : c
- Deposition rate : over 1-2 um/hr
- Substrate size : max. dia. 200 mm
- Process temperature - furnace (R/T to 1000 °C ± °C)
  - /Vaporizer (R/T to 300 °C ± 3 °C)
- Thickness variation : less than ± 10 % within wafer

Applications

- MEMS / NANO Device
- SAW filters
- UV embossing / Nano imprint lithography
- Telecommunication devices



Principle

This machine can grow polymer mono-layer with very solid bonding force by forming O-H layer by natural oxygen on sample and supplied polymer source from vaporizer.

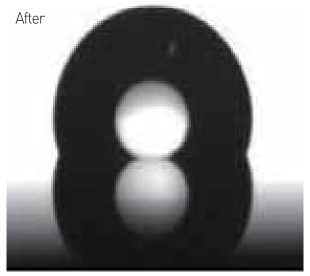
Room #B101

Specifications

- Contact angle : 5 ° ~ 110 ° (water)
- Work of adhesion : 3 ~ 100 uJ/m2
- Wafer sample size : ≤ 300 mm
- Precursor usage : (0.1 cc/batch (depends on application and throughput)
- Surface treatment : RF Plasma (100 ~ 300 W)
- Reactor cleaning by O_2 plasma oxide material

Applications

- Nano patterning of bio devices by imprinting & display panel by imprinting
- Polymer memory device by imprinting

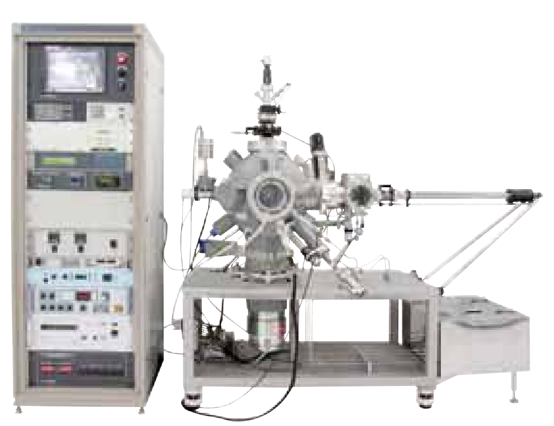


10 [Ultra High Vacuum | Low Pressure] Chemical Vapor Deposition

Model ● UHV-CVD [Wooshin cryovac, Korea] | KVL206 [KSM, Korea]

Principle

UHV CVD system is the device which creates new qualified wafer based on chemical reaction between gas and sample by spraying a gas to keep base pressure at $1x10^{-10}$ torr



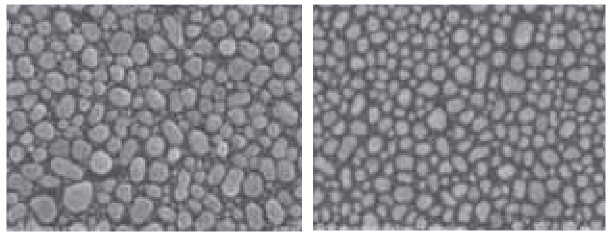
Room #B101

Specifications

- Main chamber : 500 mm (vacuum range : 1×10^{-10})
- Load lock chamber : 200 mm
- Magnetic transfer probe : 800 mm stroke include linear guide & sample transfer line
- Heater stage : 1,500 °C temp. 2" target
- Gas supply : MFC 5 sets (SiH_4, GeH_4, C_2H_4, H_2, N_2)
- LEED package : 3 grid LEED, LEED electronics, LEED retraction, LEED fan shutter
  - max. beam current : 〉30 μA for LaB6 filament
  - transfer width : 〉250 Å at E = 100 eV
  - fixed focus range : 20 ~ 500 eV

Applications

- High quality thin film deposition for MEMS / nano device



Principle

LPCVD refers to a thermal process used to deposit thin films from gas-phase precursors at subatmospheric pressures. LPCVD is used to deposit a wide range of possible film compositions with good conformal step coverage.

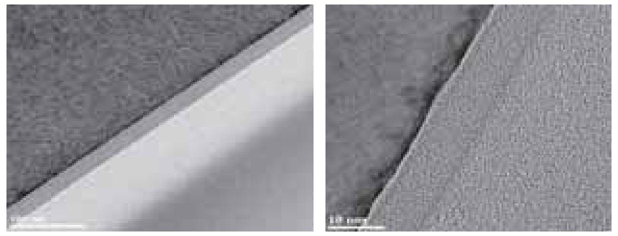
Room #B101

Specifications

- Wafer size : 6 inch silicon wafer
- Vertical furnace type
- D-Poly
  - process gas : SiH_4, PH_3
  - process temp : 500 ~ 600 °C
  - thickness uniformity : less than ± 3 % within wafer
  - Rs uniformity : less than ± 3 % wafer to wafer
    less than ± 5 % within wafer
- Nitride
  - process gas : DCS, NH_3,
  - process temp : 700 ~ 800 °C
  - thickness uniformity : less than ± 3 % within wafer
    less than ± 3 % wafer to wafer

Applications

- Nitride, Poly-Si layer deposition
- Impurity doping for solar cell
- Research of semiconductor, MEMS process



11 [Plasma Enhanced | Silicon Carbide Plasma Enhanced] Chemical Vapor Deposition

Model ● PEH-600 [SORONA, Korea] | FABStar-PECVD [TTL, Korea]

Principle

PECVD System is a multipurpose tool capable of deposition silicon oxide, silicon nitride using electron energy (plasma) as the activation method to enable deposition at a low temperature and at a reasonable rate.

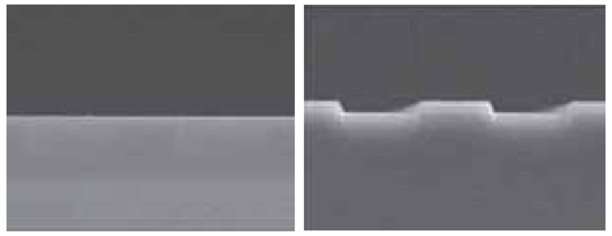
Room #B101

Specifications

- Wafer Size : 4 ~ 6 inch silicon wafer
  Max Substrate Temperature : 400 °C
- High Plasma Density, High Dep. rate PE-CVD
- Power Supply : 600 W, 13.56 MHz RF Generator
- Process guarantee : 1000 Å ~ 2 um
- Uniformity : less than ± 3 % within wafer
- Wafer to Wafer Uniformity : ± 3 %
- Uniform process gas flow distribution

Applications

- Passivation layer of semiconductor
- Inter metal dielectric of semiconductor
- Inter layer dielectric of semiconductor



Principle

SiC PECVD System is capable of deposition silicon carbide using electron energy (plasma) as the activation method to enable deposition at a low temperature and at a reasonable rate.

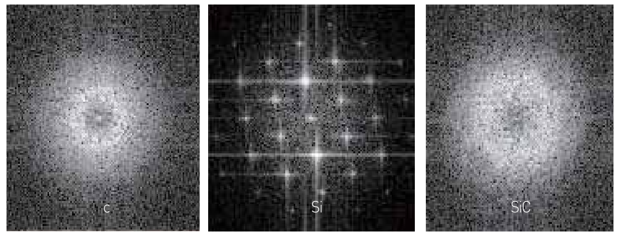
Room #B101

Specifications

- Wafer size : 4 ~ 6 inch silicon wafer
  Substrate temperature : 250 ~ 350 °C
- High plasma density, high dep. rate PE-CVD
- Process gas : N_2, SF_6/O_2, pure SiH_4/CH_4
- Power supply : 600 W, 13.56 MHz RF Generator
- Process guarantee : 1000 Å ~ 1 um
- Uniformity : less than ± 3 % within wafer
- Uniform process gas flow distribution

Applications

- High rate and high quality silicon carbide deposition with stress control
- Passivation layer
- Inter metal dielectric of semiconductor
- Inter layer dielectric of semiconductor



12 E-Beam evaporator system

Model FC-2000 [Temescal, USA] | WC-4000 [WOOSUNG HI-VAC, Korea]

Principle

Electron beam source is shown by the power supply to the hot filament electron beam by the magnetic field induced by magnet.

Room #B101

Specifications

- E-beam source assembly by Temescal in USA
- 15 cc, 6 pocket (Au, Cr, Ni, Ti, Al, Pt, Pd)
- Power supply : 6 kw (CV-6SLX)
- Source control module (Temescal)
- Substrate heat : 300 °C (4 kW)
- Programmable sweep controller (Inficon)
- Uniformity : less than ± 5 % within wafer
  less than ± 5 % wafer to wafer

Applications

- Conventional materials coating
- Lift off process
- Metal electrode deposition on surfaces

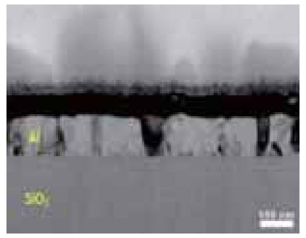
Room #B101

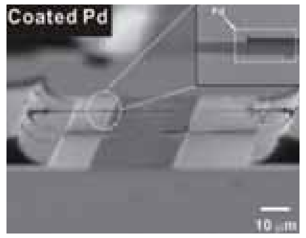
Specifications

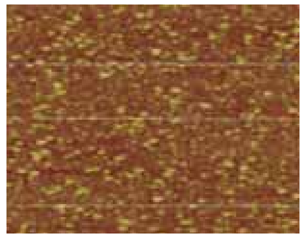
- E-beam source assembly by TELEMARK in USA
- 7 cc, 6 pocket (Au, Cr, Cu, Ni, Ti, Al, Pt, Pd)
- Power supply : 6 kW (SJ Power)
- Substrate Rotation Speed: 0 ~ 80 rpm
- Programmable sweep controller (Sycon)
- Uniformity : less than ± 5 % within wafer
  less than ± 5 % wafer to wafer

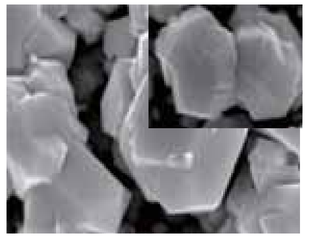
Applications

- Conventional materials coating
- Lift off process
- Metal electrode deposition on surfaces









13 [DC | RF] sputtering system

Model SRN-120M ; SRN-120 [SORONA, Korea]

Principle

DC Sputtering system is a multi-purpose tool generating plasma inside chamber by supplying 3 kw DC power to cathode and capable of thin film deposition of metal materials on wafer by sputtering a metal target by DC negative voltage.

Principle

RF Sputtering system is a multi-purpose tool generating plasma inside chamber supplying 13.56 Mhz RF power to cathode and capable of thin film deposition of insulator on wafer by sputtering an insulator target by self bias voltage.

Room #B101

Specifications

- Substrate size : 4, 6 inch silicon wafer
- Substrate rotation speed : 0 ~ 60 rpm
- RF pre-cleaning : 300 W, automatic processing
- Substrate heating : 300 °C ± 3 % (wafer temp)
- Number of target : max. 4 different targets
- Power source : 3 kW DC power processing
- Uniformity : less than ± 5 % within wafer

Applications

- Thin film for semiconductor
- Fabrication of contacts interconnects

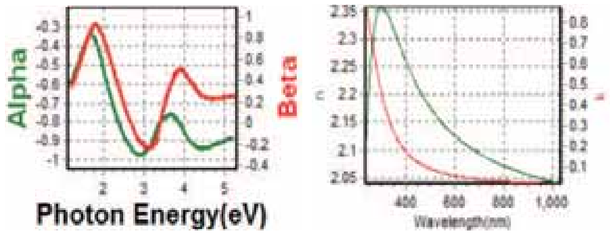
Room #B101

Specifications

- Substrate size : 4, 6 inch silicon wafer
- Substrate rotation speed : 0 ~ 60 rpm
- RF pre-cleaning : 300 W, automatic processing
- Substrate heating : 500 °C ± 3 % (wafer temp)
- Target : ITO, ZnO, SiO_2, Al_2O_3, TiO_2
- Power source : 13.56 Mhz RF power
- Uniformity : less than ± 5 % within wafer

Applications

- Thin film for semiconductor
- Insulation layer deposition



<Deposited ITO 100 nm>

14 Furnace system (Oxide & $POCl_3$)

Model KHD-306 [KSM, Korea]

Principle

Silicon dioxide (SiO2) is a main insulating material used in micro technology and the most common technique in a furnace. There are two methods of oxidation. (Dry and wet)

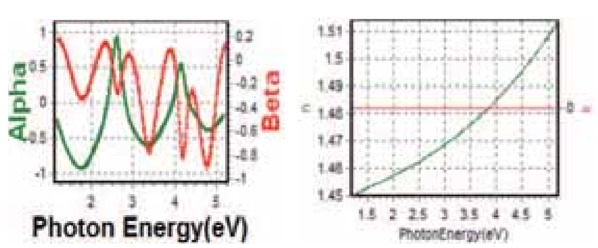
Room #B101

Specifications

- Heater spec (3 zone) : 200 ~ 1200 °C
- Wafer size : 4 ~ 6 inch sillicon vapor
- Wet oxidation chamber
  - thickness uniformity : less than ± 3 % within wafer
    less than ± 3 % wafer to wafer
- Dry oxidation chamber
  - thickness uniformity : less than ± 3 % within wafer
    less than ± 3 % wafer to wafer
- Metal & dielectric film annealing chamber
- $POCl_3$ doping chamber
  - resistivity uniformity : less than ± 5 % within wafer

Applications

- Oxidation layer growth on silicon wafer
- Metal & dielectric layer annealing process
- N-type doping and anneal process



Photon Energy(eV)

15 MO-CVD

Model MARVEL 260S [SYSNEX, Korea]

Principle

MOCVD is a chemical vapor deposition method of epitaxial growth of materials, especially compound semiconductors, from the surface reaction of organic compounds or metal organics.

Room #B101

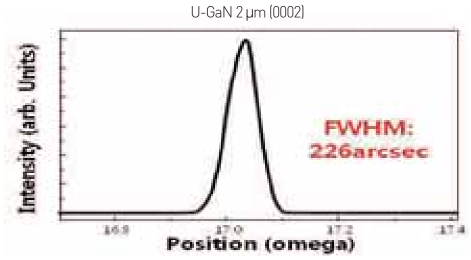
Specifications

- 6 x 2 inch reactor system
- RF generator max. power 30 kW
- SiC coated graphite susceptors (2 EA)
- Hydrogen and nitrogen gas manifold for selection each of the MO-source
- One set MKS Differential controller with pressure sensor, control valves
- MO line : TMAl, TMIn, TMGa1, TEG, Cp_2Mg

Applications

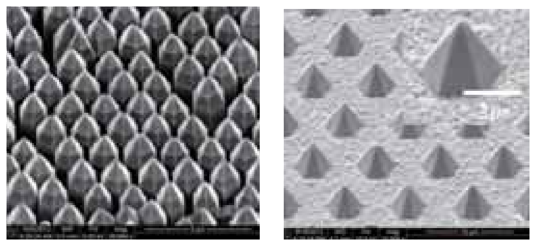
- InGaN LED Epi growth
- Undoped GaN, n-GaN, p-GaN Epi

U-GaN 2 μm (0002)



Position (omega)

InGaN Nanostructure



16 Normal scanning electron microscope

Model S-3400N [Hitachi, Japan]

Principle

SEM is a microscope that uses electrons instead of light to form an image. The scanning electron microscope has many advantages over traditional microscopes.

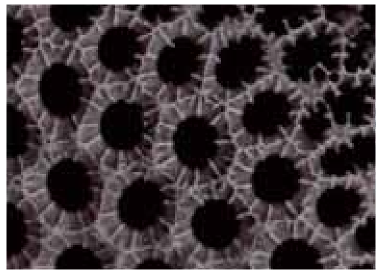
Room #B101

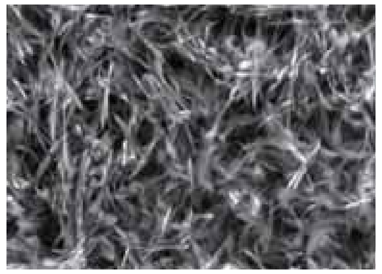
Specifications

- Resolution : 3.0 nm at 30 kV, 10 nm at 3 kV (SE mode)
- Magnification : x 5 to x 300,000 (continuous)
- Accelerate voltage : 0.3 to 30 kV (0.1 kV/step)
- Detector : SE+BSE
- Electrical image shift : ± 50 μm (WD = 10 mm)
- Electron gun : precentered cartridge filament
- Traverse : X axis 0 ~ 100 mm, Y axis 0 ~ 50 mm

Applications

- Microstructure analysis of the sample, such as a wide range of metal, materials, semiconductors, fiber and polymer material.
- Surface microstructure of the metal, the material and shape of analysis.





17 Digital inspection microscopy system | Measurement microscope

Model ● DM4000M *[Image Corrector]* [Leica, Germany] | Axio scope A1 *[Image Corrector]* [CarlZeiss, Germany]

Principle

Versatile functionality and analysis is only of use if high-quality original images can be obtained. The Digital Microscope has succeeded in producing sharper, super high resolution observation images by applying sophisticated technologies to every process from lighting to image generation.

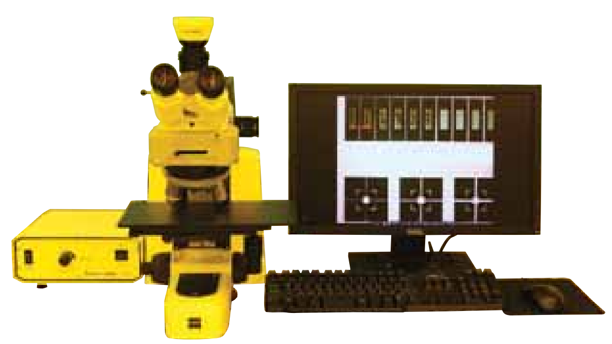
Room #B101

Specifications

- 6-position nosepiece (M32), manual
- 4-position turret for filter cubes
- Field of view : 25 mm
- Contrast methods RL : BF, DF, Pol, ICR, Fluo
- Optional contrast methods TL : BF
- Large samples up to 150 * 150 mm
- Rotatable through 360 degree sample stage
- Ultra-bright LED Illumination with high-power LED (Life time : 50,000 hours)
- Magnification (Objective lens) : 2.5 x , 5 x, 10 x, 20 x, 50 x, 100 x
- Magnification (Ocular) : 10 x

Applications

- Electric/Electronics device inspection
- Image capture & measurement



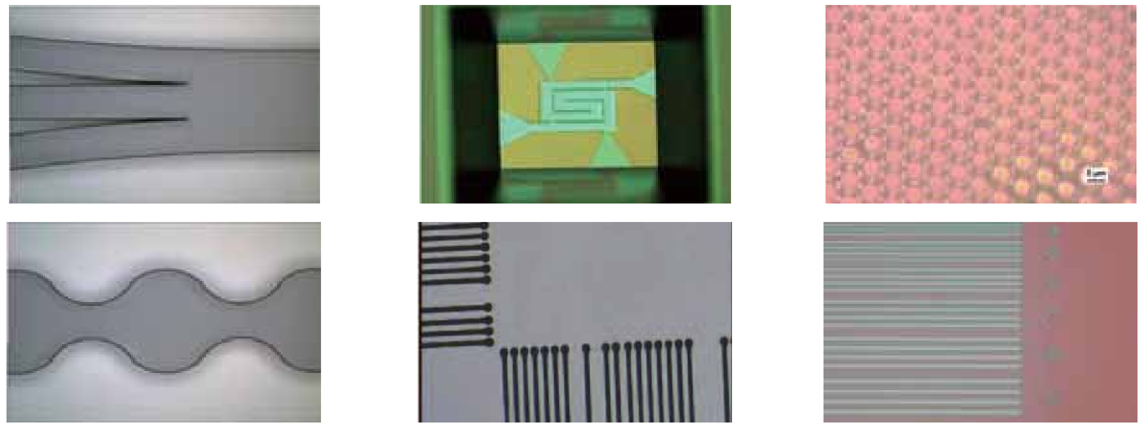
Room #B101

Specifications

- Image CCD : 1/2 inch, 211 mil-pixel CCD image sensor
- Frame rate : 7.5 F/S & 30 F/S (Optional)
- Gain : auto, normal, manual
- Electronic shutter : auto/manu/off, 1/15 ~ 1/5000
- Supercharge shutter : 0.2 sec. to 17 sec. can be set in increments
- Magnification (Objective lens) : 2.5 x , 5 x, 10 x, 20 x, 50 x, 100 x
- Magnification (Ocular) : 10 x

Applications

- Electric/Electronics device inspection
- Image capture & measurement



18 Surface profiler | Thin film measurement

Model ● P-6 [KLA Tencor, USA] | ST4000-DLX [K-MAC, Korea]

Principle

The P-6 stylus profiler and surface analysis system offers a combination of advanced features for process development and manufacturing control of scientific research, and other industrial metrology applications.

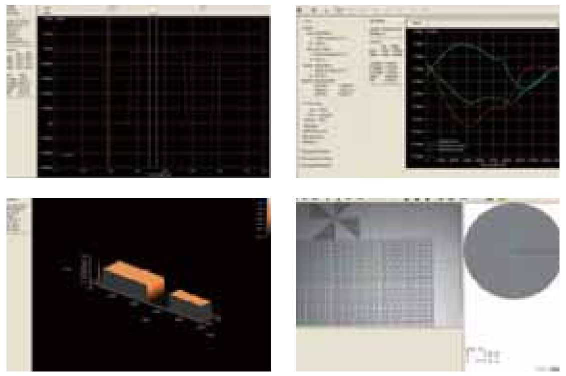
Room #B101

Specifications

- Single 2D & 3D scanning profiler
- 150 mm diameter vacuum & motorized sample stage or bigger
- Manual or auto theta sample stage
- Zoom optic : top view 185 ~ 750 or 115 ~ 465 x
- Automatic step detection and multiple cursor positioning
- Scan length : 150 mm
- CCTV zoom : top view 185 ~ 750 or 115 ~ 465 x
- Stylus force : adjustable between 1 ~ 15 mg
- L-stylus : 2 um radius 60 degree

Applications

- MEMS / NANO device
- LEDs
- Storage device
- UV embossing / Nano imprint lithography



Principle

Some portion of the light that is incident on the thin film surface is reflected from the upper surface of the sample, other portion is reflected from the interfaces between the thin film and the substrate.

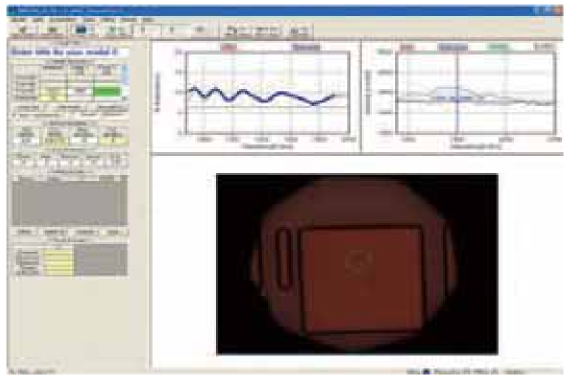
Room #B101

Specifications

- Detector : used wavelength range is 400 ~ 800 nm
  linear silicon CCD array (2048 pixel)
- Stage size : 300 mm x 300 mm (12 inch wafer)
- Lens : m 5 x, m10 x, m 50 x
- Spot size : 40 µm, 20 µm, 4 µm
- Reflection probe : choose wavelength (300 ~ 800 nm)
- Thickness measurement range : 100 Å ~ 50 µm
- Theoretical resolution : 1 nm

Applications

- Semiconductor : Poly-Si, GaAs, GaN, ZnS, SiGe, ONO, SOI, SiLk
- Dielectric material : SiO_2, Si_3N_4, ITO, TiO_2, ZrO_2, BTS, HfO2
- Polymer : PVA, PET, PP, PR

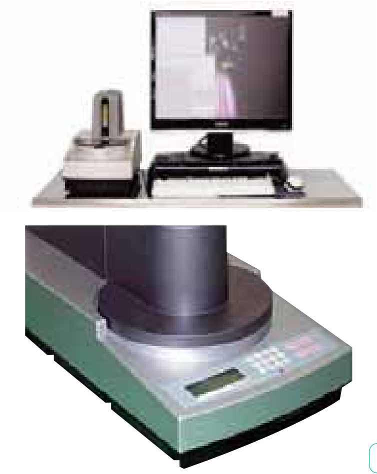


19 Full auto 4-Point probe system | Contact angle

Model ● CMT-SR2000N [AIT, Korea] | Phoenix 300 [SEO, Korea]

Principle

Full automatic system measures sheet resistance and resistivity silicon wafer, metal, and solar cell, etc. This system can be operated by itself. Furthermore, perfect remote control is available using a PC and exclusive software, and it gives various data analysis.



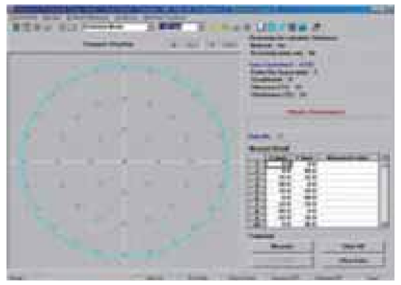
Room #B101

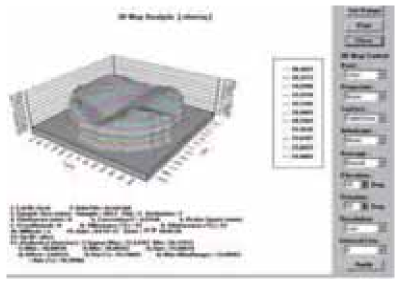
Specifications

- Measurement range : 1 mΩ/sq ~ 2 mΩ/sq
- Measurement accuracy : ± 0.5 % (standard resistor)
- Measurement pattern : ASTM, SEMI, customer design
- Data analysis : data map, contour & 3D mapping
- Measurement range : Ω, Ω/sq, Ω/cm
- Current source : 10 nA ~ 100 mA
- Voltage : 0 ~ 2,000 mV
- Substrate size : 200 mm (wafer) / 140 × 140 mm (square)

Applications

- Sheet resistance measurement of thin film





Principle

The contact angle is the angle between the tangent to the drop's profile and the tangent to the surface at the intersection of vapor, liquid and solid.

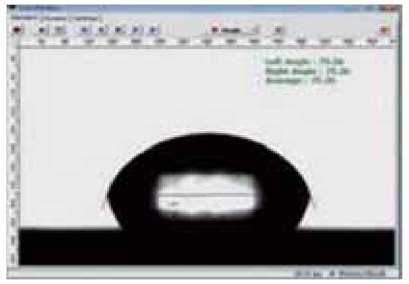
Room #B101

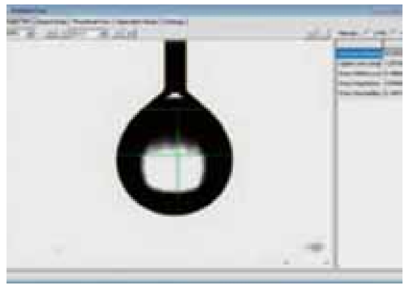
Specifications

- Static / dynamic contact angles
- Advancing and receding contact angle by captive method
- Sequence image captures by time basis & dynamic movies
- Sessile drop/ pendent drop, surface tension
- Real time contact angles, display

Applications

- Semiconductor applications
- Evaluation of cleanliness / treatment / coating processing
- Hydrophobicity and hydrophilicity of solid surfaces
- Adsorption / wettability of powder and pharmacy





20 Substrate sawing machine | Substrate bonder

Model ● AR06DM *[Image Corrector]* [Aaron, Korea] | SB-6L *[Image Corrector]* [SUSS MicroTec, USA]

Principle

Device to cut Silicon wafer into small chips using high-speed rotating diamond blade.

Room #B101

Specifications

- Substrate size : 2 ~ 6 inch
- Cutting materials : silicon, glass, quartz & GaAs
- X-axis (chuck table horizontal movement)
- Work-piece width setting range : 0.01 ~ 160 mm
- Cutting range : 160 mm
- Cut speed : 0.05 ~10 mm/s or more

Applications

- Wafer dicing for chip scale semiconductor
- Si/glass wafer dicing for fabrication process

Principle

Anodic bonder performs fine alignment and permanent bonding between 2 wafers by heat, voltage and pressure in a vacuum chamber

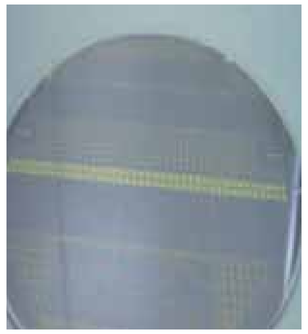
Room #B101

Specifications

- Wafer size : 6" semi standard wafer
- Pressure regulation accuracy : ± 2 %
- Maximum temperature : 500 °C
- Temperature uniformity : ± 3 %
- Maximum bond force : 8 kN
- Bond voltage and current (Anodic optional)
- Maximum voltage : 2,000 V ± polarity
- Maximum current : 60 mA

Applications

- Anodic bonding for wafer to glass
- Thermo-compression bonding
- Eutectic bonding using metal layer



UNIST Design & Manufacturing Center (UDMC)

UNIST Design & Manufacturing Center (UDMC) is instituted to supporting professors, graduates, collegians as well as to provide with precise experiment equip ments, any material test or etc., which are required by local industry or institute at appropriate time. UDMC building was completed in December 2009 in building next to engineering building after having manufacture machines such as Ultra-Precision Nano Machine, 3-axes and 5-axes machining center, lathe and bench drilling machine, surface grinding and band saw which can cut materials and arc welder to produce iron structure. It offers measuring equipments such as coordinate & vision measurement machine, laser inter ferometer, surface, microscope and various products including material testing machine, detail machine parts, precise experiment equipment and 3D Print, which is a physical model as the same as 3D CAD Data.

List of Instruments

Lab	No.	Equipment	Model	Maker	Page
CNC Manufacture	1	Ultra-Precision Nano Machine	Robonano α-0iB	FANUC, Japan	51
	2	CNC 5-axes Machining Center	C40U	Hermle, Germany	52
		CNC 3-axes Machining Center	B300V	Hermle, Germany	52
	3	CNC Lathe	TLS-6	S&T, Korea	53
	4	CNC Surface Grinding	DGS-630	Daesan, Korea	53
Special Manufacture	5	3D Print	sPro60 SLS	3DSystems, USA	54
	6	CNC Wire-Cut EDM	SL 400G	Sodick, Japan	55
	7	Fiber Laser Cutting M/C	K2CMS1	K2Laser System INC., Korea	55
	8	Electron Pika Machine	PF-32B	Sodick, Japan	56
Manufacture	9	Milling	STM-2VM	Stonic, Korea	57
	10	Lathe	TIPL-410	S&T, Korea	57
Measurement	11	Coordinate Measuring Machine	PGS	Dukin, Korea	58
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Office Phone Number : 4066, 4069
Office Email : machine-shop@unist.ac.kr

CNC Manufacture

1 Ultra-Precision Nano Machine

Model Robonano α-0iB [FANUC, Japan]

Principle

Ultra-Precision Nano Machine is combining nano servo technology with the newest linear motor and on same machine built in motor and air bearing technology, measures the slope by using rotation axes, and controls 5-axes (3 of linear curve axes : X, Y, Z and 2 of rotation axes : B, C) simultaneously. It is convenient to install spindles or manufacture materials in all tables, as its tables of rotation axes B and C have the same structure and function.

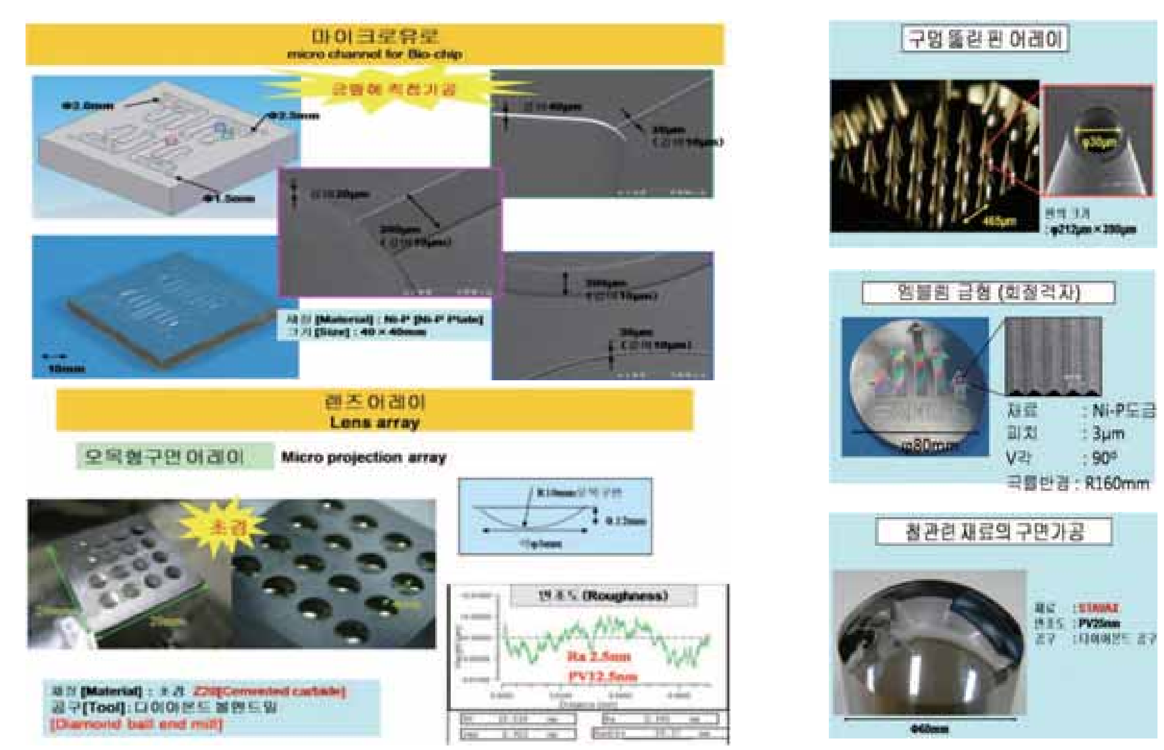
Room #B106

Specifications

- Stroke - axes (X-Z-Y) : 280 x 150 x 40 mm - axes (B-C) : 360 °
- Command resolution - axes (X-Z-Y) : 1 nm - axes (B-C) : 0.000001 °
- Bearing type : Hydrostatic air bearing
- Milling spindle
  - diameter of shank : Φ6 mm
  - maximum rotation speed : 50,000 min^{-1}
  - size/mass : Φ74 x 84 mm/1.5 Kg
- Turning spindle
  - diameter of shaft table : Φ72 mm
  - maximum rotation speed : 7,000 min^{-1}
  - size/mass : Φ184 x 77 mm/4.8 Kg
- Nanochecker
  - maximum measuring angle 3-axes : ± 60 ° / 5-axes : ± 90 °

Applications

- Diffraction grating • Prism groove • Lens array • Micro channel for Bio-chip • Free curved surface • Spherical process



2 CNC 5-axes Machining Center | CNC 3-axes Machining Center

Model ● C40U ; B300V [Hermle, Germany]

Principle

A numerically controlled milling machine can improve accuracy and efficiency by attaching the automatic tool changer. It is capable of perform ing up to 5-axes simultaneously.

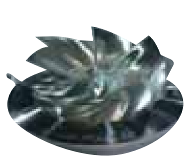
Room #B105

Specifications

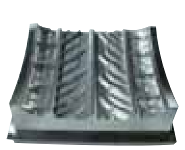
- Table
  - size : over than Φ 800 mm
  - swivel range : + 25 ° ~ - 110 °
  - max. load capacity : over than 1,200 Kg
  - speed-swiveling axes A : over than 25 rpm
  - speed-rotary axes C : over than 30 rpm
- Work area
  - traverse X-Y-Z : over than 850 x 700 x 500 mm
  - linear rapid traverse X-Y-Z : over than 45 m/min
- Main spindle speed : over than 18,000 rpm
- Automatic tool changer
  - magazine pockets : over than 38 pockets
  - max. tool length : over than 300 mm
  - max. tool diameter : over than Φ 90 mm

Applications

- Geometric image processing
- Round cam, propeller, ship screw, under cut, tire mold



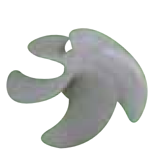
Compressor impeller



Tire mold

Mirror

Lens



Shipping Screw

Principle

The CNC general milling machine equipped with an automatic tool changer enables a series of multiple processing tasks automatically.

Room #B105

Specifications

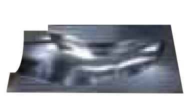
- Table
  - size : over than 1,000 x 560 mm
  - max. load capacity : over than 700 Kg
- Work area
  - traverse X-Y-Z : over than 700 x 550 x 500 mm
  - linear rapid traverse X-Y-Z : over than 30 m/min
- Main spindle speed : over than 15,000 rpm
- Automatic tool changer
  - magazine pockets : over than 24 pockets
  - max. tool length : over than 300 mm
  - max. tool diameter : over than Φ 80 mm

Applications

- Geometric image processing
- Precision machining flat
- 3D image processing

Tube mold

Sample test



Aircraft mold

Mirror

Bonnet mold

3 CNC Lathe

Model ● TSL-6 [S&T, Korea]

Principle

The rotation of the servo motor is transferred into the linear translation by the ball screw, which makes the movement of the work piece or ATC. This relative movement between the work piece and ATC manufactures the parts ordered by customers.

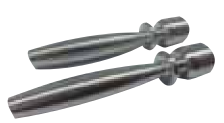
Room #B105

Specifications

- Capacity
  - max. bar working dia : Φ 42 mm
  - spindle speed : 50 ~ 5,000 rpm
- Travel
  - X-axes travel : 170 mm
  - Z-axes travel : 480 mm
- Rapid traverse
  - X-axes rapid traverse : 20 m/min
  - Z-axes rapid traverse : 24 m/min
- Spindle motor : 7.5/11 KW
- Floor space (LXWXH) : 2,400 x 1,400 x 1,800 mm
- CNC controller : FANUC

Applications

- The mass production of various kinds
- Round machining
- Geometric image processing



4 CNC Surface Grinding

Model ● DGS-630 [Daesan, Korea]

Principle

This machine tool is capable of producing the accurate flat surface or grooving other shapes using a cylindrical wheel.

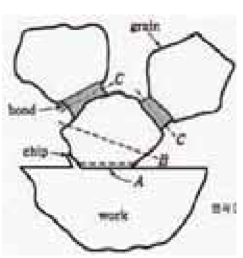
Room #B105

Specifications

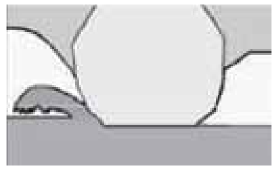
- Capacity
  - working surface of table : 650 x 300 mm
  - max. travel : 750 x 340 mm
  - distance from table surface to wheel center : 550 mm
  - electro magnetic chuck : 600 x 300 x 110 mm
  - graduation of hand wheel : 0.001, 0.01, 0.1 mm
- Grinding wheel
  - speed : over than 1,800 rpm
  - diameter x width x bore : Φ 305 x 38 x 127 mm
- Motor grinding wheel spindle : 3.75 KW/4 p

Applications

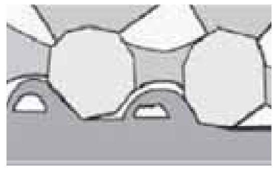
- Precision machining flat
- Precision grooving



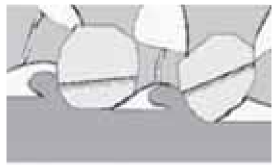
Structural elements



Glazing



Loading



Shedding

Special Manufacture

5 3D Print

Model ● sPro60 SLS [3Dsystems, USA]

Principle

With an input 3D CAD data into SLS machine, machine makes slice date automatically and CO_2 laser scans the surface of deposited nylon powder. The powder scanned by laser sintered / solidified and the powder that is not scanned remains the statue of powder. If the machine works correctly as the description above, it is able to build 3D physical models coresponding to 3D CAD data.

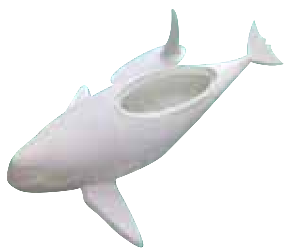
Room #B105

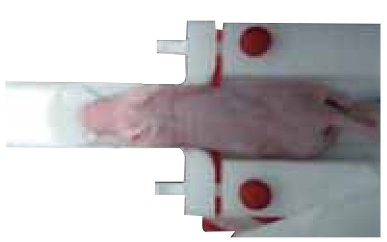
Specifications

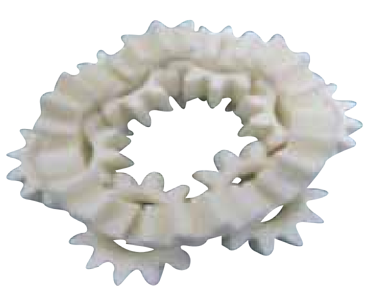
- Technology : Selective laser sintering process
- Laser & Scanning : 30 watt CO_2 Laser
- Scan speed : 5 m/sec
- Minimum layer thickness : 0.08 mm
- Build envelope : 330 x 381 x 457 mm (X, Y, Z)
- Powder layout : precision counter rotating roller
- Input data file format : STL
- Smart feed calculations outside of preview
- Caculates scale and offset factors
- STL add & delete on the fly software

Applications

- Design prototype
- Functional prototype
- Rapid manufacturing part
- Metal part
- Q.D.M
- Master precision casting







6 CNC Wire-Cut electrical Discharge Machine

Model ● SL 400G [Sodick, Japan]

Principle

A material is manufactured by series of current discharges between the material (+) and a wire (-). A servomotor, which is controlled by CNC (Computerized Numerical Control), receives signals from a control device and moves X-Y table. The wire cuts through the material with work ing fluid (water) and makes desired shape by electrical discharges.

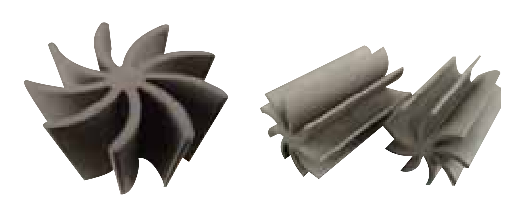
Room #B105

Specifications

- X/Y/Z axes travel : 400 x 300 x 250 mm
- U/V axes travel : 150 x 150 mm
- Max. workpiece weight : 500 Kg
- Taper angle : ± 25 °
- Wire diameter : Φ 0.1 ~ Φ 0.3 mm
- Wire tension : 3 ~ 23 N
- Max wire speed : 420 (mm/sec)
- Machine tool dimensions : 2,115 x 2,490 x 2,330 mm
- Machine weight : 3,350 Kg

Applications

- Graphite cutting
- Medical equipment part cutting
- Mold cutting



Material : TTK5, Diameter: 50mm, Roughness : 0.57 μm (Rz)
Cutting time : 10 hour 40 min, Cutting liquid : Water

Material : SKD 11, Diameter: 70, 100 mm
Roughness : 2.5 μm (Rz), Geometric tolerance : ± 3 mm
Wire : Φ 0.02 mm, Cutting liquid : Water

7 Fiber Laser Cutting Machine

Model ● K2CM S1 [K2laser System INC. Korea]

Principle

Fiber Laser cutting machine is a precise cutting equipment of metal and nonferrous metals by the fiber optic system with 3 axes motion control.

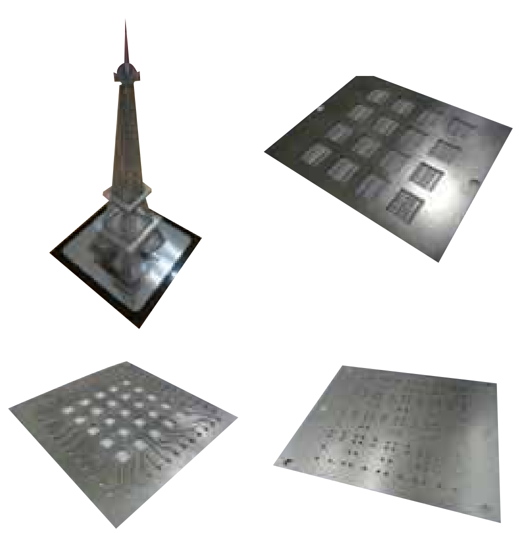
Room #B104

Specifications

- Stroke : axes (X-Y-Z) : 900 x 600 x 30 mm
- Laser oscillator : ytterbium pulsed fiber laser
- Output : 500 W
- Wavelength : 1,070 nm
- Positioning accuracy : 0.012 mm/300 m
- Repeatability : 0.002 mm
- m^2 : 1.05 (Typical) / 1.1 (Max)
- Beam parameter product (BPP) : < 0.38 mm .mrad
- X axes, Y axes linear motor stage
  - positioning accuracy : 10 um
  - repeat accuracy : 5 um
- Feed rate : up to 1,000 mm/sec
- Compressed air : 4 ~ 6 Kg/cm²

Applications

- Design prototypes
- Functional prototypes
- Precise cutting for sheet metal
- Precise cutting for nonferrous metal



8 Electron-Beam Pika Machine

Model ● PF-32B [Sodick, Japan]

Principle

The appratus is used for surface clearance and hardening by repeated cooling and anealing of the metal surface, as the argon plasma is applied to the metal surface with the pulse state of high electron beam.

Room #B105

Specifications

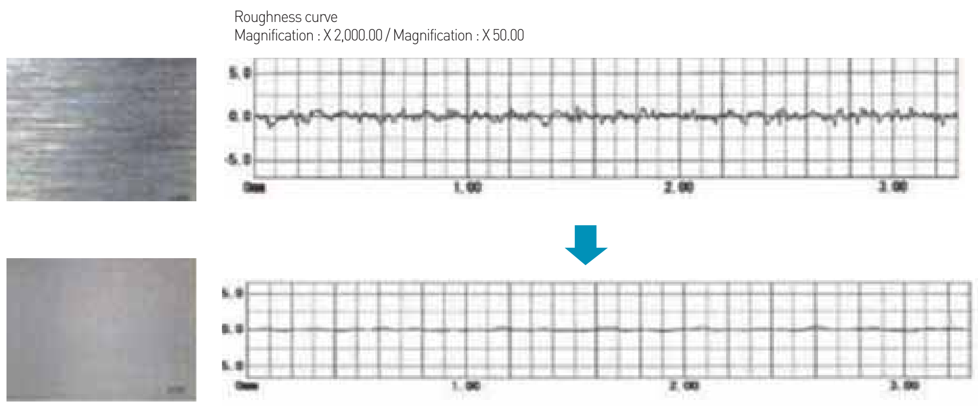
- Machine dimensions (W × D × H) : 1500 × 1600 × 1800 mm
- Table stroke : 300 × 200 mm
- Z-axes stroke : 100 mm
- Max. workpiece size (W × D × H) : 350 × 250 × 100 mm
- Electric capacity : 1.5 KVA/h
- Input voltage : 3-phase, 200 / 220 VAC, 30 A, 50/60 Hz
- Beam energy density : 10 J/cm²
- Beam diameter : 60 mm

Applications

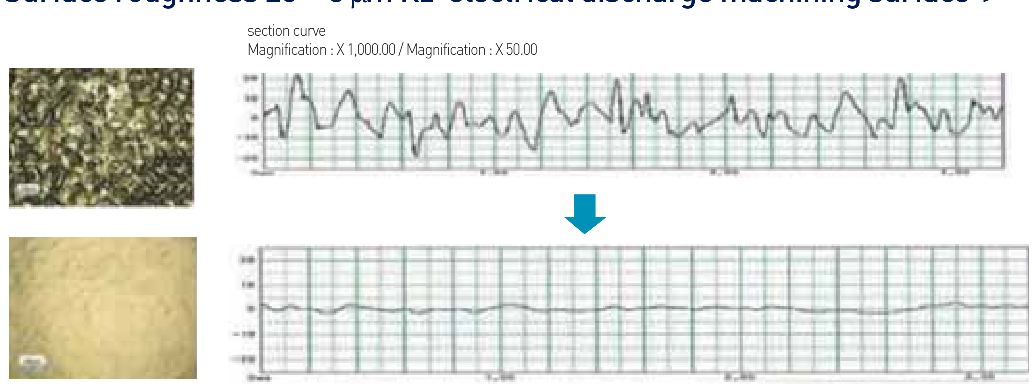
- Improvement of metal surface roughness
- Metal surface hardening
- Surface toughness relaxation of injeted mold product

[Effect of surface dissolution by the electron beam energy]

< Surface roughness 2.0→0.5 µm Rz Polishing surface >



< Surface roughness 28→3 µm Rz electrical discharge machining surface >



Manufacture

9 Milling

Model ● STM-2VM [Stonic, Korea]

Principle

The vertical milling machine uses that the milling cutters with that are placed at regular intervals. Materials can be adjusted vertically, hori zontally, back and forth, by moving the feed table.

Room #B104

Specifications

- Table
  - max travel (longitudinal) : 820 mm
  - max travel (cross) : 300 mm
  - max travel (vertical) : 450 mm
  - table load (max) : 250 kg
- Spindle
  - taper of spindle bore : 50 NT
  - number of spindle speeds : 9 step
  - taper of spindle speeds : 90 ~ 1,400 rpm
  - head tilting angle : ± 45˚
- Motor
  - main spindle motor : 3.7 (5 HP)
  - long & cross feed motor : 1.5 (2 HP)
  - vertical rapid motor : 1.1 (1.5 HP)

Applications

- Drilling machining
- Spiral groove machining
- Groove machining
- Flat machining
- Angle machining

10 Lathe

Model ● TIPL-410 [S&T, Korea]

Principle

This machine is primarily designed to produce the cylindrical shape from the raw metal. The machine is also able to create conical, oval, curved and screw shapes and perform operations such as cutting and grinding.

Room #B104

Specifications

- Capacity
  - swing over bed : Φ 410 mm
  - swing over carriage : Φ 220 mm
  - distance between centers : 1,060 mm
- Spindle
  - spindle nose : KS B4022-A-6
  - spindle taper : MT NO.6
  - spindle speed : 60 ~ 1,500 rpm
- Feed
  - longitudinal feed : 0.039 ~ 0.541 mm/rev
  - cross feed : 0.019 ~ 0.271 mm/rev
  - metric thread : 0.5 ~ 7 mm/p

Applications

- Taper machining
- Screw machining
- Nulling
- Groove machining
- Machining diameter

Measurement

11 Coordinate Measuring Machine

Model PGS [Dukin, Korea]

Principle

This coordinate measuring machine measures numerical values pre cisely digitalizing an object's position in space by using a probe.

Room #B107

Specifications

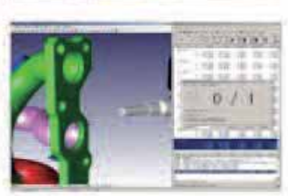
- Measuring range (xyz) : 700 x 1,000 x 660 mm
- Resolution : 0.39 µm
- Max. permissible error per ISO 10360-2 (µm, L : mm)
  : E : 1.5+L/330 P : 1.5
- Max. velocity (mm/s) : 520
- Air requirements (kg/cm, NL/min) : 5.35

Applications

- Automotive parts test
- Measurement test
- Mold parts test
- Plastic injection part test








12 Three-Dimensional Measurement

Model NV-3000 [Nanosystem, Korea]

Principle

Probe system moves towards an optical axes at very small intervals of scores of nm. It inspects whether interference is generated from all pixels in image. height in an optional pixel point is set on a place where in terference signal is maximized, and by preforming this in pixel an entire image, this method produces three dimensional form.

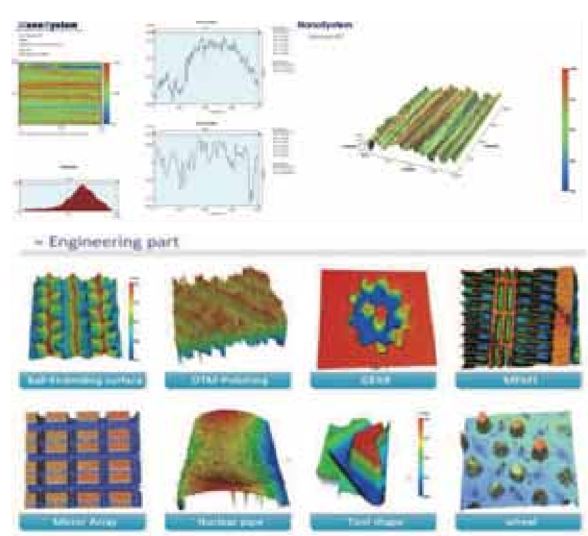
Room #B107

Specifications

- Interferometric objective : 5 lens available
- Scan range : 0 ~ 180 µm (option 270 µm, 5 mm)
- Vertical resolution : WSI < 0.5 µm/PSI < 0.1 µm
- Lateral resolution : 0.2 ~ 4 µm
- Tip/tilt : ± 6 ° (probe tip/tilt)
- Workpiece stage :
  - NV-P2020 / 200 x 200 mm (motorized)
  - NV-P4050 / 400 x 500 mm (motorized)

Applications

- 3D analysis of surface
- Semiconductor parts test
- Roughness average measurement



13 Semi Auto Formtracer System

Model SV-C3100 [Mitutoyo, Japan]

Principle

The form tracer is a surface roughness tester and surface outline measuring device embedded in a single unit. In total, two kinds of sur face roughness and facets are measured.

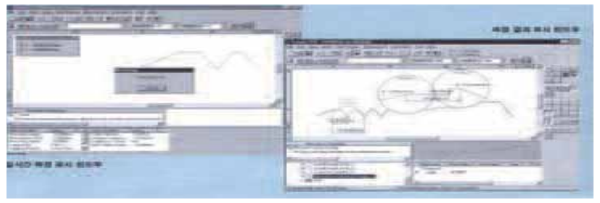
Room #B107

Specifications

- X-axes measuring range : 100 mm
- Measuring force of detector : 0.75 mN
- Vertical travel : 300 mm power column
- Granite base size (W x D) : 610 x 450 mm

Applications

- Surface roughness measurement
- Profile measurement
- Height measurement
- Cylindricity measurement




14 Multi-Component Dynamometer

Model 2825A [Kistler, UK]

Principle

This instrument measures the force of machinery. when the charge to the voltage amplifier is raised the signal transition occurs through the final measurement, which will be converted into a physical description.

Room #B107

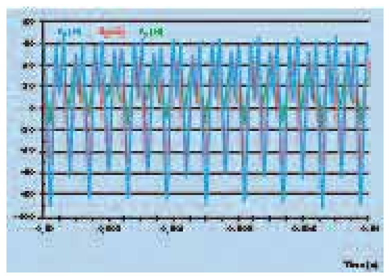
Specifications

- Measuring range - Fx, Fy, Fz : - 250 ~ 250 N
  - Mx, Mz : - 11 ~ 11 N
- Overload (Fx, F y, Fz) : - 300 ~ 300 N
- Threshold : < 0.002 N
- Sensitivity - Fx, Fz : - 26 pc/N - Fy : - 13 pc/N
- Linearity, all ranges : < ± 0.4 % FSO
- Hysteresis, all ranges : < ± 0.5 FSO
- Crosstalk : < ± 2 %
- Degree of protection EN60529 : IP 67

Applications

- Measurement of cutting resistance
- Measurement of machinability
- Measurement of tool lifespan
- Interpretation of cutting force

High speed milling of aluminum with Dynamometer type 9256C2

Material : Hardend steel HRC 56
Tool : Carbide spherical Endmilling cut,
r = 1 mm Twin cutters
N : 50,000 1/min, Vf : 40 mm/s, Ap : 0.3 mm, Ae : 0.3 mm

15 Laser Interferometer

Model ● XL-80 [Renishaw, UK]

Principle

This machine measures accuracy of movement in the machine tool through the use of a laser [Helium and neon gas combination]. This is made possible by the laser wavelength and precise measurement.

Room #B107

Specifications

- Accuracy : ± 0.5 ppm
- Linear resolution : 1 nm
- Maximum travel velocity : 4 m/s
- Between each automatically updated environmental compensation : 7 secs
- Dynamic capture rate : 50 KHz
- Linear range as standard : 80 m

Applications

- Measurement of pitch error
- Measurement of straightness
- Measurement of angle
- Measurement of rotary index

Linear

Specification	Metric	Imperial
Linear measurement range	0 m – 80 m	0 in – 3200 in
Measurement accuracy (with XC-80 compensation)	±0.5 ppm (parts per million)	
Resolution	0.001 µm	0.1 µin
For measurements over 40 m it is recommended to use the long range linear accessory kit. Performance specifications for linear (above) and other measurement modes are quoted to 95% confidence level (k = 2), and are valid across the full environmental operating range.		

Angular

Specification	Metric	Imperial
Axial range	0 m – 15 m	0 in – 590 in
Angular measurement range	±175 mm/m	±10°
Angular accuracy	±0.2% ±0.5 ±0.1M µm/m	±0.2% ±0.1 ±0.007F arc sec
Resolution	0.1 µm/m	0.01 arc sec
Where M = measurement distance in metres; F = measurement distance in feet % = percentage of calculated angle * With high accuracy angular optics (±0.6% with standard optics)		

16 Powerful Microscope

Model ● MF-1010B [Mitutoyo, Japan]

Principle

This microscope has a fine moving table which can move in every direction. The user can recognize how far it moves through a standard microscope or micrometers.

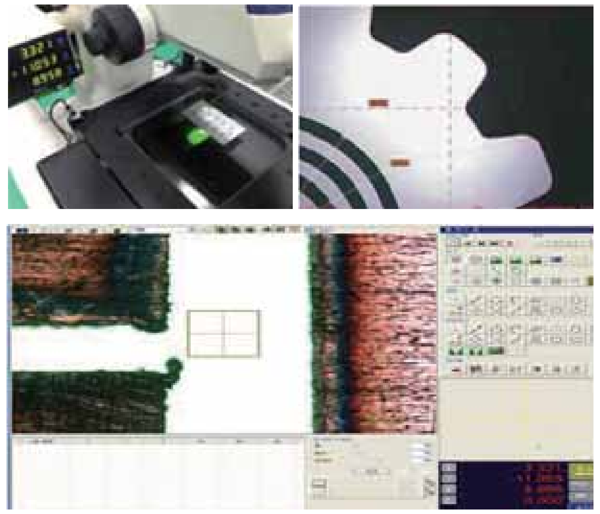
Room #B107

Specifications

- Measuring range : X- 100 mm, Y- 100 mm
- Z-axes height of the max. mass : 150 mm
- Effective class size : 180 mm x 180 mm
- Max. weight : 10 Kg
- Digital counter resolution : - 0.001 / 0.0005 / 0.0001 mm

Applications

- Measurement of surface roughness
- Measurement of pitch screw
- Measurement of tool
- Measurement of gauge



17 Box type 3D Scanner

Model ● REXCAN DS2 [Solutionix. Korea]

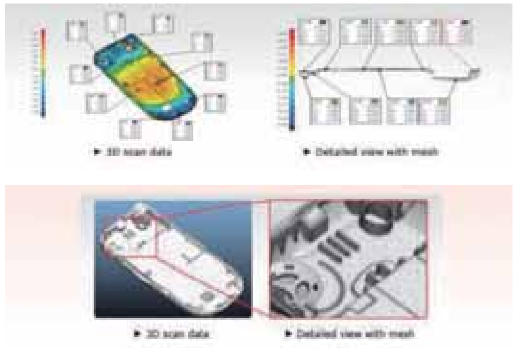
Principle

The compact, automatic 3D scanner that can only be obtained with precision detail with the three-dimensional shape measurement of water and a small jewelry and two cameras equipped with high reso lution scanner.

Room #B107

Specifications

- Camera resolution : 1.3 mega pixels
- 3D scanning area : 80 mm x 60 mm x 60 mm
- Point spacing : 0.05 mm, 0.065 mm
- 3D scanning principle : phase shifting optical triangulation
- Triangulation angle : 15 °
- Rotary stage : 2 axes movement
- Size (W x H x D) : 212 mm x 370 mm x 449 mm
- Light source : LED
- Interface : USB 2.0 High-speed
- Output data format : STL



18 Universal Testing Machine

Model ● AGS-100 NX [Shimadzu, Japan]

Principle

This is a test equipment to construct systematic database by examining the tension and flexural strength of electronic components, graphene, and advanced materials.

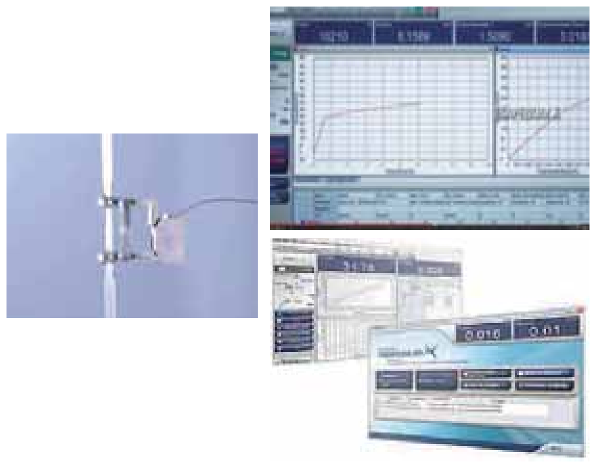
Room #B107

Specifications

- Max load capacity : 100 N
- Crosshead to table distance : 1200 mm
- Effective specimen width : 425 mm
- Dimensions : W 653 x D 520 x H 1603
- Weight : 85 kg
- Power supply capacity : 1.2 KVA
- Drive motor : 400 W AC Servo motor
- Power consumption : 300 W
- Position control resolution : 0.033 um
- Testing speed range : 0.001 mm/min to 1000

Applications

- The tensile test of lamination, rubber, graphene device
- Indirect measurement of the tensile strength
- Compression, bending cycle test



UNIST Environmental Analysis Center (UEAC)

The UNIST Environmental Analysis Center (UEAC) has been providing support in the area of tracing of toxic substance measurements (Dioxins, PCBs, Heavy metals), through the application of cutting-edge environmental equipments including GC/HRMS and ICP-MS and various sample preparation apparatuses. The Environmental Analysis Center obtained "Accreditation of Waste Analysis" and "Accreditation of POPs Sampling & Analysis" which was authorized by the Minister of Environment. Based on the cutting-edge measurement experience, skillful sample preparation and analysis knowhow, all staff will strive to provide the best services in environment analysis by conducting various studies and outsourcing of contracts.

List of Instruments

Lab	No.	Equipment	Model	Maker	Page
Environmental Analysis	1	GC/HRMS	Autospec Premier	Waters, USA	63
	2	GCxGC/TOFMS	Pegasus 4D	LECO, USA	64
	3	GC/MSD	7890A GC/5975C MSD	Agilent, USA	65
	4	GC/μ-ECD	7890A GC/μ-ECD	Agilent, USA	65
	5	LC/MS/MS	Xevo TQ-S	Waters, USA	66
	6	ICP-MS	ELAN DRC-II	Perkin Elmer, USA	67
	7	ICP-OES	720-ES	Varian, USA	67

< Accreditation of POPs Sampling & Analysis >

< Accreditation of Waste Analysis >

Office Phone Number : 4067, 4068
Office Email : u-eac@unist.ac.kr

1 Gas Chromatograph/High Resolution Mass Spectrometry (GC/HRMS)

Model ● Autospec Premier [Waters, USA]

Principle

GC/HRMS incorporates Waters' unique EBE, double-focusing geometry with the extra-wide gap magnet of the proven Ultima NT System. This latest development in magnetic sector technology provides an unmatched combination of high sensitivity, high resolution, and low background noise. The AutoSpec Premier is a powerful platform for high-resolution selected ion recording applications, such as dioxin, polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), or drugs-of-abuse analysis.

Room #B103

Specifications

- Sensitivity
  - 5×10^{-7} C/ug for methyl stearate at m/z 298.3, EI, 1000 resolution
  - 5×10^{-8} C/ug for methyl stearate at m/z 298.3, EI, 10000 resolution
- Mass range : 2-1,200 Daltons or more at full sensitivity
- Resolution : Continuously variable above 60,000 (10% valley) or more. ducts

Applications

- Trace analysis of persistent organic pollutants (Dioxins. PCBs, OCPs etc.)
- Quantitative analysis of various pollutants in environmental samples.
- Identification of impurities and by-products

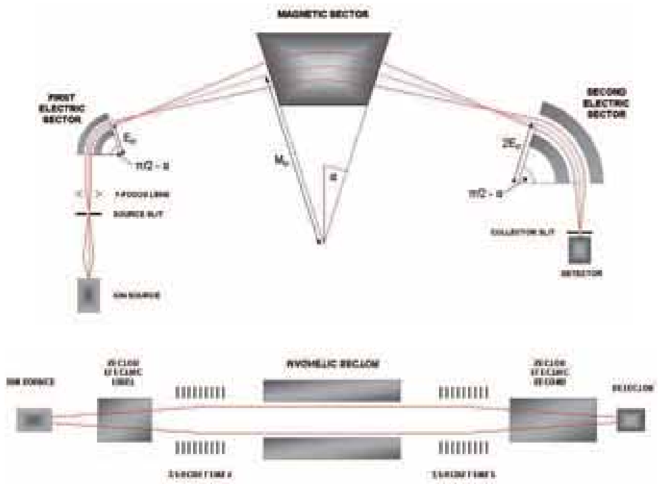


Figure 1. Lens geometry

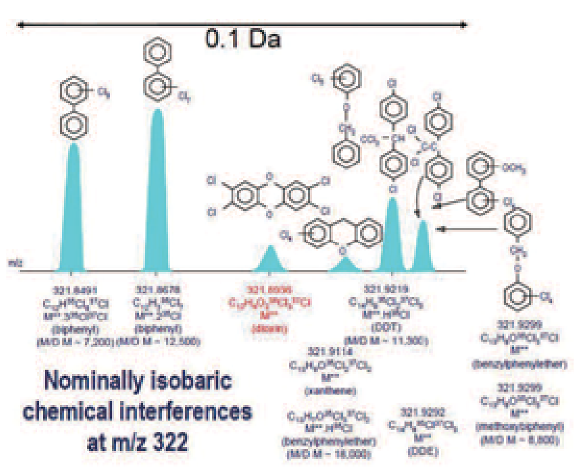


Figure 2. Selectivity at m/z 322

2 Multidimensional Gas Chromatograph /Time of Flight Mass Spectrometry (GCxGC/TOFMS)

Model Pegasus 4D [LECO, USA]

Principle

- GCxGC provides high peak capacity by trapping compounds eluting from the first chromatographic column and then systematically injecting them into the second column to obtain the second separation.
- LECO's LN_2 modulator delivers the ability to modulate these volatile analyses.
- The Pegasus 4D, data acquisition rates of 100 to 500 spectra/second are commonly utilized, giving sufficient data density to obtain spectral deconvolution of the chromatographic peaks, using acquired data.

Room #B103

Specifications

- Carrier Gas Flow : 0 to 10 mL/min Helium
- LN_2 Modulator Volatility Range : C_4 to C_{40} n-alkane at amounts equal to or less than column sample capacity
- LN_2 Modulator Maximum Temperature : 400 °C
- LN_2 Modulator Maximum Heating Rate : 40 °C/min
- Modulation Periods : 1 to 65 seconds
- Ionization Source : Electron Impact
- Mass Range : 5 ~ 1,000 amu
- Spectral Generation Rate : 1 to 500 spectra/second

Applications

- Petroleum
- Environmental
- Food and Flavors
- Forensics
- Geological
- Metabolomics
- Pharmaceutical
- Identify of complex

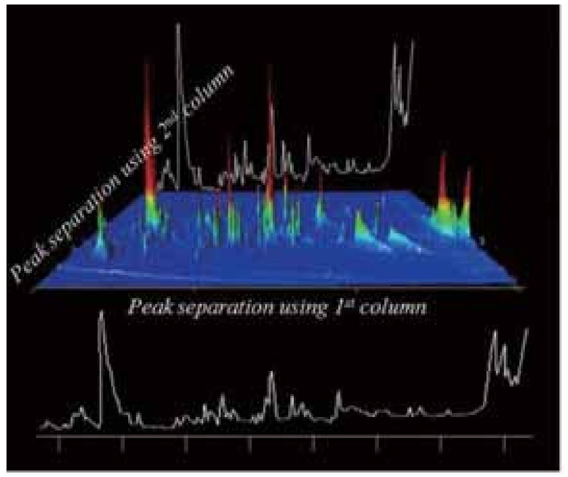


Figure 1. 4D face sample chromatogram

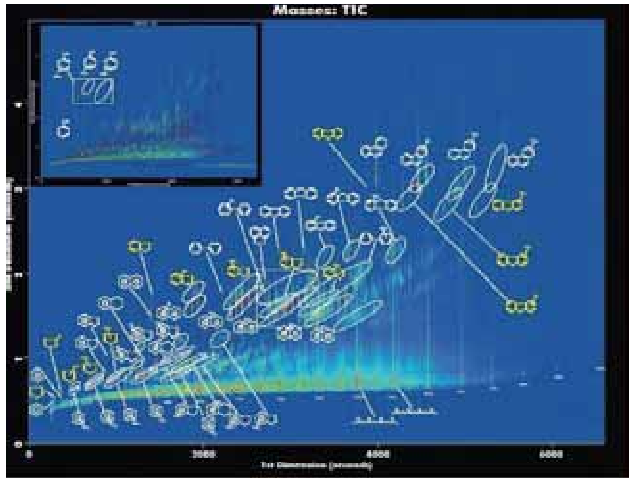


Figure 2. 4D flat sample chromatogram

3 Gas Chromatograph/Mass Spectrometry (GC/MSD)

Model 7890A GC/5975C MSD [Agilent, USA]

Principle

GC/MSD makes an effective combination for chemical analysis. Mixtures of volatile substances are separated by gas chromatograph. Via a transfer line, the fractions of each peak are transferred into the ion source where the ionization takes place. After acceleration, the ions pass through a magnetic-field which causes deviation of their linear flight curve according to their respective mass. After this magnetic field the detector counts the ions.

Room #B103

Specifications

- Ionization mode
- electron ionization
- positive / negative chemical ionization
- Mass range : 1.6 ~ 1,050 amu
- Mass scan speed : max. 12,500 amu/sec
- Detector : triple-axis HED-electron multiplier
- Vacuum pumping system : 262 L/sec
- Library : wiley 8th with NIST 2008 MS library

Applications

- Analysis of organic compound structure
- Identification of molecular weight
- Identification of impurities and byproduct

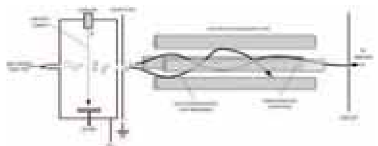


Figure 1. Schematic of quadrupole mass filter

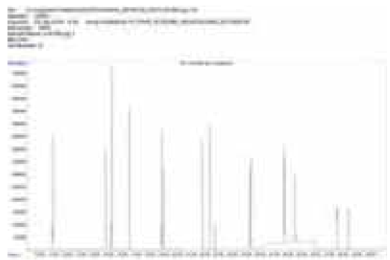


Figure 2. Sample chromatogram (PAHs)

4 Gas Chromatograph/Electron Capture Detect (GC/μ-ECD)

Model 7890A GC/μ-ECD [Agilent, USA]

Principle

Chromatograph is a method separating complex compounds with components. Target compound to separate is distributed to both stationary phase and mobile phase, so it makes separation of the difference between the two. This case of using gas to mobile phase is called Gas chromatograph. It has a little restraint that compound is volatility and thermal safety, but it is widely used for its high resolution and its prompt and simple operation.

Room #B103

Specifications

- Column oven
- 35 ~ 450 °C with typical oven cool-down
- Micro-electron capture detector
- max. temperature range : 400 °C
- radioactive source : 15 mCi, Ni-63 foil
- min. detectable : < 0.006 pg/sec lindane
- accuracy : 3 mL/min
- repeatability : 0.35 %

Applications

- Analysis of polychlorinated biphenyls, pesticides and halogen compounds.

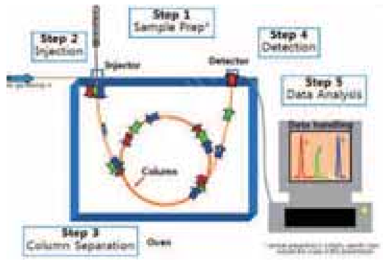


Figure 1. Separation flow chart

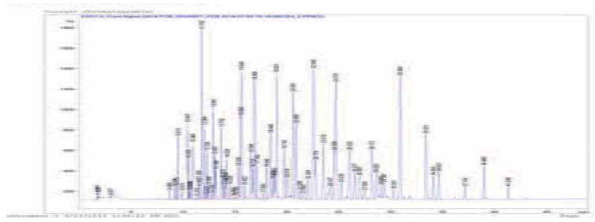


Figure 2. Sample chromatogram (PCBs)

5 Liquid Chromatograph/Tandem Mass Spectrometry (LC/MS/MS)

Model XEVO TQ-S [Waters, USA]

Principle

LC/MS/MS is a powerful and widely used tool in qualitative and quantitative residue and contaminant analysis. The mixture is separated with HPLC preferably using a reversed-phase column. The analyses can be ionized with a suitable ion source by various methods, followed by partial fragmentation. After acceleration, they are deflected by a magnetic field which resolves them according to their mass.

Room #B103

Specifications

- Ion source : ESI, APCI
- Mass range : 2 ~ 2048 m/z
- Dynamic range : 4 X 106
- Collision cell : Two-wave collision cell
- Detector : Dynolite photomultiplier detector
- Sensitivity : ESI (S/N ration = 300 : 1)
  ACSI (S/N ration = 100 : 1)
- Scan speed : 10,000 amu/sec
- Mass stability : within ± 0.05 Da
- Number of MRM channels
  : Up to 16,384 MRM channels

Applications

- Analysis of environmental samples (water, waste, soil, PPCPs)
- Analysis of organic composition
- Identification of molecular weight
- Analysis of DNA, RNA, proteins

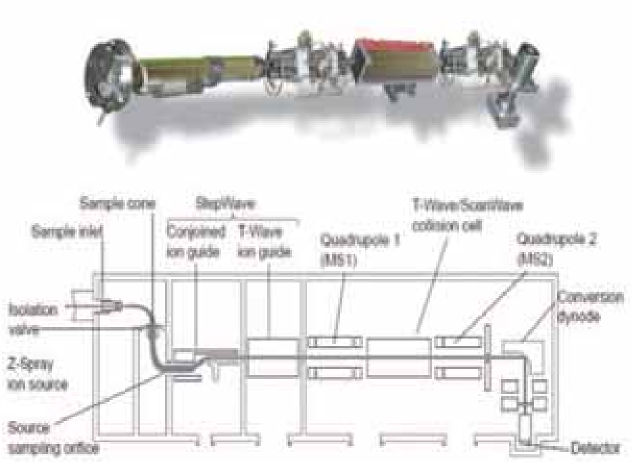


Figure 1. Schematic of tandem mass

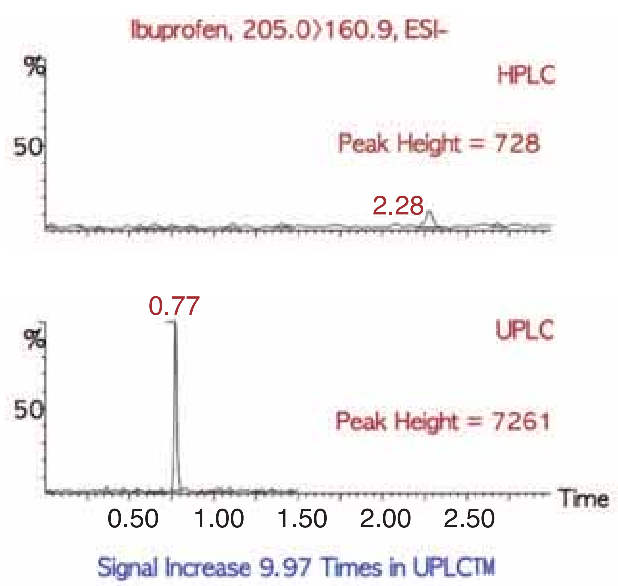


Figure 2. Comparison of HPLC and UPLC for analysis of ibuprofen

6 Inductively Coupled Plasma-Mass Spectrometry (ICP-MS)

Model ELAN DRC-II [Perkin Elmer, USA]

Principle

ICP-MS combines a high-temperature ICP (Inductively Coupled Plasma) source with a mass spectrometer. The ICP source converts the atoms of the elements in the sample ions. These ions are then separated and detected by the mass spectrometer.

Room #B103

Specifications

- Dual turbo-molecular pumps with ceramic bearings
- Vacuum levels : 1 x 10-6 Torr
- 27.12 MHz ~ 40 MHz RF Generator
- Dynamic Reaction Cell
- Thermal stabilization of the quadrupole power supply (QPS) at > 2.5 MHz mass spectrometer

Applications

- Quantitative analysis of various atoms
- Analysis of samples in the life sciences
- Isotope ratio measurement

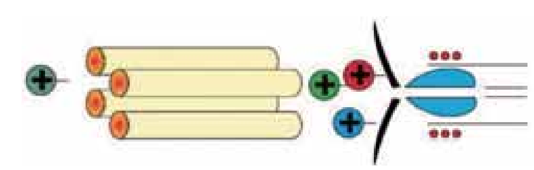


Figure 1. Schematic of quadrupole mass filter

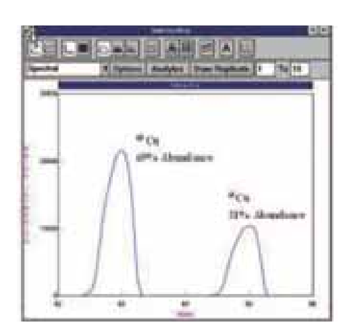


Figure 2. Spectrum showing copper isotopes

7 Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES)

Model 720-ES [Varian, USA]

Principle

ICP-OES is based on the introduction of the liquid sample to be analyzed towards an argon plasma, created by a radio frequency generator. The plasma energy (more than 6000 K) is transferred to the atoms of every sample elements, promoting the excitation of their electrons to higher energy levels. The decay of these electrons from excited states to low energy levels, the additional energy is emitted as electromagnetic radiation in the ultraviolet/ visible range of the radiation spectrum.

Room #B111

Specifications

- Wavelength range : 167 ~ 785 nm
- Simultaneous analysis
- 40 MHz free running RF generator
- CCD detector with image map technique
- Cooled cone interface mechanism
- Plasma : axially viewed system

Applications

- Qualitative analysis of various atoms
- Analysis of trace element in environmental samples
- Compositional analysis of metals and alloy

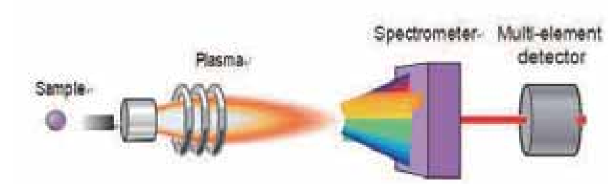


Figure 1. Schematic of an ICP-OES

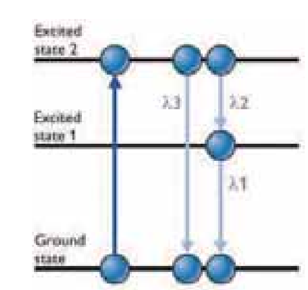


Figure 2. Process of excitation of atoms resulting in generation of element characteristic wavelengths

UNIST Olympus Biomed Imaging Center (UOBC)

- The UNIST Olympus Biomed Imaging Center (UOBC) was established in 2009 with the aim to enhance research capabilities and achieve global competitiveness using state of the art equipments.
- UOBC is located on the 7th floor of Engineering building 1. The center provides state-of-the-art technologies in the areas of optical equipment and advanced imaging tools including systemic microscopes, general microscopes and imaging analysis system.
- The center will build up the systemic bio image and information database pursuing the qualitative growth through the development of real time image analysis and appliance skills with cells.

List of Instruments

Lab	No.	Equipment	Model	Maker	Page
MP (Multi-Photon) Microscopy	1	Multi-Photon Confocal Microscopy	LSM 780 NLO -OPO	ZEISS, Germany	69
Super Resolution Microscopy	2	Structured Illumination Microscopy (SIM)	ELYRA S.1	ZEISS, Germany	70
		Photoactivated Localization Microscopy (PALM)	ELYRA P.1	ZEISS, Germany	70
Confocal Microscopy	3	Laser Scanning Confocal Microscope	FV1000 LSM700	Olympus, Japan ZEISS, Germany	71
TIRF	4	Total Internal Reflection Flourescence Microscopy	Cell^TIRF	Olympus, Japan	72
Live Cell		Live Cell Imaging System	Cell^R	Olympus, Japan	72
System Microscopy	5	Virtual Microscope	.Slide	Olympus, Japan	73
		Microview Imaging System	MVX10	Olympus, Japan	73
	6	All-In-One Confocal Microscope	FV10i	Olympus, Japan	74
		Bio Imaging Navigator	FSX100	Olympus, Japan	74
	7	Laser Capture Microdissetion	PALM	ZEISS, Germany	75
		Fluorescence Inverted Microscopy	IX71	Olympus, Japan	75

Office Phone Number : 4161, 4162
Office Email : biomed-imaging@unist.ac.kr

MP (Multi-Photon Microscopy)

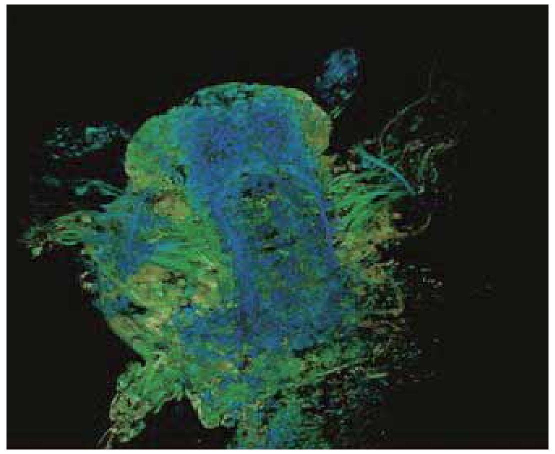
1 Multi-Photon Confocal Microscopy

Model LSM 780 NLO OPO [ZEISS, Germany]

Principle

The point excitation with a pulsed IR laser is minimally invasive with a low level of phototoxicity, thereby creating the ideal conditions for the examination of living specimens. The infrared excitation light penetrates deeper into tissue due to low scattering.

104 Room #705-7

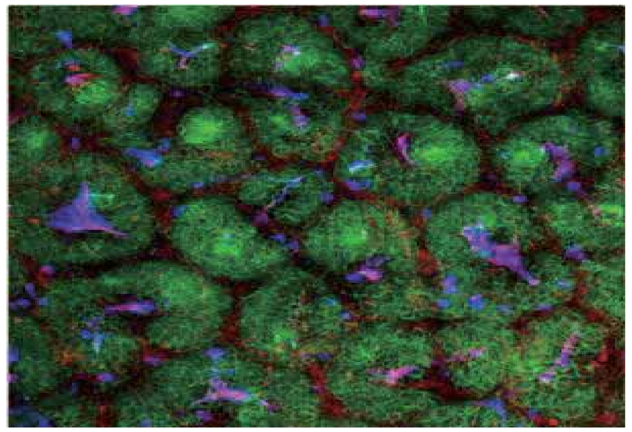


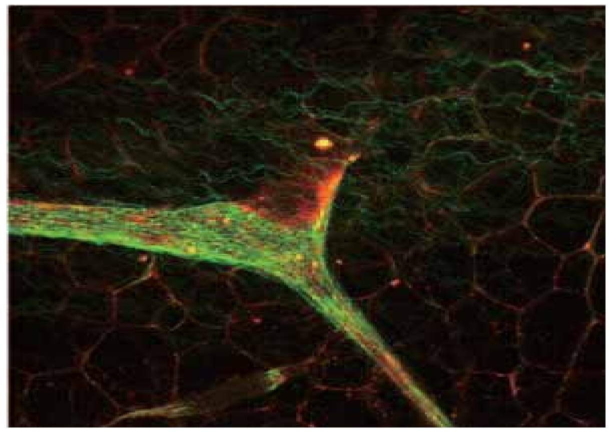
Specifications

- Body : ZEISS Axio Observer Z.1
- Objectives : 10 x, 20 x, 40 x (Water, Oil), 63 x (Water, oil), 100 x (oil)
- Transmitted Light Source : 100 W Halogen
- Fluorescence Light Source : 100 W Metal Halide
- Observation : Bright Field, DIC, Fluorescence, Deep Imaging
- Laser : 405, 458, 488, 514, 561, 640 and 700 - 1300 nm (IR)

Applications

- Deep Imaging with subcellular level
- the more specific excitation of red fluorescent proteins/dyes increases the amount of possible fluorescent markers being used in the same preparation
- Manipulating cells using photoactivation or conversion; labelling and monitoring their development (dividing, interaction)





Super Resolution Microscopy

2 Super Resolution Structured Illumination (SR-SIM) | Photoactivated Localization Microcsopy (PALM)

Model ● ELYRA S.1 ; ELYRA P.1 [ZEISS, Germany]

Principle

Superresolution structured illumination (SR-SIM) images fine structural details while remaining free to label samples with conventional dyes. ELYRA S.1 images any fluorophore – with up to twice the resolution of a conventional light microscope (XY 120 nm, Z 300 nm).

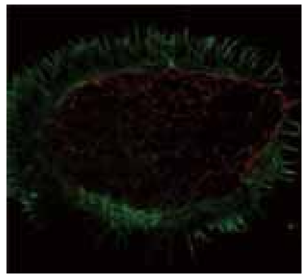
104 Room #705-7

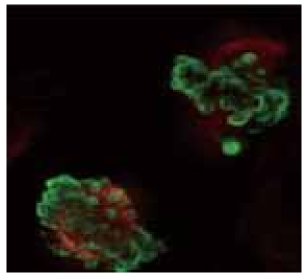
Specifications

- Body : ZEISS Axio Observer Z.1
- Objectives : 10 x, 20 x, 40 x (oil), 63 x (oil), 100 x (oil)
- Transmitted Light Source : 100 W Halogen
- Fluorescence Light Source : 120 W Metal Halide
- Observation : Bright Field, DIC, Fluorescence, Superresolution Imainging
- Laser : 405, 488, 561, 640 nm

Applications

- Multi-Color SR Imaging (4ch)
- Live cell imaging (1ch DIC)
- Resolution : XY 120 nm, Z 300 nm
- Investigate arrangement of cellular components and proteins
- Study structural changes of slower dynamics
- Explore interaction of molecules





Principle

PALM, Detection with an effective resolution down to 20 nm can show substructure and patterns where conventional microscopy will reveal "merely" co-localization. This can achieve effective lateral resolutions down to 20 - 30 nm and 50 - 80 nm axially.

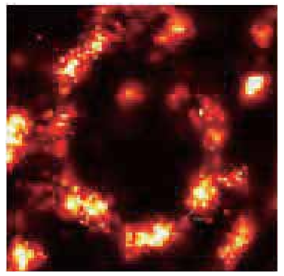
104 Room #705-7

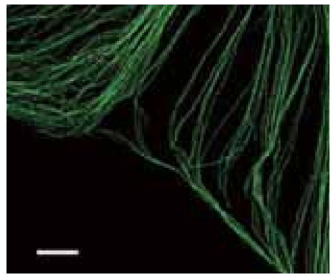
Specifications

- Body : ZEISS Axio Observer Z.1
- Objectives : 10 x, 20 x, 40 x (oil), 63 x (oil), 100 x (oil)
- Transmitted Light Source : 100 W Halogen
- Fluorescence Light Source : 120 W Metal Halide
- Observation : Bright Field, TIRF, Fluorescence, Superresolution Imainging
- Laser : 405, 488, 561, 640 nm

Applications

- Two-Color SR Imaging
- PALM use photoswitchable proteins; excellent Z capture range
- Resolution : XY 20 nm, Z 50 nm
- Map protein localization onto a structural context
- Track many molecules and retrieve diffusion behavior





Confocal Microscopy

3 Laser Scanning Confocal Microscope

Model ● FV1000 [OLYMPUS, Japan] | LSM700[ZEISS, Germany]

Principle

The innovative, Olympus-developed SIM Scanner incorporates two independent, fully synchronized laser scanners in a single compact design for simultaneous laser stimulation and confocal observation

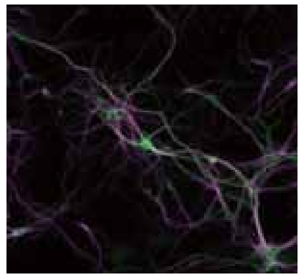
104 Room #705-7

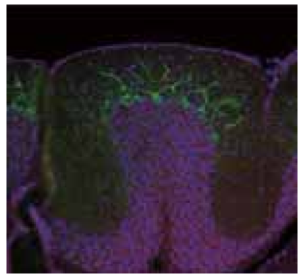
Specifications

- Olympus motorized inverted microscope IX81
- Spectral detector : 1 ~ 100nm band-pass (emission)
- Objectives : 10 x, 20 x, 40 x, 60 x (oil), 100 x (oil)
- Observation : BF, DIC, Fluorescence, SIM Scanner : Synchronizing laser light stimulation & confocal imaging
- Laser : 405, 440, 473, 559, 635 nm

Applications

- FRET efficiency
- Live cell imaging (1ch DIC)
- Confocal imaging (4ch fluorescences)
- Analysis of kinetics (FCS, FCCS, RICS and FRAP / FLIP)
- Photoactivation and photoconversion (Kaede, Dronpa and PA-GFP)





Principle

Simple & Strong LSM 700 is equipped with low-noise PMT detectors for high signal to noise ratio imaging. Intuitive ZEN software lets researcher to handle with easiest manners using 'Smart Setup' for multi-color confocal fluorescence imaging.

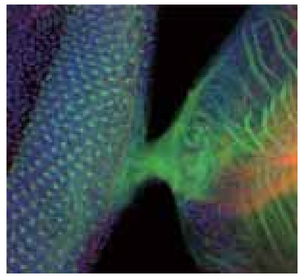
104 Room #705-7

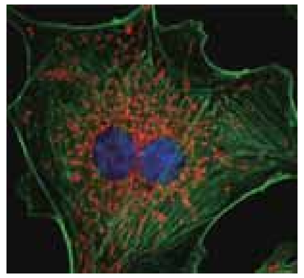
Specifications

- Body : ZEISS Axio Observer Z.1
- Objectives : 10 x, 20 x, 40 x (water), 100 x (oil)
- Transmitted Light Detector : DIC Imaging
- Fluorescence Detector : Up to 4CH Confocal Imaging
- Observation : BF, DIC, Fluorescence
- Laser : 405, 488, 555, 639 nm

Applications

- Confocal Fluorescence Imaging (up to 4CH)
- DIC Imaging
- Protein Colocalization Analysis
- Resolution : XY 200 nm, Z 500 nm
- 3D Reconstruction from Optically Sectioned Images
- Protein Kinetics & Photoactivation Experiments
- Whole Slide Scanning or Tile Scanning





4 Total Internal Reflection Flourescence Microscope | Live Cell Imaging System

Model Cell^TIRF ; Cell^R [OLYMPUS, Japan]

Principle

The TIRF illuminator offers four motorized channels for simultaneous image capture. Intuitive software control of TIRF parameters allows in stant setting and confirmation of TIRF angle and seamless transition back and forth to widefield fluorescence. With the TIRF illuminator, each laser wavelength is optimally focused and each angle is individually set, allow ing different wavelengths to have the same penetration depth.

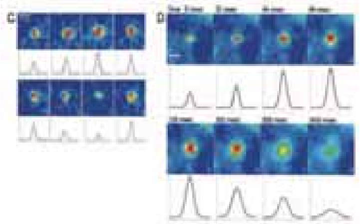
104 Room #705-7

Specifications

- Olympus motorized Inverted Microscope IX81
- Objectives : 0 x, 20 x, 40 x, 60 x (oil), 100 x (oil)
- Transmitted light source : 100 W halogen
- Fluorescence light source : 150 W Xe
- Observation : BF, DIC, fluorescence, TIRF
- Laser : 405, 491, 561 nm

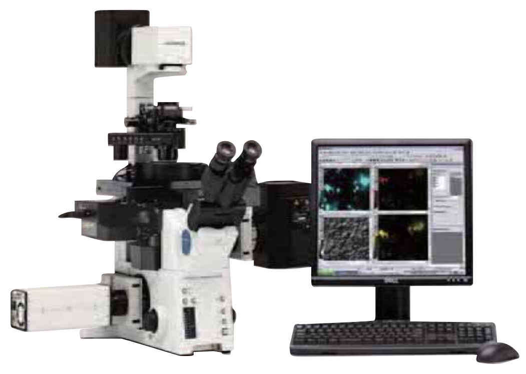
Applications

- Single molecule and membrane research
- Exocytosis, endocytosis
- Dynamic imaging



Principle

The xcellence platform combines optical quality with high-speed real-time control. This powerful, comprehensive platform features an intuitive graphical interface to set up experiments in a convenient and efficient way. It also offers a wide range of advanced functions, including spectral unmixing, image analysis and a sophisticated database for archiving and documentation.



104 Room #705-7

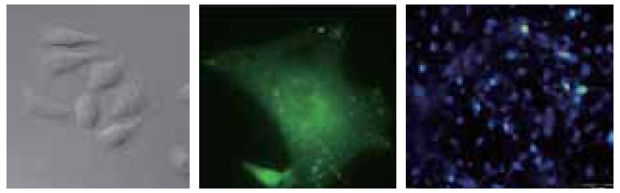
Specifications

- Olympus motorized inverted microscope IX81
- Objectives : 10 x, 20 x, 40 x, 60 x (oil), 20 x, 40 x (LW)
- Transmitted light source : 100 W halogen
- Fluorescence light source : 150 W Xe
- Observation : BF, DIC, fluorescence

Filter	Ex [nm]	DM [nm]	Em [nm]
Fura	340, 380	409	510/84
DAPI	360-370	400	420-460
GFP	460-480	485	495-540
RFP	535-555	565	570-625

Applications

- Short or long time lapse - Live cell imaging
- Calcium ratio analysis - Fura-2, Fluo-3 or 5
- Fluorescence imaging (DAPI, GFP, RFP)



5 Virtual Microscope | Macroview Imaging System

Model .Slide ; MVX10 [OLYMPUS, Japan]

Principle

Virtual Microscopy is computer-based technology that offers the full range of traditional microscope functionality and more. A virtual slide is a digitally captured glass slide which is comprised of high-resolution images. The convenience of a computer is then used to view, navigate, change magni fication and focus through the virtual slide with speed and ease.

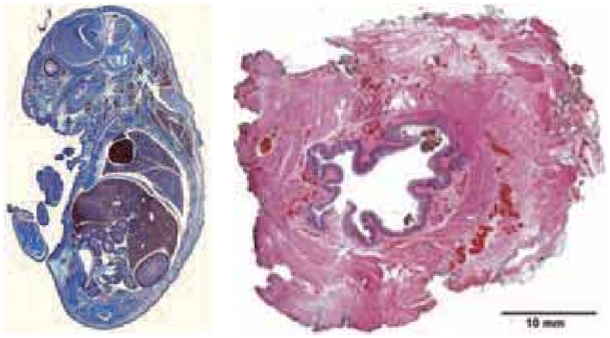
104 Room #705-7

Specifications

- Olympus upright microscope B x 51
- Objectives : 2 x, 10 x, 20 x, 40 x
- Transmitted light source : 100 W halogen

Applications

- Virtual high quality image
- H&E / IHC slide image analysis



Principle

MacroView is a research Macro Zoom Fluorescence Microscope. The MVX10 addresses the tradeoffs between stereo and compound imaging systems, offering high numerical apertures from a compound microscope along with long working distances and larger fields of view from a stereo microscope.

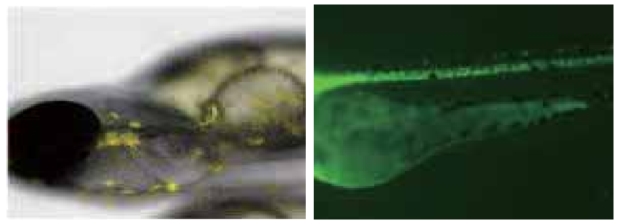
104 Room #705-7

Specifications

- Magnification : 0.63 ~ 6.3x (2 x : 1.26 ~ 12.6 x)
- Zoom ratio : 1 : 10
- Magnification : 1 x or 2 x
- Total magnification : 12.5 ~ 125 x
- Working distance : 20 mm
- Fluorescence light source : 120 W metal halide

Applications

- Observation of fluorescence from thick sample (Zebra fish, egg and C-elegance)
- Stereo-view imaging



6 All-in-One Confocal | Bio Imaging Navigator

Model ● FV10i ; FSX100 [OLYMPUS, Japan]

Principle

Its compact design can fit any space, on a desktop or lab bench, without the need for a dedicated darkroom, bringing the power and clarity of confocal imaging to your side. Designed with ease-of-use in mind, the software has a navigator to guide even novice users to high quality data acquisition. With a powerful set of standard capabilities, the value for your research is clear.

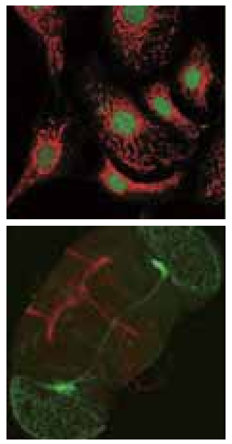
104 Room #705-7

Specifications

- Objectives : 10 x, 60 x (zoom : 1 x ~ 10 x)
- Detector module fluorescence : 2 channels
- Phase contrast : 1 channel
- Laser light source : 405 nm (22 mW), 473 nm (15 mW), 559 nm (18 mW), 635 nm (12 mW)
- CO_2 Incubator

Applications

- Confocal Imaging with Live cell imaging (1ch Phase Contrast, 2ch Fluorescences)
- 3-Dimensional image
- Multi time-lapse image
- Stitching image



Principle

Bio Imaging Navigator all-in-one microscope system: a compact, innovative fluorescence and brightfield microscope and camera system that allows the capture of high quality microscope images with load-and-go simplicity, just by following the intuitive workflow displayed on the screen.

104 Room #705-7

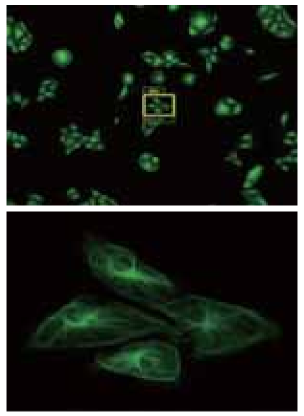
Specifications

- Objectives : 10 x, 40 x (zoom : 4.2 x ~ 80 x)
- Fluorescence light source : 100 W metal halide
- Observation : BF, phase contrast, fluorescence

Filter	Ex [nm]	DM [nm]	Em [nm]
DAPI	360 - 370	400	420 - 460
GFP	400 - 495	505	510 - 550
RFP	530 - 550	570	575

Applications

- Multiple-fluorescence image
- Live cell imaging
- Stitch imaging
- Phase contrast imaging

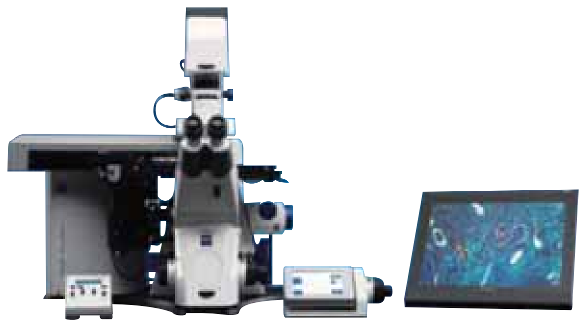


7 Laser Capture Microdissection | Fluorescence Inverted Microscope

Model ● PALM [ZEISS, Germany] | IX71 [OLYMPUS, Japan]

Principle

Laser Capture Microdissection is a contact-free method of isolation & manipulation of live cells and fixed materials with precision. Researchers can obtain region of interests without contaminations and even images of superior quality.



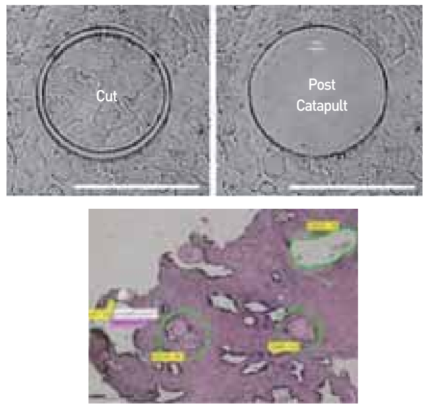
104 Room #705-7

Specifications

- Body : ZEISS Axio Observer Z.1
- Objectives : 5 x, 10 x, 20 x, 40 x, 63 x, 100 x (oil)
- Transmitted Light : Phase Contrast Imaging
- Reflected Light : Fluorescence Imaging
- Observation : BF, Phase Contrast, Fluorescence
- Laser Microdissection : 355 nm UV (pulsed solid-state laser)

Applications

- Cell Biology & Fluorescence Imaging
- Morphology Imaging (Phase Contrast)
- Chromosome Analysis & Cytogenetics
- Forensic Study & Genetic Engineering
- Embryonic Stem Cell Cloning
- Phenotyping & Characterization
- DNA, RNA & Protein Studies



Principle

Inverted research microscope is designed to accommodate a wide range of advanced research techniques. The IX71's modular frame and optical design provides 9 access ports for multiple input or output devices. Up to four ports can have simultaneous access to a primary image. The IX71 system can easily accommodate multi-wavelength, advanced fluorescence techniques.

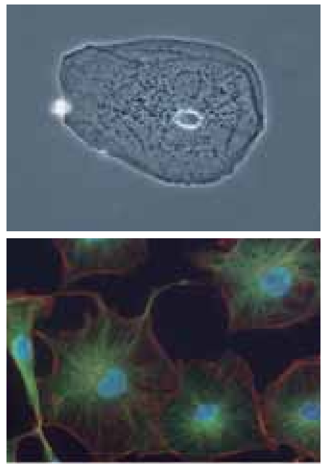
104 Room #705-7

Specifications

- Objectives : 4 x, 10 x (PHC), 20 x (PH1), 40 x (PH2)
- Fluorescence light source : 100 W Hg Apo
- Observation : BF, fluorescence, phase contrast

Applications

- FRET efficiency
- Live cell imaging (phase contrast)
- Fluorescence imaging (blue, green, red)



In Vivo Research Center (IVRC)

IVRC (area of 2,500m^2) opened in January 2013. IVRC is composed of 4 animal zones and 4 efficacy analysis laboratories: Animal zones consist of Strain preservation zone, Small animal zone, BSL-2 (Biosafety Level-2) zone, Return animal zone. Efficacy analysis laboratories include *In vivo* imaging lab, Behavior analysis lab, Histopathology lab, Biopsy lab. The goal of IVRC is to provide a validation system using facility to raise *in vivo* efficacy of functional biomaterials which are newly created by advanced multi-disciplinary technology in UNIST. The primary function of IVRC is to provide facilities and equipments for animal research and to support techniques for animal care and development of animal models of various disorders.

List of Instruments

Lab	No.	Equipment	Model	Maker	Page
Animal Zone	1	Individually Ventilated Caging System (IVC system)	#5-63-9-7-1-4-5WMAL	Thoren Caging System Inc., USA	77
In vivo Imaging Lab.	2	Preclinical Magnetic Resonance Imaging (MRI)	Bio Spec® 70/16 US	Bruker, Germany	78
	3	*In vivo* Optical Imaging System	Xtreme	Bruker, Germany	79
	4	Micro CT (Micro computed tomography)	Skyscan 1176	Bruker, Germany	79
Histopathology Lab.	5	Tissue Processor	STP120	Thermo Scientific Microm, Germany	80
	6	Embedding Center	EG1150 H+C	Leica Microsystems, Germany	80
	7	Microtome	RM2255	Leica Microsystems, Germany	81
	8	Cryostat	CM1950	Leica Microsystems, Germany	81
Behavior Lab.	9	Telemetry System	TA10EA-F20 Neuroscore software	DSI, USA	82
	10	Exercise system	Activity wheel : LE905, LE3806, Rota-rod : LE 8500	Panlab, USA	82
	11	Video-tracking System	Smart 2.5	Panlab, USA	83
	12	Pain Measurement System	Tail flick : LE7106 Hot plate : LE7406	Panlab, USA	83

Office Phone Number : 5212, 5225
Office Email : iv-rc@unist.ac.kr

Animal Zone

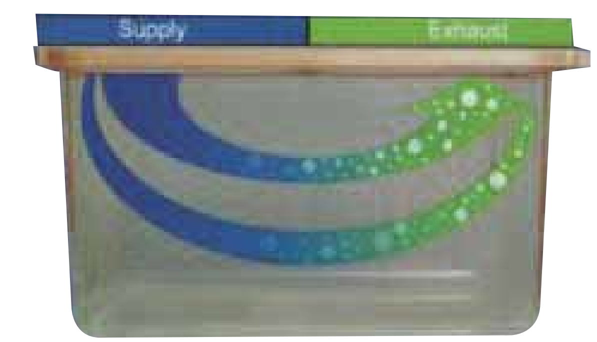
1 Individually Ventilated Caging System (IVC system)

Model ● #5-63-9-7-1-4-5WMAL [Thoren Caging System Inc., USA]

Room #B66, #B48, #B84, #B22 Animal zone

Principle

PIV Cage Air Flow Technology - Pressurized Individual Ventilation: Low velocity HEPA filtered air is supplied through our sealed shelf plenums directly into the cage through air supply orifices above the filter top. Exhaust air passes from the cage through exhaust air orifices also located above the filter top into the exhaust plenum. This design eliminates devices that penetrate the side wall of the cage that create turbulance inside the cage. Depending on your isolation requirements, the system can maintain either positive or negative pressure with respect to the room.



Specifications

- Rack Size : 1,880 mm (W) X 685 mm (D) X 2,100 mm (H)
- Cage Size : 222 mm (W) X 300 mm (D) X 162 mm
- Cage Floor Area : 503 cm^2
- Cage capacity : Polysulfone 63 Cages Set
- Blower Unit : Supply/Exhaust HEPA filter Unit (1) Set
- Electrical Requirements : 100 - 240 V, 50/60 Hz

Applications

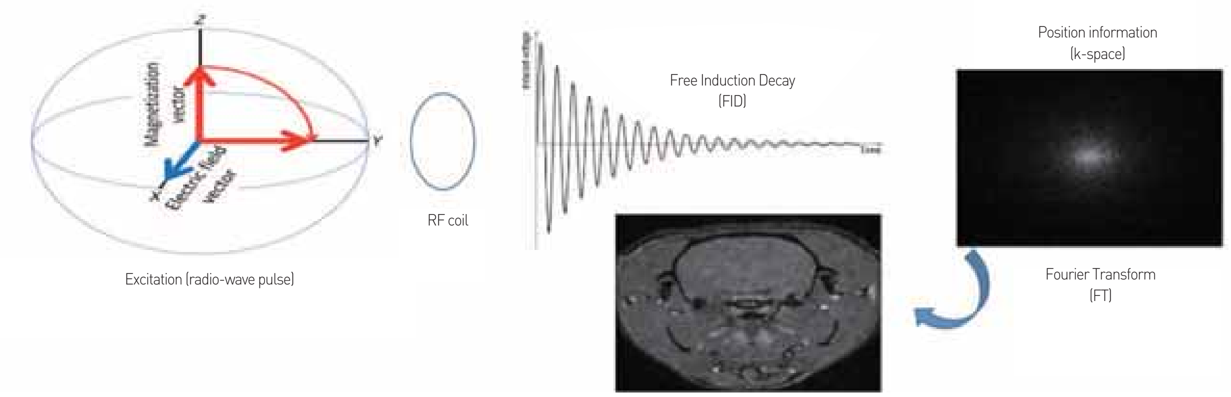
- Zoology
- Animal care
- Genetics
- Histology

In vivo Imaging Lab.

2 Preclinical Magnetic Resonance Imaging (MRI)

Model ● Bio Spec® 70/16 US [Bruker, Germany]

Principle



Specifications

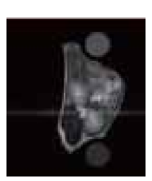
- Ultra Shield superconducting magnet : 7T / bore size 160 mm
- Gradient and shim equipment (BGA-9S HP) : gradient strength, 760 mT/m; slew rate, 6840 T/m/s
- Multiple RF Transmitter Channels and one RF receiver channel for 1H/19F or X-nuclei (13C, 23Na, 31P)
- Para vision® 6 for MRI/MRS data acquisition and evaluation

Applications

- MRI/MRS research for the small rodents (~ 400 g)
- Functional MRI for rat and mouse brain
- Diffusion and perfusion research
- Relaxation measurement and Spectroscopy
- Ultra short TE imaging
- MR Contrast agent validation

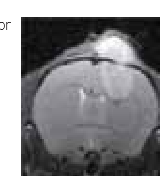
Room #B44 *In vivo* imaging lab.1

Kidney perfusion (DCE-MRI, GFR)



Angiography (Iron oxide nanoparticle assisted)

Brain tumor model (C6 cell)



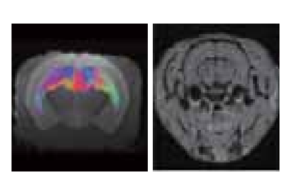
Heart motion (Intragate, no ECG required)

Stroke model (MCAO, Diffusion weighted)

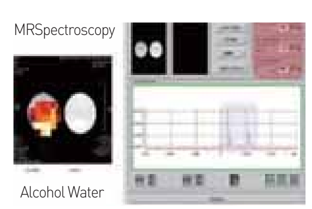
Brain anatomy (50 um x 50 m x 100 um)

Brain artery All vessels Finer vessels

Diffusion Tensor imaging (CC)



MRSpectroscopy

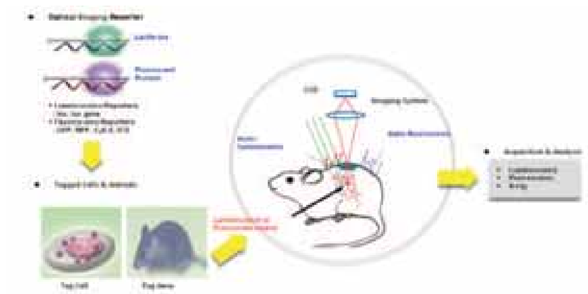


Alcohol Water

3 *In vivo* Optical Imaging System

Model ● Xtreme [Bruker, Germany]

Principle



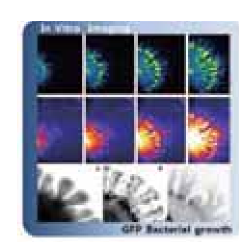
Specifications

- footprint (W x D x H) : 72 x 84 x 183cm
- Back-thinned, back-illuminated (BI) 3MP CCD detector
- 400W Xenon illuminator
- X-ray Spot size : < 60 um
- Energy Range : 20 - 45 kVp

Room #B42
In vivo imaging lab.3

Applications

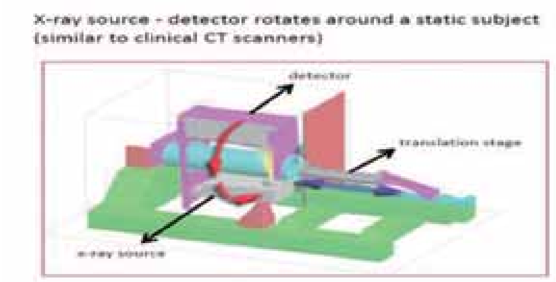
- fluorescence, luminescence, radio isotopic and radiographic Imaging
- 360 ° view Multimodal Animal Rotation System
- Oncology
- Infectious Disease
- Neurosciences
- Stem cell Biology
- Cardiovascular



4 Micro CT (Micro computed tomography)

Model ● Skyscan 1176 [Bruker, Germany]

Principle



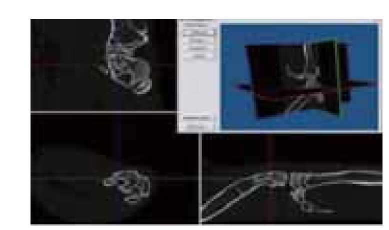
Specifications

- X-ray Source
- Continuous ariable from 20 - 90 KV, 15 micro typical spot size : 25 W, air cooled sealed type
- X-ray detector
- 11 Megapixel (4000 x 2670) 12 bit cooled digital X-ray CCD Camera with fiber optic cooling to scintillator

Room #B42
In vivo imaging lab.3

Applications

- 3D bone analysis
- Soft tissue research
- Bone morphometry
- Vascular studies
- Food studies/fat studies



Three orthogonal reconstructed slices, 8.8 um pixel size

3D rendering with front top part virtually removed (CTan+CTvol programs)

Histopathology Lab.

5 Tissue Processor

Model ● STP120 [Thermo Scientific Microm, Germany]

Principle

Once fixed, tissue is processed as follows, using gentle agitation, usually on a tissue processor, as follows :

Stage	Reagent	Period
Dehydration	70 % Ethanol	1.5 hr
	80 % Ethanol	1.5 hr
	90 % Ethanol	1.5 hr
	95 % Ethanol	1.5 hr
	Absolute Ethanol - 1, 2, 3	1 hr, 1hr, 1hr
Clearing	Xylene_ 1, 2, 3	1 hr, 1hr, 1hr
Paraffin infiltration	Paraffin_1 (at 61 °C)	1.5 hr
	Paraffin_2 (at 61 °C)	1.5 hr

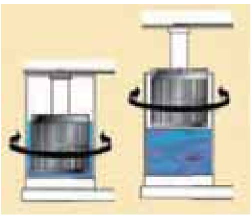
Room #106
Histopathology lab.

Specifications

- Immediate and delayed start processing modes
- Programmable spinning speed of either 60 or 70 rpm
- Programmable immersion time in each station
- Basket capacity of 120 or 240 cassettes
- Battery backup system in case of power failure
- Electrical Requirements : 100 - 240 V, 50/60 Hz

Applications

- Histology
- fixation
- Dehydration
- Paraffin impregnation



6 Embedding Center

Model ● EG1150H+C [Leica Microsystems, Germany]

Principle
[Hot plate]

- Height-adjustable, rotary and fold-back clip for activating the paraffin flow with the embedding mold, manually or via foot switch
- Spacious, heated work surface with paraffin drain system for interim storage of molds and cassettes
- Adjustable temperatures for paraffin reservoir, working surfaces and integrated warming trays, between 55 °C to 70 °C in 5 K increments
- Programmable on and off timer

[Cold plate]

- Constant temperature of the cold plate at – 5 °C
- Approx. 70 cassette molds capacity

Room #106
Histopathology lab.

Specifications

- Work Surface Dimensions : 8.26˝ x 6.89˝ (2x)
- Work Surface Temperature : 55 °C - 70 °C
- Paraffin Reservoir Capacity : 3 Liters
- Cold Plate Dimensions : 13˝ x 14.56˝
- Cold Plate Temperature : - 5 °C

Applications

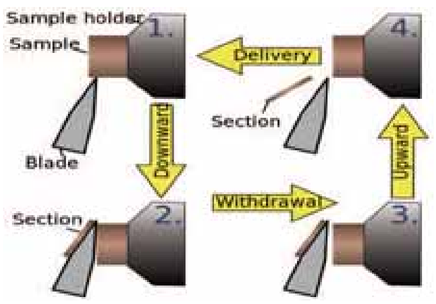
- Histology
- Paraffin embedding of tissue specimens
- Paraffin block

7 Microtome

Model ● RM2255 [Leica Microsystems, Germany]

Principle

Sample movement for making a cut on a rotary microtome



Room #106
Histopathology lab.

Specifications

- Section Thickness Setting Range : 0,5 – 100 µm
- Trimming Section Thickness Setting Range : 1 – 600 µm
- Object Feed 28 mm ± 1 mm
- Vertical Specimen Stroke : 70 mm
- Sectioning Modes : 4
- Specimen Retraction Manual 5 – 100 µm
- Sectioning Speed 0,5 – 420 mm/s ± 10 %
- Specimen Orientation Horizontal : 8 °, vertical : 8 °

Applications

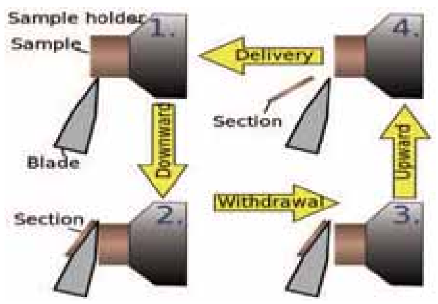
- Histology
- Pathology

8 Cryostat

Model ● CM1950 [Leica Microsystems, Germany]

Principle

Sample movement for making a cut on a cryostat



Room #106
Histopathology lab.

Specifications

- Electrical Requirements : 120 V, 50/60 Hz
- Temperature Range
  : -35 °C (chamber), -42 °C (cooling shelf), -52 °C (Peltier)
- Trimming Thickness (Research) : 1 - 60 µm
- Sectioning Thickness : 1 - 100 µm
- Self Cleaning System : UVC (30 or 180 - minute cycles)
- Manual Defrost Time : 12 minutes
- Max Specimen Size : 50 x 80 mm

Applications

- Histology
- Pathology

Behavior Lab.

9 Telemetry System

Model TA10EA-F20 (Neuroscore software) (DSI, USA)

Principle

Measure the EEG (Electroencephalography) and ECG (Electrocardio graphy) by using Transmitter.

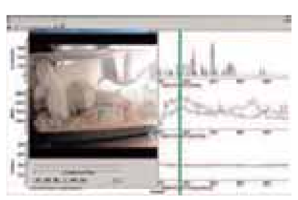
Room #B46
Behavior Analysis Lab. 3

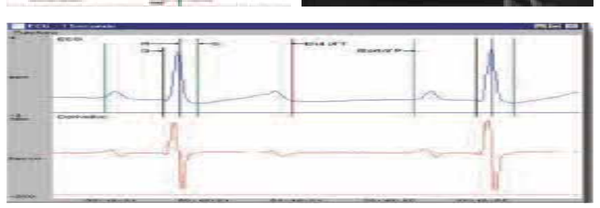
Specifications

- Small animal transmitter for mice
  - Battery life : 4 months - Weight : 3.9 g
  - Min. animal weight : 20 g
- EEG analysis software
  - Data format : DQ ART, Ponemah
- Accessories
  - Sensor lead - Mouse brain matrix

Applications

- Analysis of EEG and ECG
- Monitoring of sleep behavior
- Monitoring of seizure behavior





10 Exercise system (Activity wheel, Rota-rod)

Model LE905, LE3806 (Activity wheel), LE8500 (Rota-rod) (Panlab, USA)

Principle

These provide a measuring method for lab rodents' physical activity in response to chemical or environmental stimuli.

Room #B45
Behavior analysis Lab. 1

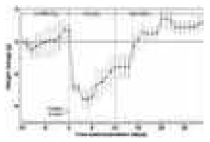
Specifications

- Activity wheel
  - Home cage : 36 (W) x 20 (D) x 1 (H) cm
  - Wheel diameter : 16 cm
- Rota-rod
  - Constant speed : 4 - 40 RPM
  - Acceleration rate : 30 seconds, 1, 2, 5, 10 minutes

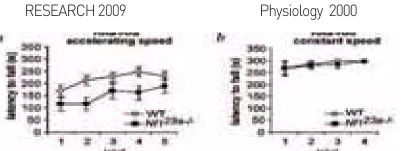
Applications

- Activity wheel
  - Circadian rhythm
  - Pharmacologic study
- Rota-rod
  - Muscle coordination
  - Cerebellum study

Hydock et al. ANTICANCER RESEARCH 2009



Mills et al. Journal of Applied Physiology 2000



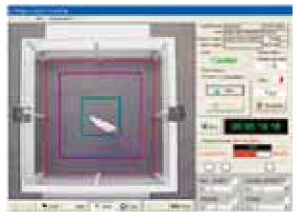
Costa et al. Nature Genetics 2001

11 Video-tracking system

Model Smart 2.5 (Panlab, USA)

Principle

Video tracking is the process of locating a moving object (or multiple objects) over time using a camera.



Room #B45
Behavior analysis Lab. 1

Specifications

- Image sources
  - Video camera, video tape, DVD player, digital video files
- Related Hard wares
  - Open field box, circular pool, radial maze, elevated plus maze, black and white box, spatial place preference box

Applications

- Flexible and precise analysis of animal behavior
- Automated detection of head, center mass and base-tail
- Digital video analysis capabilities
- Immobility detection for forced-swimming test and freezing

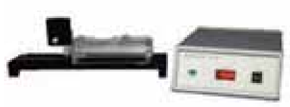
"Advancing Drug Discovery for Schizophrenia"
The New York Academy of Sciences 2011

12 Pain Measurement System (Tail flick, Hot plate)

Model TLE7106 (Tail flick), LE7406 (Hot plate) (Panlab, USA)

Principle

The animal's pain sensitivity resulting from exposure to heat or cold is tested by placing the animal on the surface of the plate or heating on the animal's tail.



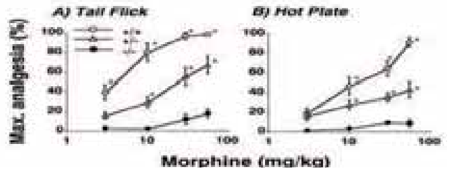
Room #B45
Behavior analysis Lab. 1

Specifications

- Tail flick
  - Dimensions : 35 (W) X 35 (D) X 13 (H) cm
  - Reaction time : Until 99 s. Resolution : 0.01 s steps
  - Heat stimulus : Halogen lamp (50 W - 12 V)
- Hot plate
  - Plate dimensions : 165 x 165 mm
  - Temperature range : - 3 °C to 65 °C
  - Temperature accuracy : ± 0.5 °C

Applications

- Pain disorders
- Hyperalgesies
- Analgesics screening
- Phenotyping



Sora I et al. PNAS 1997

UNIST Radiation Safety Lab (URSL)

The UNIST Radiation Safety Lab (URSL) has been providing a support for the management of safe and efficient radioactive substances by supervising radioactive isotopes and radioactive generators used in UNIST. The laboratory is equipped with instruments for the measurement of radioactivity and the prevention of radioactive contamination. The radiation manager provides technical assistance for the safe use of radioisotope using instruments and radiation generators.

List of Instruments

Lab	Equipment	Model	Maker	Page
URSL	Liquid Scintillation Beta Counter	Tri-carb 2910TR	PerkinElmer, USA	85
	Automatic Gamma Counter	2470 WIZARD2	PerkinElmer, USA	86
	IP Biomolecular Imager	Typhoon FLA 7000	GE, USA	86
	Biomolecules Purification System	ÄKTAFPLC	GE, USA	87

Office Phone Number : 2504
Office Email : radiation-safety@unist.ac.kr

1 Liquid Scintillation Beta Counter

Model ● Tri-Carb 2910TR [PerkinElmer, USA]

Principle

Tri-carb is the most versatile and sensitive instruments available in detecting small amounts of alpha and beta radioactivities.

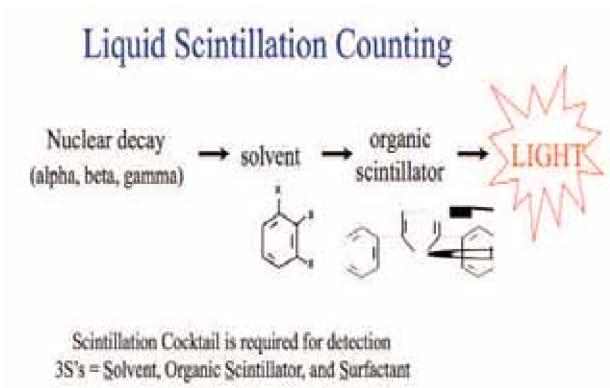
Room #EB1 704-2

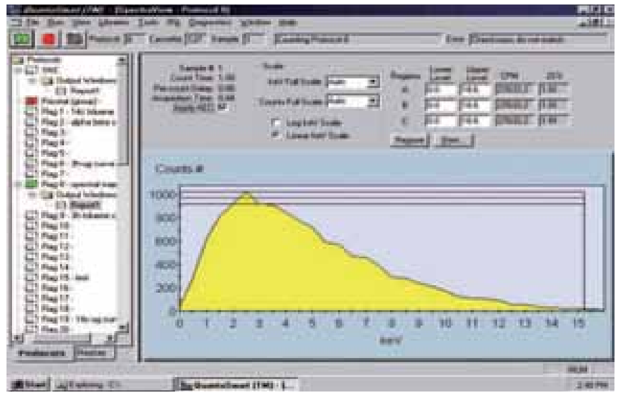
Specifications

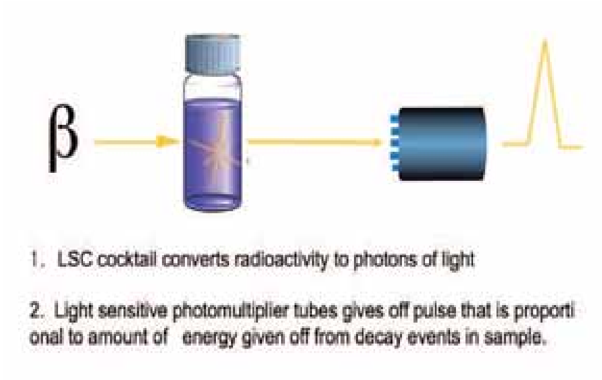
- Energy range : 0 ~ 2,000 keV
- Efficiency & (E2/B)
  - ^{3}H 60 %, 180 - ^{14}C 95 %, 380
- Background
  - ^{3}H 17.3 CPM - ^{14}C 24.3 CPM

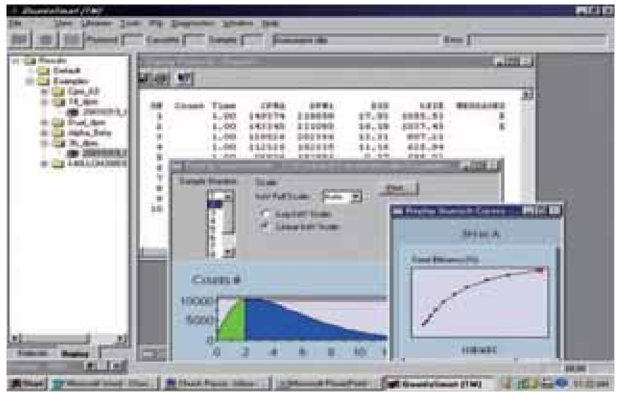
Applications

- General purpose biomedical research using radiotracer
- Swipe or wipe assays
- Environmental monitoring
- Nuclear power effluent/contamination monitoring







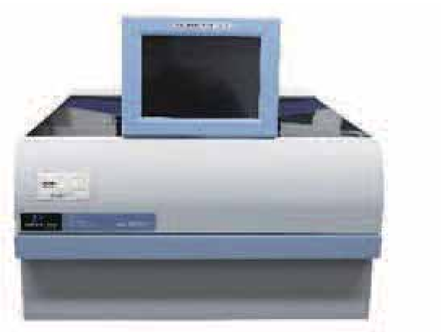


2 Automatic Gamma Counter

Model ● 2470 WIZARD2 [PerkinElmer, USA]

Principle

WIZARD is designed for superior counting performance with all types of samples and for every gamma counting applications.



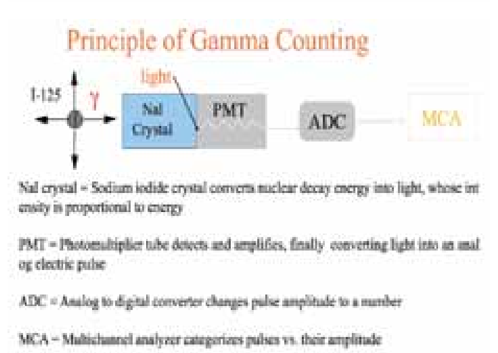
Room #EB1 704-2

Specifications

- Radio library : 45 type
- Energy range : 15 ~ 1000 keV
- Max. count rate : 6 million DPM for 125

Applications

- RIA using ^{125}I
- Chromium release with ^{51}Cr- (cell cytotoxity)
- Receptor binding with ^{51}Cr
- Vitamin B12 deficiency with ^{57}Co and ^{58}Co (Dicopac test)
- Monitoring of blood samples in Positron Emission Tomography
- Hemoglobin testing with ^{59}Fe
- Environmental samples with ^{137}Cs



3 IP Biomolecular Imager

Model ● Typhoon FLA 7000 [GE, USA]

Principle

Typhoon FLA 7000 is a fast laser scanner optimized for quantitative phosphorimaging, ECL, Plus Westerns, visible single fluorescence and gel documentation.

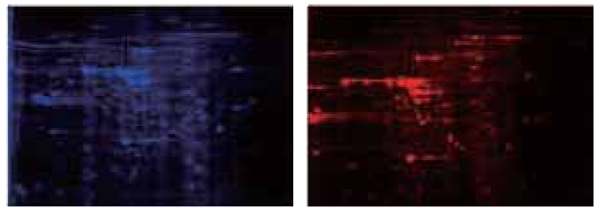
Room #EB1 704-2

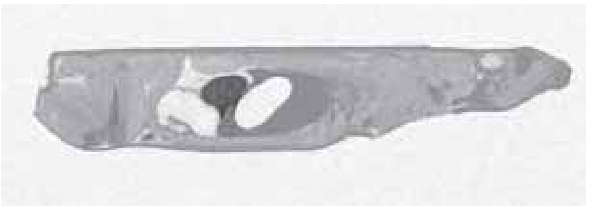
Specifications

- Detection modes
  - Fluorescence, chemifluorescence, filmless autoradiography, digitization
- Excitation wavelengths
  - 473 nm (blue LD laser), 532 nm (green SHG laser),
  - 635 nm (red LD laser), 650 nm (red LD laser)
- Radioisotopes : ^{3}H, ^{14}C, ^{32}P, ^{33}P, and ^{35}S

Applications

- Quantitative westerns
- Phosphorimaging
- Visible fluorescence
- Cell documentation



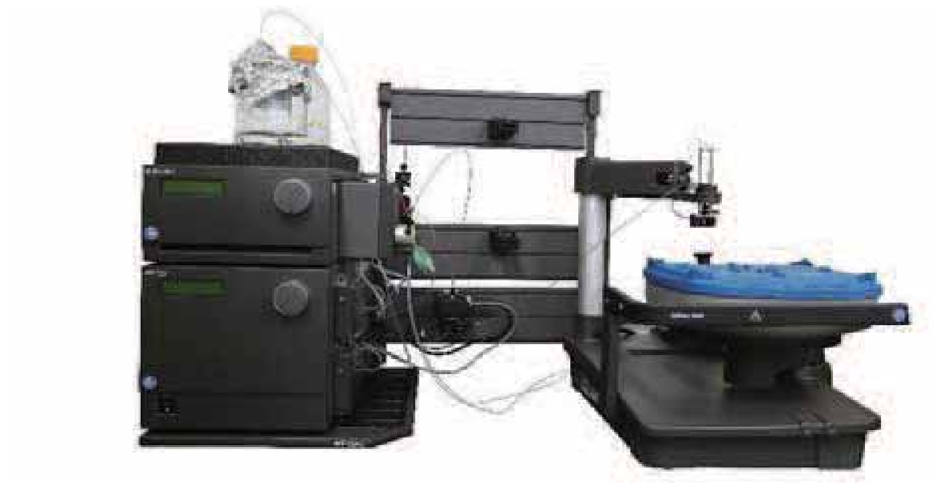


4 Biomolecules Purification System

Model ● ÄKTAFPLC [GE, USA]

Principle

ÄKTAFPLC™ is a biocompatible, high performance liquid chromatography system for fast and easy purification of proteins. The rack system gives built-in flexibility for the use of longer chromatographic columns, changes in system configuration, and increased automation



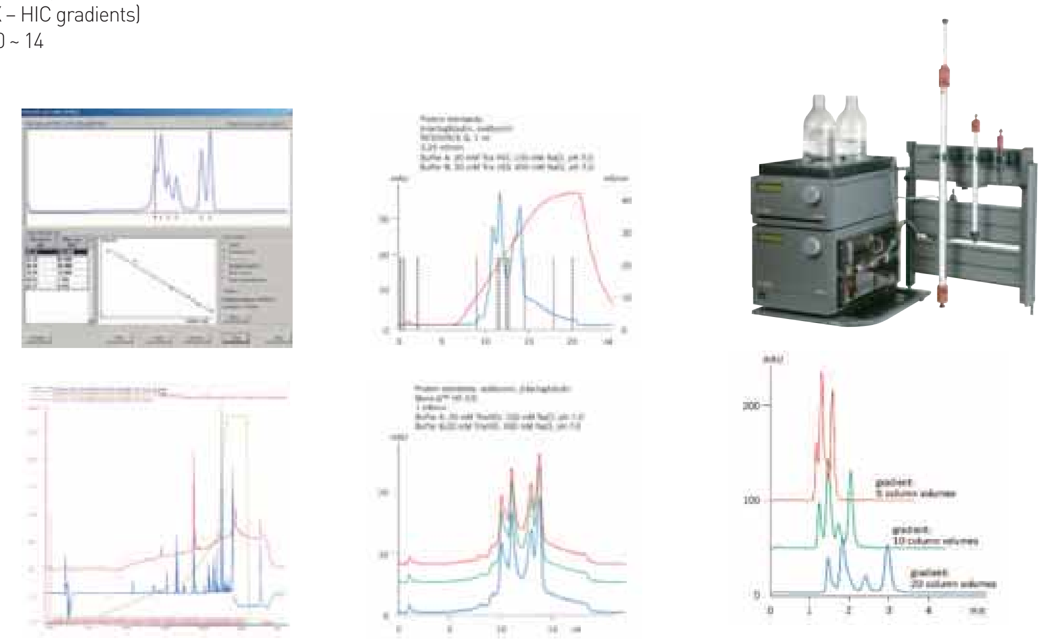
Room #EB1 704-2

Specifications

- Flow-rate range 0.05 – 20 ml/min
- Pressure range 0 – 5 MPa (50 bar, 725 psi)
- Wavelength
  - 254, 280, 313, 405, 436, 546 nm (with Hg lamp)
  - 214 nm (with Zn lamp)
- Conductivity range 1 µS/cm ~ 999.9 mS/cm (RPC – IEX – HIC gradients)
- pH range 0 ~ 14

Applications

- Automatic Protein and Enzyme purification
- Nucleic acids and Peptide Purification



UNIST Synchrotron Radiation Center (USRC)

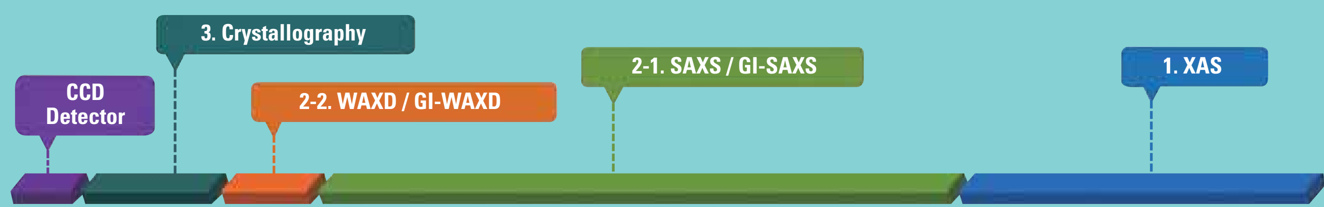
The UNIST Synchrotron Radiation Center (USRC) is based on 6D UNIST-PAL X-ray Crystallography & Scattering Beamline located at Pohang Accelerator Laboratory. USRC will supply state of the art research opportunities using high flux synchrotron radiation source in the various scientific and industrial fields of physics, chemistry, material science, earth science, and life science.

Beamline Specifications

Beam port	GD UNIST-PALC & S beam line
Beam energy, current	3.0 GeV, 400 mA
X-ray source	Bending magnet
Energy range	4 ~ 30 keV
Energy resolution (ΔE/E)	~ 2 x 10^{-4}
Monochromator	Double Si(111) crystals
Focusing mirror	Toroidal, Bendable, (Rh 50 Å, Pt 450 Å coated)
Beam size	~ 1 mm x 1 mm (XAS), ~ 0.5 mm x 0.5 mm (XAS),
@sample position	~ 0.1 mm x 0.1 mm (Crystallography)
Beam flux	~ 1 x 10^{11} @ 10 keV

Multi-experimental Station of 6D UNIST-PAL Beamline

Among various synchrotron radiation based experiments, three most popular experimental stations (X-ray Absorption Spectroscopy, Small- and wide-angle X-ray Scattering, and Crystallography) are equipped at UNIST-PAL beamline.



List of Instruments

6D UNIST-PAL Crystallography & Scattering Beamline

XAS
- 7-Element Ge array detector
- High-precision I.C. detectors
- PIPS detector (Fluorescence)
- Automatic battery cycler system
- Multi-sample chamber
- Vacuum/Helium chamber

SAXS
- Rayonix CCD detector MX225-HS (Common)
- Tr-SAXS/WAXD stage (bulk)
- GI-SAXS/WAXD stage (film)
- Temp. sample stage
- Vacuum sample stage
- Automatic battery cycler system
- Capillary solution sample stage

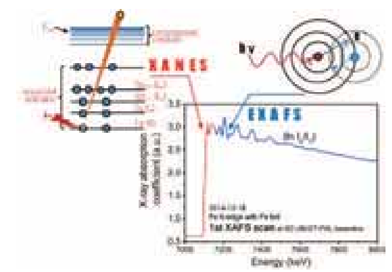
Crystallography
- Rayonix CCD detector MX225-HS (Common)
- 3-axis Goniostat
- High resolution Microscope
- Oxford Instruments Cryojet 5
- HKL 3000sm software
- Data storage & processing Server
- In-situ Raman Spectroscopy

Beamline Phone Number : 054-279-1623
Contact Email : obsoledge@unist.ac.kr

1 XAS
X-ray Absorption Spectroscopy

Principle

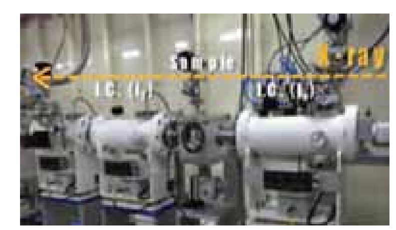
X-ray absorption spectroscopy (XAS) is the measurement of the X-ray absorption coefficient of a material as a function of energy. Each element has a set of unique absorption edges corresponding to different binding energies of its electrons, giving XAS element selectivity.



Information

XAS (X-ray Absorption Spectroscopy)	
XANES (X-ray absorption Near-Edge Spectroscopy)	EXAFS (Extended X-ray Absorption Fine-Structure)
Oxidation states Covalency Local symmetry	Bond distances Coordination numbers Debye-Waller factors

Experimental station



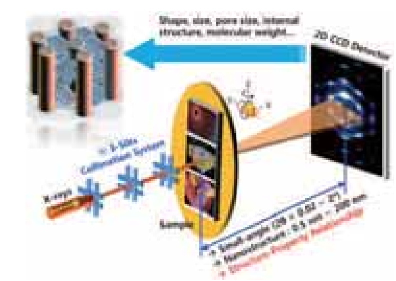
Applications

XAS is for understanding the local structure in:
- Glass, amorphous and liquid ystems, solid solutions
- Doping and ionic implantation materials for electronics
- Local distortions of crystal lattices
- Organometallic compounds, metalloproteins,
- metal clusters, vibrational dynamics, ions in solutions

2 SAXS
Small-angle X-ray Scattering

Principle

SAXS is a small-angle scattering (SAS) technique where the elastic scattering of X-rays by a sample which has inhomogeneities in the nm-range, is recorded at very low angles (typically 0.02 - 2°). This angular range contains information about the shape and size of macromolecules, characteristic distances of partially ordered materials, pore sizes, and other data. SAXS is capable of delivering structural information of macromolecules between 1 and 25 nm, of repeat distances in partially ordered systems of up to 150 nm.



Experimental station

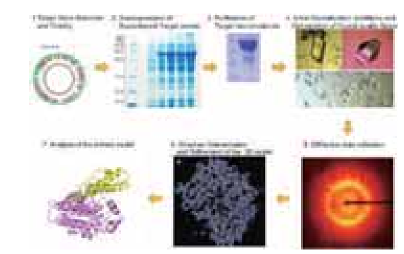
Applications

SAXS is for interpreting the structures in:
- molecular/nano structured polymer
- polymer blends, block copolymer
- composite nanomaterials, inorganic systems
- non-crystalline systems of various nature
- biological macromolecules (protein, DNA, RNA)

3 Crystallography
Supramolecular & Protein Crystallography

Principle

X-ray crystallography is a tool used for identifying the atomic and molecular structure of a crystal, in which the crystalline atoms cause a beam of incident X-rays to diffract into many specific directions. By measuring the angles and intensities of these diffracted beams, a three-dimensional picture of the density of electrons within the crystal can be produced. From this electron density, the mean positions of the atoms in the crystal can be determined, as well as their chemical bonds, their disorder and various other information.



Experimental station

Applications

- crystal structure of biological macromolecules such as protein, DNA, and RNA and their complexes in nearly physiological environments
- crystal structure of supramolecules and small molecules
- Mineralogy and metallurgy

UNIST Campus Map

UCRF Office Location

- UNIST Mechanical Analysis Lab Office : Natural Science Building, Room B122, B123 (B1F)
- UNIST Nano Fabrication Center Office : Natural Science Building, Room B122 (B1F)
- Machine Shop Office : Machine Shop Building, Room 103 (1F)
- UNIST Environmental Analysis Center Office : Natural Science Building, Room B123 (B1F)
- UNIST Olympus Biomed Imaging Center : Engineering Building 1, Room 705-7 (7F)
- *In Vivo* Research Center Office : Stem Cell Research Building, Room 109 (1F), Room B7 (B1F)
- UNIST Radiation Safety Lab office : Natural Science Building, Room 201-11 (2F)

Mail address

- ***Office Location as stated above +*** 50, UNIST-gil, Eonyang-eup, Ulju-gun, Ulsan, 689-798 Rep. of KOREA

How to get to UNIST

By Car

Kyungbu Highway ▶ West Ulsan IC ▶ Road 24 to Ulsan ▶ UNIST (10 minutes from West Ulsan IC)

By Airplane

Take bus no. 402 or 452 from the airport and exit at Taehwaru. Take bus no. 807, to UNIST. For the 5003 KTX Limousine, exit in front of Gulhwa Jugong Apt., then take bus numbers 337 or 733, to UNIST. More information can be found on the Korean Airline or Asiana Airlines Homepages. It takes about 30 minutes by taxi.

By Train

Take bus no. 337 from Ulsan KTX Station (Tongdosa), or bus numbers 327 or 807 to UNIST. It takes about 5 minutes by taxi.or

By Express Bus

Take bus numbers 133, 733 or 337 at the Ulsan Express / Intercity Bus Terminal to UNIST, or take busses 327 or 807 to UNIST. It takes about 20 minutes by taxi.

Take bus no. 733 at Shinbok rotary (the first bus stop after entering Ulsan) to UNIST. It takes about 10 minutes by taxi.