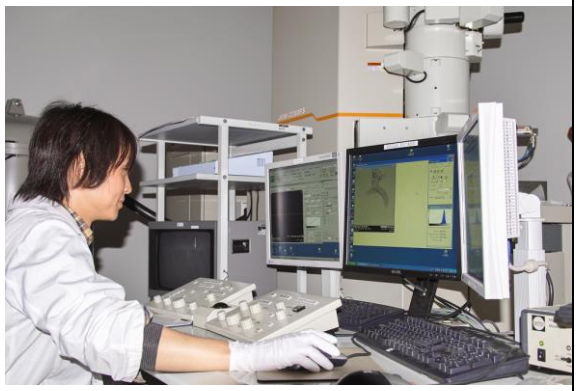
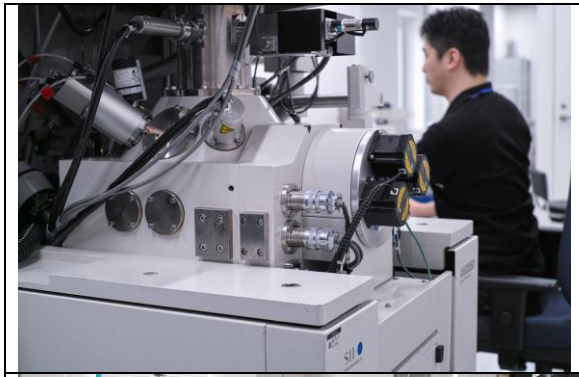
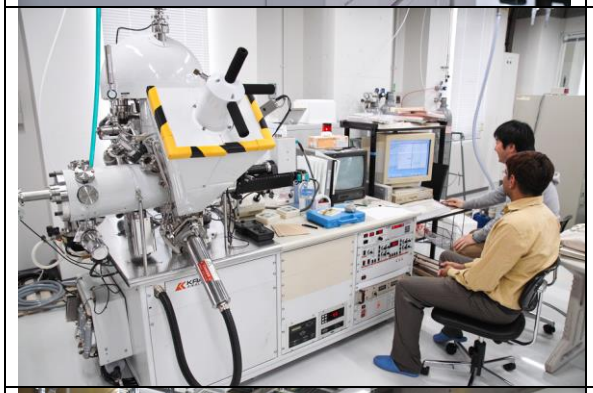
Facilities in Bio-Nano Electronics Research Centre, Toyo University

	Name	Specifications, Performance	Remarks
	Electron beam(EB) lithography system	**<u>125 [kV]</u>** 6inch-wafer **<u>Resolution 5 [nm]</u>** L&S min.30-80 [nm] 20 [kV] 3inch- photo masks Resolution 100 [nm]	Direct writing of ultra-fine patterns Fabrication of Masks for UV lithography
	Manual Aligner (UV-Exposure)	**<u>i-line,</u>** Two-sided type 30mmx30mm, 2inch, 3inch	UV lithography
	Reactive ion Etching (RIE) system	ICP(Inductively Coupled Plasma), L&S 0.5[um], HBr,CHF_3,Cl_2,CH_4,O_2,N_2,Ar L&S 2 [um], Cl_2,SF_6,CH_4,O_2,N_2,Ar ICP(Inductively Coupled Plasma), L&S 0.5 [um], HBr,CHF_3,Cl_2,CH_4,O_2,N_2,Ar	Plasma etching for **<u>sub-micron gates</u>** of Si MOSFETs Plasma etching for GaAs devices Plasma etching for **<u>deep trenches</u>** in SiO_2 or quartz substrates

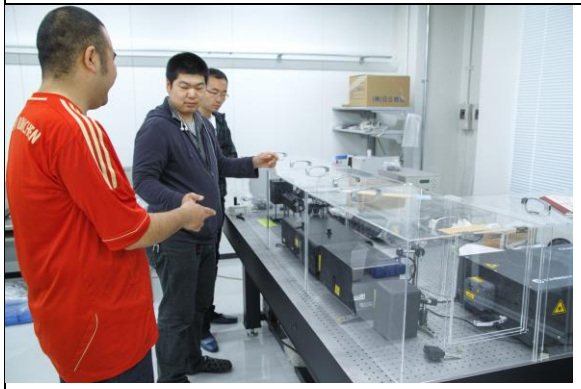
	Evaporator (Electron beam (EB)) Evaporator (Resistance heating)	Three-crucible type	Formation of metal films Ti,Ni,Au etc.
	Spectroscopic ellispsometry		φ200 mm motorized stage Multi-layer film thickness of up to 6 layers
	Wet station Furnace	 300-1150 °C,O_2,N_2 Si wafer (30mmx30mm)	Wet etching process Dry oxidation of Si wafers Wet oxidation of Si wafers Annealing for ohmic contact formation Activation annealing after ion implantation

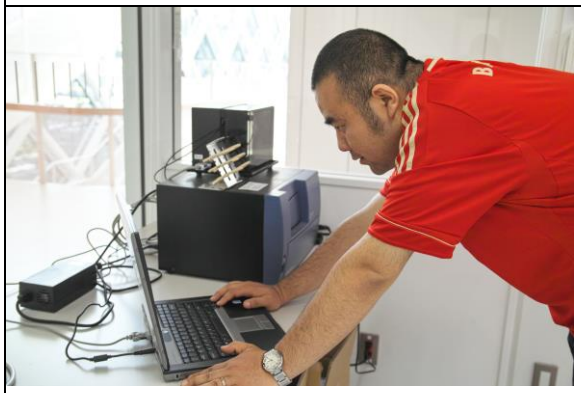
	Sputtering system	Magnetron Sputtering 3 targets, Temp. RT-300°C Power supplies (DC, AC, and Pulse)	Formation of thin films SiO_2,Si_3N_4,ITO,Au,Al,Ni,Fe etc. Surface roughness of films : Ra 1.0 [nm]
	Ion implanter	30-200 [kV], B (solid source), P (solid source), Si (SiF_4 gas source) etc.	**5**-30[kV] for formation of shallow junctions
	Transmission electron microscope (TEM)	EB-gun, 200 [kV], (Cold-type Field emission) In-column omega type energy filter, Resolution 0.1-0.19 [nm] EB-gun (LaB6) 40-200 [kV], Resolution 0.14-0.25 [nm] EB-gun, 40-200 [kV], (Shottky Field emission) In-column omega type energy filter, Resolution; 0.08nm (STEM-HAADF) 0.19 [nm] (TEM) 0.11 [nm] (Cs Correction)	Scanning TEM (STEM)+Energy dispersion spectroscopy (EDS) B(5)~U(92)+Electron energy loss spectroscopy (EELS) Electron diffraction 3D Electron Tomography System Scanning TEM (STEM)+HAADF+ Energy dispersion spectroscopy (EDS) B(5)~U(92)

	Scanning electron microscope (SEM)	EB-gun, 0.1-30 [kV], (Cold-type Field emission) Semi In-lens type, Resolution 1.0[nm] (@15(kV)) **<u>1.5[nm] (@1(kV))</u>** Sample size Max.150mm	Secondary electron image (SEI) + Backscattered Electron Image(BEI) +Scanning TEM (STEM) +Energy dispersion spectroscopy (EDS) B(5)~U(92), Detector, 30mm^2
		EB-gun, 5-30 [kV], (Cold-type Field emission) In-lens type, Resolution **<u>0.5[nm] (@30(kV))</u>** 1.8[nm] (@5(kV)) Sample size Max.4mm x 7 mm	Secondary electron image (SEI) +Backscattered Electron Image(BEI),
		EB-gun, 0.1-30 [kV], (Cold-type Field emission) Semi In-lens type, Resolution 1.0[nm] (@15(kV)) **<u>1.3[nm] (@1(kV))</u>** Sample size Max.150mm	Secondary electron image (SEI)+ Backscattered Electron Image(BEI), +Scanning TEM (STEM), +Energy dispersion spectroscopy (EDS) B(5)~U(92), **<u>Detector, 80mm^2</u>** **<u>+Electron Beam Induced Current (EBIC)</u>**
		EB-gun, 0.5-30 [kV], (Shotttky Field emission) Semi In-lens type, Resolution **<u>1.2[nm] (@30(kV))</u>** 3.0.[nm] (@1(kV)) High Pressure: ~7×10-4 [Pa] **<u>Low Pressure: 10~300 [Pa]</u>** Sample size Max.150mm	Secondary electron image (SEI) +Backscattered Electron Image(BEI), +Scanning TEM (STEM), +Energy dispersion spectroscopy (EDS) B(5)~U(92), **<u>Detector, 50mm^2</u>** **+<u>Wave dispersion spectroscopy (WDS)</u> +<u>Cathode Luminescence</u>**
		EB-gun, 10-30 [kV], Resolution 8.0 [nm] (@ 30 kV) Sample size 0.25 mm^2	Reflection electron microscopy (REM) observation at atmospheric pressure or in a solution

	Focused ion beam (FIB)	Ga+,10-30 [kV]	Formation of nanostructures Preparation of ultra thin cross-sectional samples for TEM observation (for **semiconductors and related materials**)
	X-ray photo electron spectroscopy (XPS)	Mg/Al dual anode, **Al monochromator**	Auto neutralizer with magnet lens Ion gun for sputtering (Ar+) Zalar rotation,
	Scanning Auger electron spectroscopy (AES)	EB-gun, (Thermal-type Field emission), EBSD(Electron Back Scattering Diffraction)	Ion gun for sputtering (Ar+), Zalar rotation,

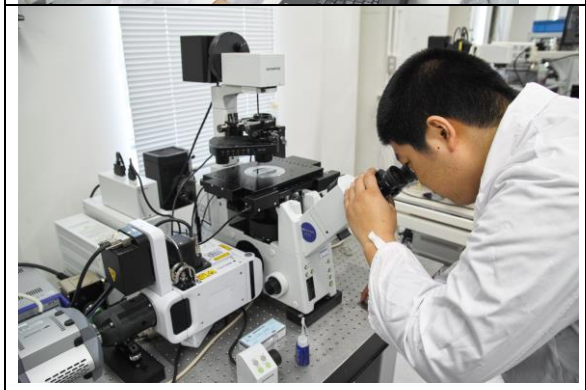
	Scanning Probe Microscope	DFM, MFM, KFM, Cell for liquid (temperature-controlled) Nano-lithography DFM, SNOM DFM, MFM, KFM Automatic stage (4inch size) DFM, High-vacuum(10-4Pa) SSRM STM, AFM, KFM, (in ultra high vacuum 10-9Pa)	Total reflection fluorescence microscope for single molecule measurement Inverted fluorescence microscope for SNOM (Scanning near field microscope) Search for CNTs on substrates SSRM for Potential contour in Si devices Atomic images of surface structures of Si, CNT and other materials
	High Resolution Microscope Raman Spectrometer	f-800[mm] **Spatial resolution 1[um]** He-Cd laser (325.0[nm]) Ar+ laser (457.9[nm], 488.0[nm], 514.5[nm]) He-Ne laser (632.8[nm])	+ PL measurement (InGaAs detector) + Cryostat (77[K]-300[K]) with terminals for electric measurement

	SNOM-Raman	**<u>Spatial resolution 0.5[um] for Raman measurement</u>** 355 [nm] solid-state laser 532 [nm] solid-state laser	Raman, AFM measurement, and Scanning near field microscope (SNOM) measurement
	Near infrared photo luminescence excitation (NIR-PLE)	Excitation 500W Xe lamp 400[nm]-1000[nm] Detector InGaAs 850[nm]-1600[nm]	Characterization of chirarity of CNTs
	Picosecond Fluorescence Lifetime Measurement System	5 ps temporal resolution <140fs,1W,90MHz, +Pulse picker 9200, 9.5[kHz]-4.75[MHz] +HG9300, SHG, THG	Streak Scope Ti Sapphire laser

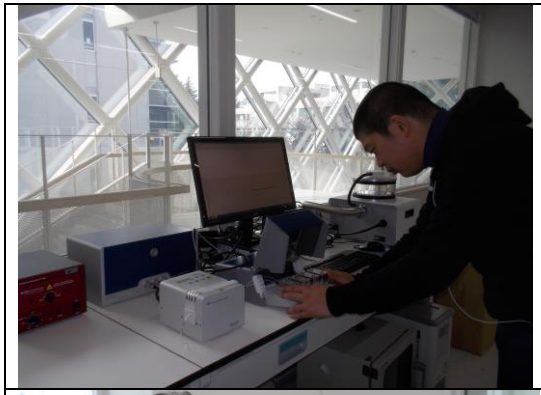
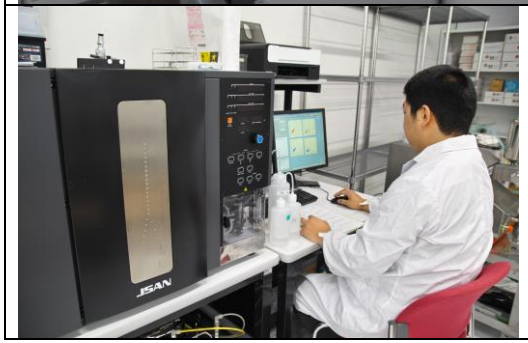
	Refractometer	Refractive index: 1.25-2.00 Measurement wavelength: 486.1, 587.6, 656.3 and 632.8 nm Temperature range: 10-70 °C	Measurement of refractive index for glasses, transparent materials and liquid samples
	Microplate reader	Absobance: Xenon lamp (200-999nm) Fluorescence & TRF: Tungusten Halogen lamp (EX;360, 485, 530, 595[nm], EM; 460, 528, 590, 620[nm])	Supported plate: 6, 12, 24, 48, 96, 384 well plate, PCR tube Injector, Incubator and Shaker are installed.
	UV-VIS-NIR Spectrum photometer	Deuterium lamp (D2), Iodine tungsten lamp 187[nm]-3200[nm] Transmittance, Reflectance	

	Fluorescence spectrophotometer	Excitation Xe lamp 200[nm]-890[nm] Detector 210[nm]-900[nm] 210[nm]-900[nm	
	Micro-FT-IR/FT-Raman	IR microscope FT-Raman (1064 nm excitation) ATR module PM-IRRAS module	Near-IR to Far-IR
	Thermal analysis -FTIR **simultaneous measurement** system (TG-DTA/FTIR)	Ambient to 800 °C (stand-alone use: 1100 °C) Detector (TGS, MCT) Transmission+Reflection	Simultaneous thermogravimetry/differential thermal analysis (TG/DTA) measurements Infrared Spectrophotometers(IR/FTIR)

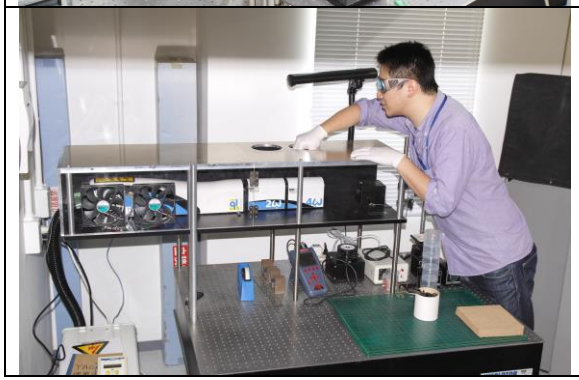
	Thermal analysis - GC/MS **simultaneous measurement** system (TG-DTA/GC-MS)		differential thermogravimetric analysis system Gas Chromatograph-Mass Spectrometer(GC/MS)
	Thermal Analysis Instrument	Ambient to 1500°C	Simultaneous thermogravimetry/differential thermal analysis (TG/DTA) measurements
	LC−MS	Type：Ion trap MS/MS efficiency：2000 fg Reserpine @ S/N 100:1 Mass range：50 - 3,000m/z, 200 - 6,000m/z mass resolution@scan speed：0.58u @ 52,000u/s, 0.50u @ 32,000u/s, 0.30u @ 8,100 u/s, 0.10u @ 4,600 u/s	

	MALDI-TOF Mass Spectrometer		
	Zeta potential measurement Instrument	Static/Dynamic Light Scattering (SLS/DLS) with Non-Invasive Back-Scattering (NIBC) Laser Doppler method	Simultaneous measurement of zeta potential, size and molecular weight of particles, Size Diameter:0.6nm～6,000nm 2℃～90℃ High salt concentration sample (~ 8x10-2 S/cm) is available.
	Confocal microscope	Laser: 405nm, 488nm and 561nm in wavelength Other observation: Brightfield, Phase contrast, Epi-fluorescence, Total internal reflection fluorescence Laser: 405nm, 488nm and 543nm in wavelength Other observation: Brightfield, Differential interference contrast, Epi-fluorescence	

	2D electrophoresis system / Fluorescent gel image analyzer	2D electrophoresis system ・Fast separation ・High reproducible ・High resolution Fluorescent gel image analyzer ・3-laser (473nm, 532nm, 635nm) ・High-accuracy matching	
	FPLC	Flow rate system pump：0.001～25 ml/min sample pump：0.01～25 ml/min Pressure range system pump：0～20 MPa sample pump：0～10MPa UV detector 190～700nm conductance meter 0.01～999.99 mS/cm	
	Jar fermenter	5L / 10L jar fermenter rotating speed：100～1000rpm temperature range：10～50℃ instrumentation control：revolving speed, temperature, pH, DO,	

	QCM-D	Sensor: Au, HA, SiO, TiO2, ZrO2, AlO3, SUS, Cr, Cu, PMMA, PS, ⋯etc. range of frequency: 1 – 70MHz Maximum Resolution: 200data points / min	
	Ultracentrifuge	Maximum speed: 150,000 rpm Rotor temperature: 0-40 °C Ultimate vacuum: below 0.6 Pa Rotor: S110AT, S50A	The CS150NX is designed to separate liquid-suspended materials having different densities and particle size. S110AT (Maximum speed: 110,000rpm, Capacity: 4 ml × 8) S50A (Maximum speed: 50,000 rpm, Capacity: 30 ml × 6)
	Cell Sorter	Droplet Sortnig, 3-laser system, (488nm,638nm,375nm) Max. 60,000 ivents/s	

	Cell homogenizer	Maximum pressure: 200 MPa Nominal capacity: 11 l/h Minimum sample size: 200 ml	Disruption of cell (animal tissues, plant tissues, yaest, and bacteria) can be achieved by passage through high-pressure homogenizer.
	Laser manipulation system	Two beam IR laser, Inverted microscopy with motorized XY stage, Stage incubation system	Bright field, phase contrast, dark field and Epi-fluorescence microscope
	Rheometer	Parallel and Cone and plate Torque range: 10nNm to 200mNm Torque resolution: Better than 1nNm Controlled speed range: 0.01 nrad/s to 600 rad/s Temperature Control: -30 to 200 ℃ ER fluid measurement system	Measurements for viscosity, viscoelasticity , relaxation, creep and recovery, and multiwave.

	Excimer laser system CO2 laser system	Wavelength and power are 193 nm, and 4W. Wavelength and power is 10.6 µm and 100W	Wavelength is in vacuum ultraviolet region. Continuous high power laser.
	Nd: YAG laser	1064, 532, 355, 266 and 213 nm wavelength are available.	High power and easy to change the wavelength.