

NANOFAB TOOL RATES
Effective 10/01/15

Category	Tool	Description	Location	Tool Usage Standard Rate	Tool Usage Reduced Rate
				\$/Hour	\$/Hour
Chemical Vapor Deposition	Oxford FlexALRPT Atomic Layer Deposition	Thermal and plasma ALD Processes for platinum, silicon oxide, aluminum oxide, titanium oxide, and hafnium oxide, up to 200 mm substrates.	C	155	83
	Plasma-Therm Versaline High Density PECVD	Low temperature deposition of oxide, nitride and amorphous silicon thin films, up to 200 mm substrates.	C	147	79
CMOS	Tystar Wet Oxidation Furnace	Pyrogenic oxidation of silicon up to 1150 °C.	C	213	115
	Tystar Dry Oxidation Furnace	Dry oxidation of silicon up to 1150 °C.	C	213	115
	Tystar Sinter Furnace	10% forming gas and nitrogen anneal.	C	116	62
	Tystar Doping Furnace	Phosphorus and boron doping of silicon.	C	116	62
	Tystar Polysilicon Low Pressure CVD	CMOS doped and undoped polysilicon deposition.	C	153	82
	Tystar Silicon Nitride Low Pressure CVD	Low stress and stoichiometric silicon nitride deposition.	C	138	74
	Tystar Low Temperature Oxide CVD	Low temperature oxide deposition.	C	145	78
Dry Etching	Unaxis Shuttleline Deep Si Etcher	Bosch process capability 1 um per minute to 15 um per minute with high selectivity (> 100:1 silicon oxide, > 40:1 photoresist).	C	134	72
	Unaxis Shuttleline ICP Etcher	Inductively coupled plasma (ICP) chlorine and fluorine etching on substrates up to 150 mm.	C	116	62
	SPTS Omega c2L Deep Silicon Etcher	High aspect ratio deep silicon etching on wafers up to 200 mm. "Bosch" process capability with higher etch rates and smoother feature sidewalls.	C	174	94
	Oxford PlasmaLab 100	Chlorine or fluorine etching especially suited to III-V, metals, and anisotropic silicon etching, cryogenic and high temperature etch capability - 150 °C to 400 °C, up to 200 mm wafer capable.	C	141	76
	Unaxis 790 RIE	General fluorine etching of dielectrics and metals.	C	116	62
	XeF2 Silicon Etcher	High rate silicon removal for mems release etch.	C	388	209
	SPTS μEtch HF Vapor Etcher	A combination of liquid hydrofluoric acid and alcohol isotropically etches silicon dioxide while not etching silicon. Substrates up to 200 mm.	C	103	55
	ULVAC Solutions ENVIRO-1Xa Downstream Plasma Asher	High rate photoresist removal and substrate clean using a remote plasma to minimize damage on substrates up to 200 mm.	C	81	44
	Microwave Asher	Polymer removal and surface clean.	C	81	44
Gen Furnaces	4Wave Ion Mill	Argon ion milling of metals and dielectrics (150 mm wafer maximum), large 22 cm ion source provides < 1% non-uniformity, low base pressure, fast cycle, SIMS endpoint detection, reactive ion beam etch capable with oxygen and fluorocarbons.	C	136	73
	Tystar Dry Ox Furnace	Dry oxidation of silicon up to 1200 °C.	C	107	58
Gen Furnaces	Tystar Wet Ox Furnace	Pyrogenic oxidation of silicon up to 1150 °C.	C	107	58
	Tystar Sinter Furnace	10 % forming gas and nitrogen anneal.	C	87	47
	Tystar Anneal Furnace	Nitrogen and oxygen anneal up to 1100 °C.	C	87	47
	Modular Process Rapid Thermal Annealer	Rapid thermal processing up to 1200 °C in nitrogen, oxygen, argon, 10% forming gas, up to 150 mm wafers.	C	163	88
	Imaging and Analysis	FEI Titan Analytical TEM	Information Limit 0.10 nm, STEM resolution 0.14 nm, 80 kV to 300 kV, Gatan Orius 2k x 2k digital camera, Fischione HAADF STEM detector, Gatan GIF for EELS and EFTEM, EDAX EDS for elemental detection and mapping. Tomography acquisition, reconstruction, and analysis software.	E	172
Zeiss Ultra 60 Field Emission SEM		1.5 nm resolution, 1 keV to 30 keV, Oxford EDS for detection and mapping of elements beryllium and heavier, in lens and Everhart Thornley secondary detectors, and in lens energy selective and four quad backscatter detectors. up to 150 mm wafers.	C	134	72
JEOL JSM-7800F Field Emission SEM		Extreme resolution analytical field emission SEM, 10 V to 30 kV, excellent imaging of magnetic and non-conducting samples, up to 200 mm wafers.	C	138	74
Fischione 1040 NanoMill Low Energy Ion Mill		Low energy ion mill for final thinning of TEM specimens.	E	107	58
Bruker Fast Scan AFM		Wafer scale AFM capability on wafers up to 200 mm for fast scanning of multiple sites on a wafer. Contact, tapping, and phase imaging modes, up to 200 mm substrates, electrostatic force microscopy, magnetic force microscopy.	C	145	78
Asylum Cypher High Resolution AFM		High resolution AFM capability on wafers up to 20 mm for multipurpose research applications. Contact, tapping, and phase imaging modes, electrostatic force microscopy, magnetic force microscopy.	E	140	75
Veeco Dimension 3100 Atomic Force Microscope		Contact, tapping, and phase imaging modes, up to 200 mm substrates, electrostatic force microscopy, magnetic force microscopy.	C	132	71
Sample Prep Lab		A variety of tools to prepare samples for SEM, FIB, and TEM work.	E	69	39

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Focused Ion Beams	FEI Helios 650 Dual Beam FIB/SEM	SEM Imaging resolution < 1 nm from 1 kV to 30 kV, FIB resolution 2.5 nm at 30 kV, STEM detector, integrated Oxford EDS for detection and mapping of elements beryllium and heavier, beam deceleration for 50 V effective landing voltage, Kleindiek in-situ probe system for nanopositioning and electrical measurement, gas injection system supports platinum, gold, carbon, insulator deposition and selective carbon and insulator enhanced etch, slice and view 3D reconstruction, TEM lamella prep, circuit editing, wafers up to 150 mm.	E	328	177
	Zeiss NVision40 Dual Beam FIB/SEM	SEM imaging resolution 1.1 nm at 20 kV, FIB resolution 4 nm at 30 kV, gas injection system supports platinum, tungsten, carbon, and insulator deposition, slice and view 3D reconstruction, TEM lamella prep, circuit editing, load lock for fast sample change, wafers up to 100 mm.	E	291	157
Lithography	JEOL E-beam JBX 6300-FS	Directly pattern a variety of substrate materials with feature sizes as small as 10 nm, 2 nm spot size, 50 MHz write speed, 200 mm loadable.	E/ C	556	299
	Raith Elphy E-beam	Ion beam 4 nm spot size at 30 kV, electron beam 1 nm spot size at 20 kV, 100 mm loadable, integrated with Zeiss N-Vision 40 FIB/SEM.	C	134	72
	ASML Stepper PAS 5500/275	High throughput 5x projection I-Line lithography; < 300 nm resolution; 3D backside alignment, 200 mm loadable, 22 mm x 27 mm field size.	C	388	209
	Suss MA6 Contact Lithography	I or G line contact exposure with front and back side alignment, 1 um resolution, up to 150 mm substrate.	C	87	47
	Suss MA8 Contact Lithography	I or G line contact exposure, 1 um resolution, up to 200 mm substrate.	C	87	47
	Heidelberg DWL-66FS Laser Writer	Less than 1 um resolution, greyscale writing modes, backside alignment capable, direct substrate write or mask exposure.	C	136	73
	Suss Microtec Delta12AQ Resist Developer	Automated photoresist developer station which supports temperature controlled spray photoresist development on substrates up to 200 mm.	C	160	80
	Suss Microtec ACS200 Resist Coater	Automated photoresist coat and bake station with cassette-to-cassette operation on substrates up to 200 mm. Supports spray coating and spin coating processes.	C	160	80
	Brewer Science CEE Model 100CB Spinner	Uniformly apply and bake photoresist on substrates ranging from 200 mm diameter wafers down to small pieces.	C	48	27
	Nanonex NX-2000 Nano-imprinter	UV and thermal large area imprint, features down to 10 nm.	C	194	104
	Nanonex Ultra-100 Molecular vapor coater	UV-Ozone clean and molecular vapor coating capabilities to support nano-imprint processes on substrates up to 150 mm diameter.	C	155	83
Metrology	Wyatt Dawn Heleos II DLS	Nanoparticle characterization system integrates several methods of field flow fractionation and light scattering to separate and measure nanoparticles in solution.	E	50	27
	Rigaku SmartLab 9kW X-Ray Diffraction	High resolution multipurpose x-ray diffractometer, 9 kW rotating anode x-ray generator, high temperature measurements up to 1100 °C in air, vacuum, and inert gas; measurements including film thickness, roughness, density, crystallographic texture, and film and crystal quality measurements.	E	153	82
Packaging	Disco 341 Dicing Saw	Wafer dicing (200 mm wafer maximum).	E	103	55
	K&S 4526 Wire Bonder	Manual wire bonder for electrical interconnect. Dedicated for gold wire usage.	E	136	73
	K&S 4526 Wire Bonder	Manual wire bonder for electrical interconnect. Dedicated for aluminum wire usage.	E	136	73
	Tresky T-3000-FC3-HF Flip Chip Bonder	Eutectic, ultrasonic, thermal, and epoxy bonding, 1 um positioning accuracy, substrates up to 40 mm thick and 150 mm diameter.	E	151	81
Physical Vapor Deposition	Denton Infinity 22	Thermal and E-beam evaporation of over 30 metal and dielectric sources provided, co-evaporation available, ion assist, ion wafer clean, fast cycle under 30 minute pumpdown.	C	138	74
	4Wave Cluster Sputter System	Physical deposition capability using the ion beam deposition or biased target deposition techniques resulting in the densest available thin films deposited at room temperature on substrates up to 200 mm.	C	194	104
	Denton Discovery 550 Loadlock	RF and DC sputtering of over 30 metal and dielectric targets provided, magnetically enhanced gun, up to 600 W, heated stage to 350 °C, co-sputtering available, wafer pre-sputter, oxygen and nitrogen available for reactive sputtering. Loadlock for fast cycling.	C	157	85
	Denton Discovery 550	RF and DC sputtering of over 30 metal and dielectric targets provided, magnetically enhanced gun, up to 600 W, heated stage to 350 °C, co-sputtering available, wafer pre-sputter, oxygen and nitrogen available for reactive sputtering.	C	148	77
	Speciality Coatings PDC-2012 Parylene Deposition	Parylene N or C only, thickness to tens of microns.	C	99	53

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Speciality Tools	Suss Microtec SB6e Wafer Bonder	Thermal, pressure and anodic bonding with vacuum or over-pressure condition.	E	234	126
	Tousimis Critical Point Dryer	Drying of high aspect ratio fragile structures on pieces to 150 mm wafers.	C	107	58
	Bruker-TMT Chemical Mechanical Planarization	Chemical Mechanical Polisher (100 mm wafer maximum).	E	105	57
Wet Chemistry	SSEC Single wafer acid spray clean tools	CMOS and general tools for RCA and Piranha clean of single substrates ranging from 200 mm diameter wafers down to small pieces.	C	100	54
	Microprocess Avenger Solvent Liftoff	Heated spray solvent liftoff, dry in dry out processing, substrates up to 150 mm.	C	153	82
Soft Lithography	Soft Lithography Lab	Dedicated tool set for soft lithography processing.	E	69	39
Access	Cleanroom Occupancy Rate	Clean room entrance fee includes gowning, most wet chemistry, and metrology including: Toho Tech FLX-2320 Laser Film Stress Measurement Firsttenangstroms FTA32 Contact Angle Goniometer Woollam XLS-100 Spectroscopic Ellipsometer Filmetrics reflectometer Bruker Dektak XT surface profilometer Four Dimensions four point probe Microscopic and Macroscopic Optical imaging and inspection Keithley 4200 Parametric test with capacitance, pulse, and high current modes.	-	76	39
	Processing Services Engineer	NanoFab Engineers can perform process development and run complex processes on your behalf in the NanoFab including mask layout with or without you present.	-	134	134
	Processing Services Technician	NanoFab Process Technicians can run standard process on your behalf with or without you present.	-	79	79

Note: Location 'C' indicates that the tool is located inside of the cleanroom and incurs the clean room occupancy fee in addition to the tool rate. Location 'E' indicates that the tool is located outside of the cleanroom.

* All CMOS tools require a one time 2 hour NanoFab CMOS protocol training prior to CMOS tool training.

NANOFAB TRAINING RATES
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Category	Tool	Typical Training Time	Individual Training Rate	Group Training Rate
		Hours	\$/Hour	\$/Hour
Chemical Vapor Deposition	Oxford FlexALRPT Atomic Layer Deposition	2	217	109
	Plasma-Therm Versaline High Density PECVD	1	213	107
CMOS	Tystar Wet Oxidation Furnace	1	249	125
	Tystar Dry Oxidation Furnace	1	249	125
	Tystar Sinter Furnace	1	196	98
	Tystar Doping Furnace	1	196	98
	Tystar Polysilicon Low Pressure CVD	1.5	216	108
	Tystar Silicon Nitride Low Pressure CVD	1.5	208	104
	Tystar Low Temperature Oxide CVD	1.5	212	106
Dry Etching	Unaxis Shuttleline Deep Si Etcher	2	206	103
	Unaxis Shuttleline ICP Etcher	2	196	98
	SPTS Omega c2L Deep Silicon Etcher	2	228	114
	Oxford PlasmaLab 100	2	210	105
	Unaxis 790 RIE	2	196	98
	XeF2 Silicon Etcher	1	343	172
	SPTS μ Etch HF Vapor Etcher	1	189	95
	ULVAC Solutions ENVIRO-1Xa Downstream Plasma Asher	0.5	178	89
	Microwave Asher	0.5	178	89
	4Wave Ion Mill	2	207	104
Gen Furnaces	Tystar Dry Ox Furnace	1	192	96
	Tystar Wet Ox Furnace	1	192	96
	Tystar Sinter Furnace	1	181	91
	Tystar Anneal Furnace	1	181	91
	Modular Process Rapid Thermal Annealer	1	222	111
Imaging and Analysis	FEI Titan Analytical TEM	40	227	114
	Zeiss Ultra 60 Field Emission SEM	4	206	103
	JEOL JSM-7800F Field Emission SEM	4	208	104
	Fischione 1040 NanoMill Low Energy Ion Mill	2	192	96
	Bruker Fast Scan AFM	2	212	106
	Asylum Cypher High Resolution AFM	2	209	105
	Veeco Dimension 3100 Atomic Force Microscope	2	205	103
	Sample Prep Lab	3	173	87
Focused Ion Beams	FEI Helios 650 Dual Beam FIB/SEM	5	311	156
	Zeiss NVision40 Dual Beam FIB/SEM	5	291	146
Lithography	JEOL E-beam JBX 6300-FS	6	433	217
	Raith Elphy E-beam	4	206	103
	ASML Stepper PAS 5500/275	6	343	172
	Suss MA6 Contact Lithography	4	181	91
	Suss MA8 Contact Lithography	4	181	91
	Heidelberg DWL-66FS Laser Writer	4	207	104
	Suss Microtec Delta12AQ Resist Developer	2	214	107
	Suss Microtec ACS200 Resist Coater	2	214	107
	Brewer Science CEE Model 100CB Spinner	1	161	81
	Nanonex NX-2000 Nano-imprinter	3	238	119
	Nanonex Ultra-100 Molecular vapor coater	2	217	109
Metrology	Wyatt Dawn Heleos II DLS	6	161	81
	Rigaku SmartLab 9kW X-Ray Diffraction	4	216	108

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Packaging	Disco 341 Dicing Saw	3	189	95
	K&S 4526 Wire Bonder	1	207	104
	K&S 4526 Wire Bonder	1	207	104
	Tresky T-3000-FC3-HF Flip Chip Bonder	2	215	108
Physical Vapor Deposition	Denton Infinity 22	2	208	104
	4Wave Cluster Sputter System	4	238	119
	Denton Discovery 550 Loadlock	2	219	110
	Denton Discovery 550	2	211	106
Speciality Tools	Speciality Coatings PDC-2012 Parylene Deposition	1	187	94
	Suss Microtec SB6e Wafer Bonder	4	260	130
	Tousimis Critical Point Dryer	1	192	96
Wet Chemistry	Bruker-TMT Chemical Mechanical Planarization	3	191	96
	SSEC Single wafer acid spray clean tools	1	188	94
Soft Lithography	Microprocess Avenger Solvent Liftoff	1	216	108
	Soft Lithography Lab	3	173	87
All Other Tools		Varies	134	67

Typical training times cover general tool operation and can vary depending on previous experience and aptitude. Application specific training beyond general tool usage will require additional training time and should be discussed with process engineer prior to training.

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