Micro/Nano Technology Center (MNTC)

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FY16 Annual Report

http://louisville.edu/micronano

Executive Summary

This document serves as the MNTC's official annual report for FY16 ending June 30, 2016. The University of Louisville's Micro/Nano Technology Center (MNTC) is a service center established in 2004. The class 100 / 1000 $30M 10,000 ft^2 cleanroom facility is used for fabrication of novel materials and devices. The facility includes a 1,000 ft^2 packaging and characterization lab with a 300 ft^2 design/layout/simulation lab for MEMS and IC devices. University of Louisville faculty, other academic institutions and external businesses utilize the facility for research while the MNTC also provides micro and nanofabrication services well beyond its borders.

The principal highlight for FY6 was the collaboration of the University of Louisville with the University of Kentucky to become members of the NSF NNCI. The new network formed a local network of the Kentucky Multi-scale Manufacturing and Nano Integration Node or http://www.kymultiscale.net/. Additionally, the MNTC hosted two summer camps for high school students during the 2006 summer. During this same time period the MNTC helped host a cleanroom experience the Research Experience for Undergraduate Students (REU) program.

Personnel

Dr. Kevin Walsh was the founding director of the MNTC and has served as its director for the past 10 years. He designed the current cleanroom in conjunction with Abbie Gregg, Inc, in addition to the previous cleanroom in Lutz Hall. Due to his dedication, time and effort the MNTC has grown to become extensive facility with numerous capabilities. On January 1, 2016, Dr. Walsh began a new chapter in his professional career by taking on the role of Associate Dean for Research with the Speed School of Engineering.

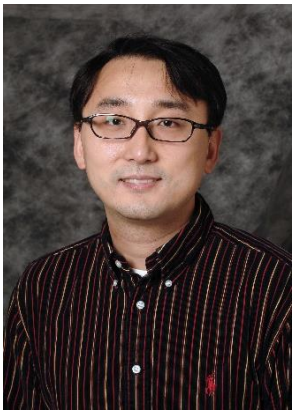
Dr. Shamus McNamara, associate professor in Electrical and Computer Engineering, gratuitously accepted and became the new director of the MNTC. Everyone in the MNTC wishes to thank Dr. Walsh for his efforts and express congratulations to him in his new venture.

Dr. Kevin Walsh

Founding Director, Inception – Dec 2015

Dr. Shamus McNamara

Director, Jan 2016 - present

 Dr. Julia Aebersold MNTC Cleanroom Manager	 Dr. Evgeniya Moiseeva Senior Process Engineer
 Dr. Xiaojin Wang Senior Process Engineer	 Curtis McKenna Research Engineer Scientist
 Mary Watson Business Manager	

Education

The MNTC was used by several classes in FY 2016. They are:

ECE 544	Fall 2015	13 students
ECE 634	Spring 2016	9 students

Outreach

The MNTC hosted two summer camps in June and July (not included in FY16) for high school sophomores, juniors and seniors. Students were learned and performed similar microfabrication techniques used by the semiconductor industry, Figure 1. Fabrication processes were discussed for solar cells, gyroscopes, pressure sensors, temperature sensors and light emitting diodes that are incorporated in ubiquitous life functions. Additionally, students experimented with developing breadboard electronic circuits with electrical components to program the Arduino microcontroller. These lessons bridged how devices fabricated in the cleanroom can be integrated with devices such as the smart phone.

Figure 1. High school participants from the MNTC's summer camp and fabricated wafer.

Facilities and Infrastructure

No major changes to infrastructure equipment or facilities were made in FY 2016 other than regular maintenance and replacements to aging equipment. Appendix B contains a summary of the facilities maintained by the MNTC.

Due to the specialized needs of the cleanroom, the MNTC is directly or financially responsible for many infrastructure systems that are typically serviced by Physical Plant in other buildings and academic institutions. Examples include the reverse osmosis (RO) and deionized (DI) water systems, air makeup and filtration systems, chiller for the air makeup handler, motorized exhaust systems, acid waste neutralization, compressed air and vacuum systems.

When the Shumaker Research Building was completed an agreement was developed with Physical Plant and Speed School of Engineering (SSoE) where annual funds of $32,000 would be provided to pay for maintenance of these infrastructure items. These funds are not reflected in the financial section of this report, yet, all funds for infrastructure maintenance were consumed this past year. It is anticipated that costs will escalate as the infrastructure ages.

Research Equipment

A list of all the equipment maintained by the MTNC is in Appendix A with no major changes to the tools in the past year. The systems require regular maintenance and consume significant

numbers of chemicals, gases and supplies. The MNTC has very good and experienced technical personnel that maintain and repair most issues that arise. Occasionally, an OEM technical or 3rd party contractor will be brought to the facility to service equipment. The MNTC currently does not have any service contracts.

Facility Usage

The MNTC is utilized by both internal and external users. Faculty that perform research with the MNTC have post-doctoral or graduate students trained on tools needed for their process. When time, experience or logistical issues arise then the MNTC staff is utilized to process for internal and external clients. During FY16 the MNTC experienced its largest growth with external clients and made up for the majority of its incoming revenue, Table 1.

External Clients	67.65 %
Internal Clients	32.35 %

Table 1: Percent usage of the cleanroom, calculated from revenue.

Usage of the cleanroom is the monitored by access entries into the facility, with exception to staff entries, and the center's Facility Online Management (FOM). Access fees are only counted and charged once per 24 hour period into the facility regardless of the number of entries. Tables 2 and 3 show the number of entries per month for internal users and by department.

Table 2. Individual entries per month into the cleanroom.

Name	Advisor	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Total
4023_AC Forensics	Ext	2	3	1	3	1	3	1	4	2				20
Adnani, Moein	Smadici (PHY)	2	1											3
Beharic_Jasmin	Harnett (ECE)	4		3	3		2	1		3			1	17
Crain_Mark_M	Keynton (BE)	1												1
ECE 634	Walsh (ECE)										11			11
ECE 544	Walsh (ECE)			11										11
Gartner, Christopher	Walsh (ECE)													0
Gu_Hengfeng	Yang (IE)													0
Harnett_Cindy	Harnett (ECE)	4		2	2				1		2		3	14
Hickman Robert	Sunkara(CHE												11	11
Hoang_Trung_V.	Berfield (ME)													0
Hoveyda	Smadici (PHY)	5	2	4		1	2	4	2	1		3	2	26
Johnson_Angelique_C	Walsh (ECE)													0
Kolli, Sowmya	Alphenaar (ECE)	4	6	11	4	1	8	2	6	6	9	8		65
Larin_Alexander_A	Dobrokhotov(PHY				2	1	2				2	2	1	10
Li_Mingxiao	Fu (CHE ENG)	1	4	1		1	5	1	1					14
Li_Qi	Fu (CHE ENG)		2	5		6	1		12	1	4	6	5	42
Lin_Ji-Tzuoh	Alphenaar (ECE)													0
MEMStim, LLC	Ext	10	15	12	17	10	12		1	8	10		5	100
Marei_Mohamed_M	Keynton (BE)				1							2		3
Martin_Michael_D.	Fried (CHE ENG)													0
Martin_Michael_D.	Walsh (ECE)													0
McNamara, Shamus	McNamara (ECE)				1							3		4
Ogunwale_Mumiye_A.	Fu (CHE ENG)									1		1		2
Baptist, Joshua	Popa (ECE)								4	2	1	2	7	16
Zhang, Ruoshi	Popa (ECE)								3	2	1		12	18
Ratnayake_Dilan	Walsh (ECE)	9	9	3	13	16	14	2	6	13	3	6	3	97
Schneider_Joseph_D.	McNamara (ECE)	11												11
Senousy, Yehya	Fu (CHE ENG)		2	7	1	3			12		3	4		32
Shuvra_Pranoy_Deb	Walsh (ECE)	1		4	9	10	4	1	2	13	9	15	9	77
Smadici_Serban	Faculty (PHY)		1								5			6
Smith_Scott_W	Mendes (PHY)													0
Trada_Hiren	Walsh (ECE)	1			1							5	8	15
Vaon			2											2
Walsh_Kevin_M	Faculty (ECE)	1	2	1	2									6
White, Robert	Spurgeon (Conn				2				4		1	1		8
Buxani, Mohith Ram	Yang (IE)					1								1
Accolla, Robert	Williams (ME)												1	
Sparks, Kelsey	Baldwin (CHEM)												1	
Yuan_Hanwen	Keynton (BE)				1		3					1	1	6
		56	49	65	62	51	56	12	58	52	61	59	70	649

Table 3. Cleanroom entries by department and external clients.

IE	1
PHY	45
ME	0
CHE ENG	109
BE	10
ECE	362
EXT	122
	649

The MNTC's equipment is reserved and accessed by using FOM. Current projects are to increase the number of tools controlled by FOM to provide additional data and a more complete picture of utilization in the cleanroom. Figure 1 shows the equipment usage captured by FOM during FY16. Each entry represents one equipment reservation, regardless of the time used or number of wafers processed.

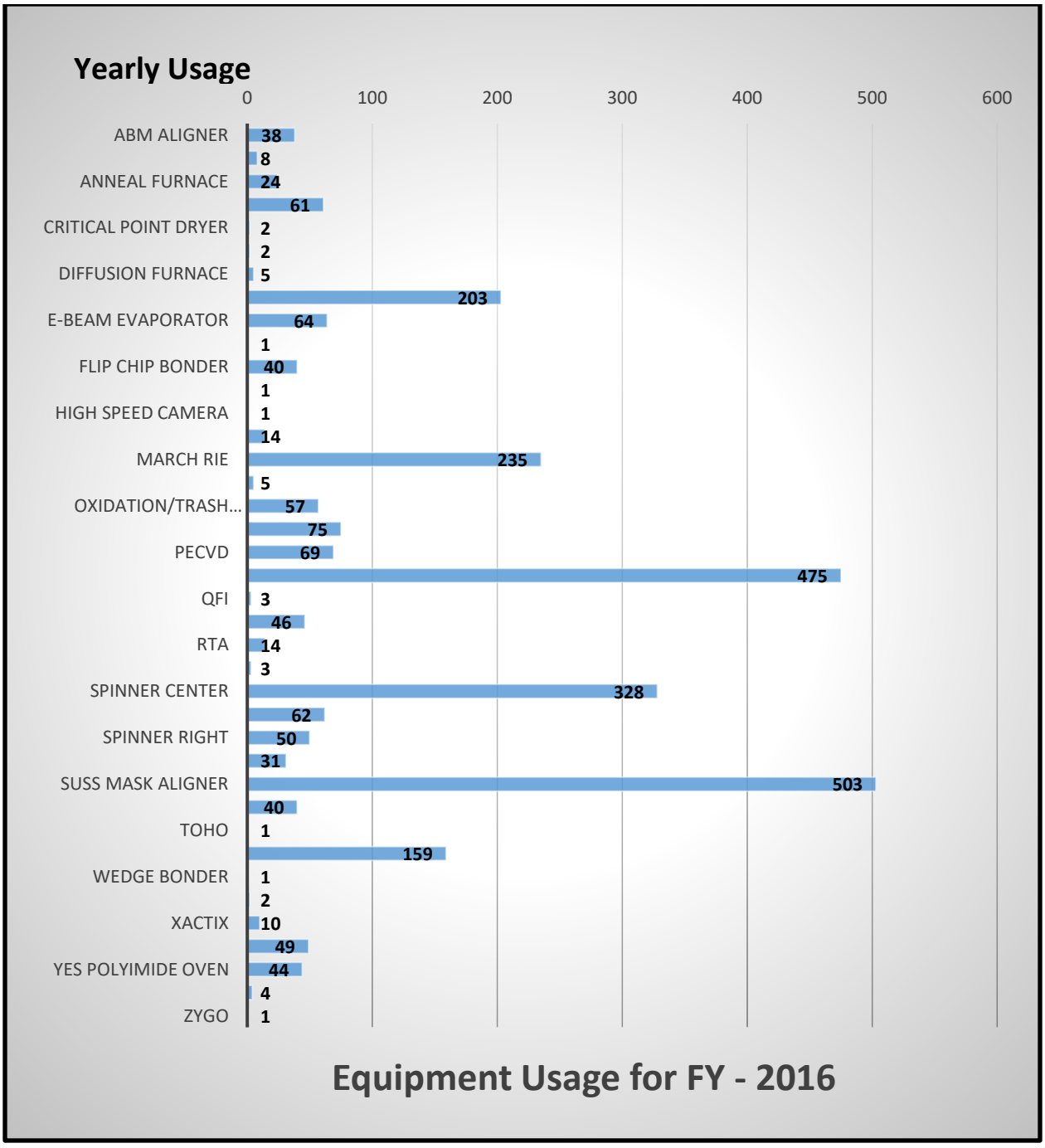


Figure 1. Equipment usage from FOM.

Financials

The MNTC ended FY16 with a surplus of $22,999.67. This is in contrast to previous years due to a deficit that accumulated because of increased salary burdens placed on the MNTC that was reversed during FY15 at the beginning of FY16. Additional factors that helped the facility return

to solvent state were controlled expenses and increased external income. Overall revenue and expenses are listed in Table 4.

Table 4. Overall revenue and expenses for FY16

Revenue	$245,213.75
Expenses	$118,897.30

Revenue

Revenue is derived from two categories of internal and external revenue. Table 5 lists revenue by internal and external clients. Table 6 is a breakdown of revenue by internal clients and their accompanying departments.

Table 5. FY16 revenue from internal and external clients.

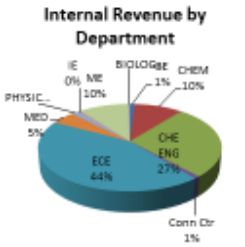
External Revenue	$ 165,429.34
Internal Revenue	$ 79,784.41
Total	$ 245,213.75

Table 6. FY16 internal revenue sources by client and department.

Internal Revenue Through June 2016 = $79,784.41

INTERNAL REVENUE		Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	TOTALS
TOTAL		$ 8,562.20	$ 5,753.20	$ 4,762.20	$ 8,198.10	$ 3,841.60	$ 6,052.80	$ 4,731.70	$ 2,719.70	$ 7,326.10	$ 6,848.80	$ 7,853.87	$ 13,895.10	$ 79,784.41
Alpheraar	ECE		$ 775.10		$ 1,128.40	$ 1,668.40	$ 240.80	$ 214.60	$ 126.40	$ 164.40	$ 3,264.80	$ 1,500.67	$ 4,823.20	$ 13,917.97
Baldwin	CHEM													$ -
Berfield	ME	$ 1,949.00	$ 995.00									$ 331.00		$ 3,275.00
Burns	CHEM	$ 90.00	$ 135.00	$ 135.00	$ 90.00	$ 90.00	$ 90.00	$ 180.00	$ 135.00	$ 90.00	$ 90.00	$ 90.00	$ 90.00	$ 1,305.00
Cardio. Innova	MED	$ 3,930.00												$ 3,930.00
Cardio. Innova	MED													$ -
Cohn	ECE	$ 15.00	$ 15.00	$ 15.00	$ 15.00	$ 140.00		$ 15.00		$ 15.00	$ 15.00	$ 15.00		$ 260.00
ECE	ECE						$ 4,745.90						$ 5,003.30	$ 9,752.20
Fried	CHE ENG													$ -
Fu	CHE ENG	$ 50.00	$ 2,000.00	$ 1,207.00	$ 1,578.60	$ 585.00		$ 785.90	$ 150.00	$ 2,777.50	$ 50.00	$ 444.40	$ 1,836.70	$ 11,511.10
Garmit	PHYSICS													$ -
Gindhesan	BE													$ -
Grappenhaus	CHEM	$ 45.00	$ 90.00		$ 495.70	$ 45.00		$ 45.00	$ 45.00	$ 90.00	$ 45.00	$ 90.00	$ 45.00	$ 1,035.70
Gutierrez	PHYSICS													$ -
Harnett	ECE	$ 423.20	$ 527.10		$ 317.00	$ 457.80		$ 134.10	$ 65.00		$ 283.66			$ 2,207.86
Keynton	BE		$ 180.00			$ 191.70	$ 120.00	$ 25.00					$ 120.00	$ 636.70
Larin, Alex (W	PHYSICS	$ 625.00		$ 109.20										$ 734.20
Machuta	CHEM													$ -
McNamara	ECE													$ -
Mendes	PHYSICS		$ 67.00	$ (150.00)	$ 300.00									$ 217.00
Panchapakesa	ME													$ -
Park	ME				$ 735.00		$ 360.00			$ 610.00	$ 580.80	$ 920.00		$ 3,195.80
Pope	ECE									$ 628.00	$ 381.78			$ 1,009.78
Remold	BIOLOGY	$ 45.00	$ 45.00		$ 45.00				$ 45.00		$ 45.00		$ 45.00	$ 270.00
Smadiki	PHYSICS						$ 137.00	$ 187.00						$ 324.00
Souky	BE		$ 45.00			$ 45.00		$ 45.00						$ 135.00
Spurgeon	CommCtr					$ 152.00		$ (42.00)		$ 503.70			$ 120.20	$ 733.90
Stolkowich	CHEM	$ 225.00	$ 180.00	$ 90.00	$ 45.00	$ 45.00	$ 45.00	$ 90.00	$ 90.00	$ 90.00	$ 45.00		$ 45.00	$ 990.00
Sunkara	CHE ENG	$ 685.00	$ 564.00	$ 3,176.00	$ 1,648.70	$ 386.60	$ 141.10	$ 1,290.00	$ 301.10	$ 965.60	$ 382.83	$ 100.00	$ 1,216.60	$ 10,777.53
Walsh	ECE							$ 1,482.10	$ 1,310.20	$ 827.40	$ 1,266.71	$ 2,349.20	$ 1,330.30	$ 8,565.91
Williams	ME	$ 200.00		$ 100.00					$ 309.00	$ 429.50		$ 700.60		$ 1,739.10
Yang	IE						$ 180.00	$ 180.00						$ 360.00
Zamborini	CHEM	$ 180.00			$ 1,648.70									$ 1,648.70
Zhang	CHEM	$ 180.00	$ 135.00		$ 270.00	$ 135.00		$ 180.00	$ 135.00	$ 135.00	$ 360.00	$ 1,313.00	$ 180.00	$ 3,023.00
WT 058													$ (1,740.20)	$ (1,740.20)

TOTAL	$	81,486.65	100%
BE	$	771.70	1%
CHEM	$	7,994.40	10%
CHE ENG	$	22,288.63	27%
Comm Ctr	$	733.90	1%
ECE	$	35,653.72	44%
MED	$	3,930.00	5%
PHYSICS	$	1,275.20	2%
IE	$	360.00	0%
ME	$	8,209.10	10%
BIOLOGY	$	270.00	0%



Expenses

The expenses incurred by the MNTC are listed in Figure 2.

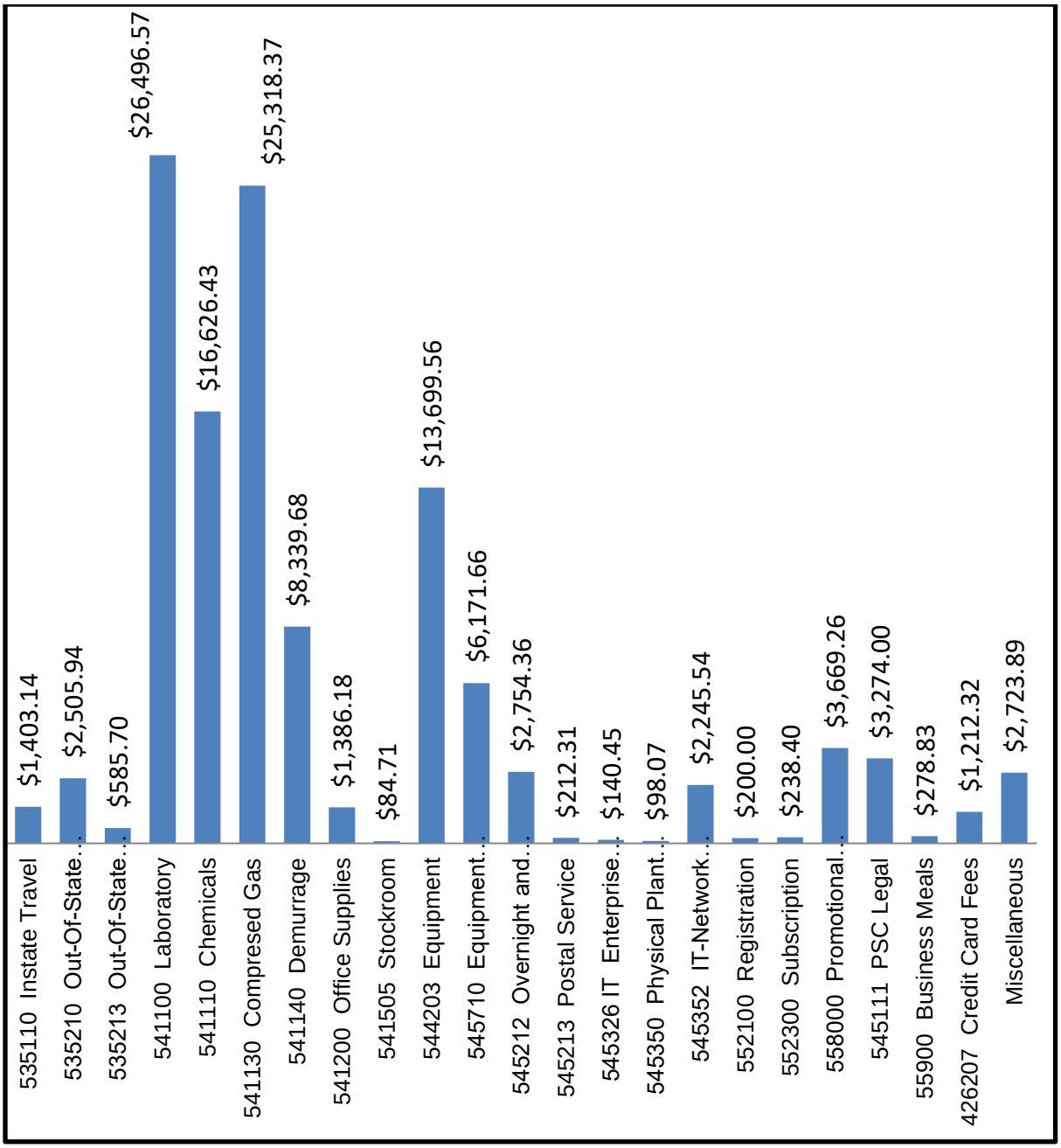


Figure 2. Itemized expenses for FY16.

Historical Perspective and Future Trends

Figures 3 and 4 show historical data of revenues and expenses for the lifetime of the MNTC since 2004. It is noted that the current cleanroom did not come online until 2007 in the Shumaker Research Building after it have been moved from Lutz Hall.

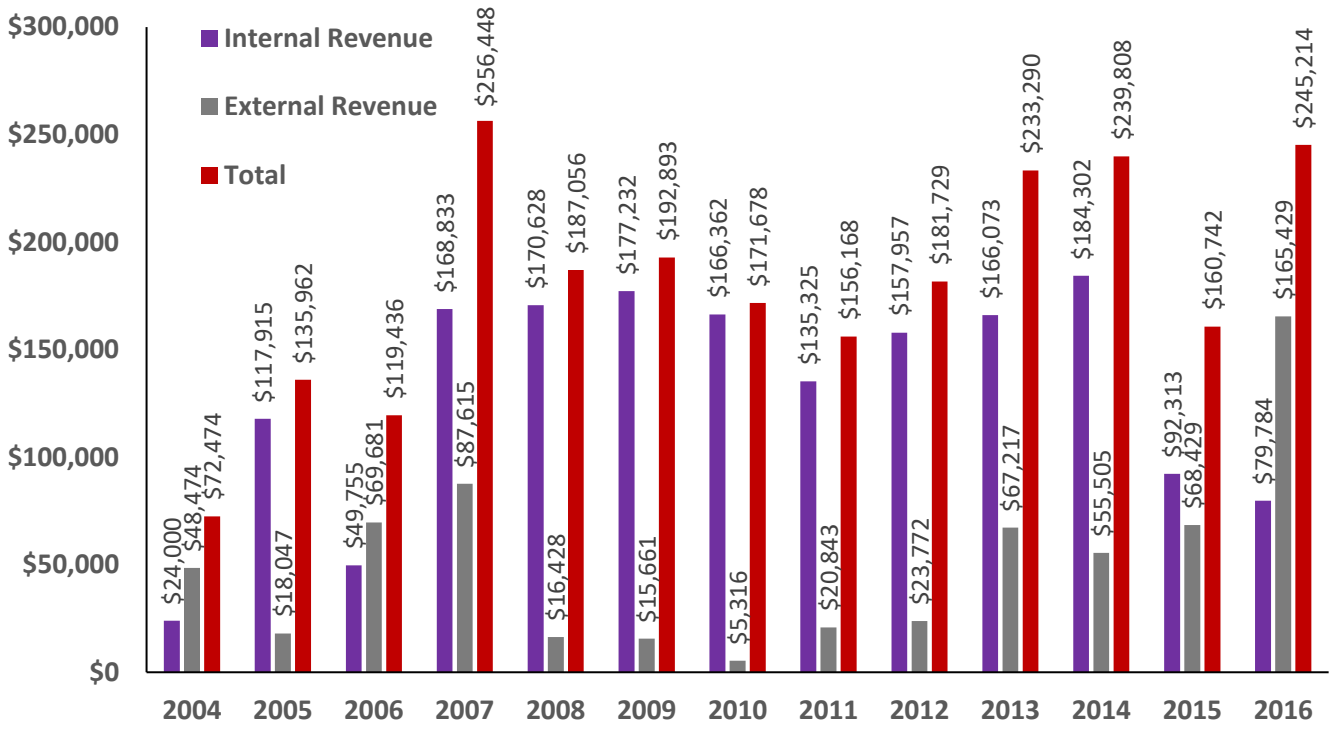


Figure 3. A comparison of internal and external revenue over the life time of the facility.

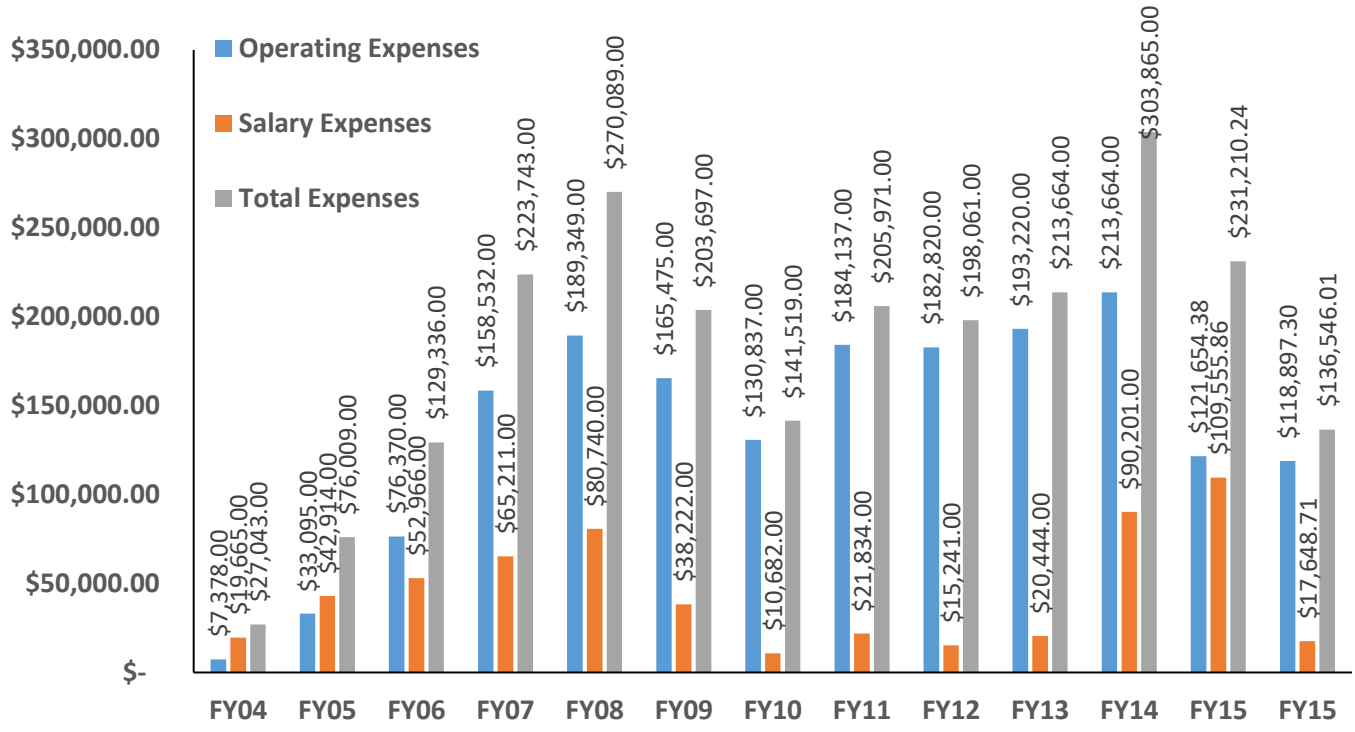


Figure 4. A comparison of expenses over the life time of the facility.

There are several conclusions that may be drawn from Figures 3 and 4. First, generated external revenue is at a record level. This is attributed to the MNTC striving to achieve exceptional customer care and performing increasingly difficult processing for clients.

Second, internal revenue is at its lowest recorded level since FY06 when the MNTC first moved into the Shumaker Research Building. This is attributed to faculty retirements, faculty moving to other universities and promotions to administrative positions. As a result the administration has not been active to hire replacement faculty to use the cleanroom. One notable exception is the recent hire of Dr. Dan Popa in FY16 in the Department of Electrical and Computer Engineering. It is anticipated that his research group will be a substantial user of the MNTC. In order to be sustainable the MNTC needs more faculty members to utilize the MNTC

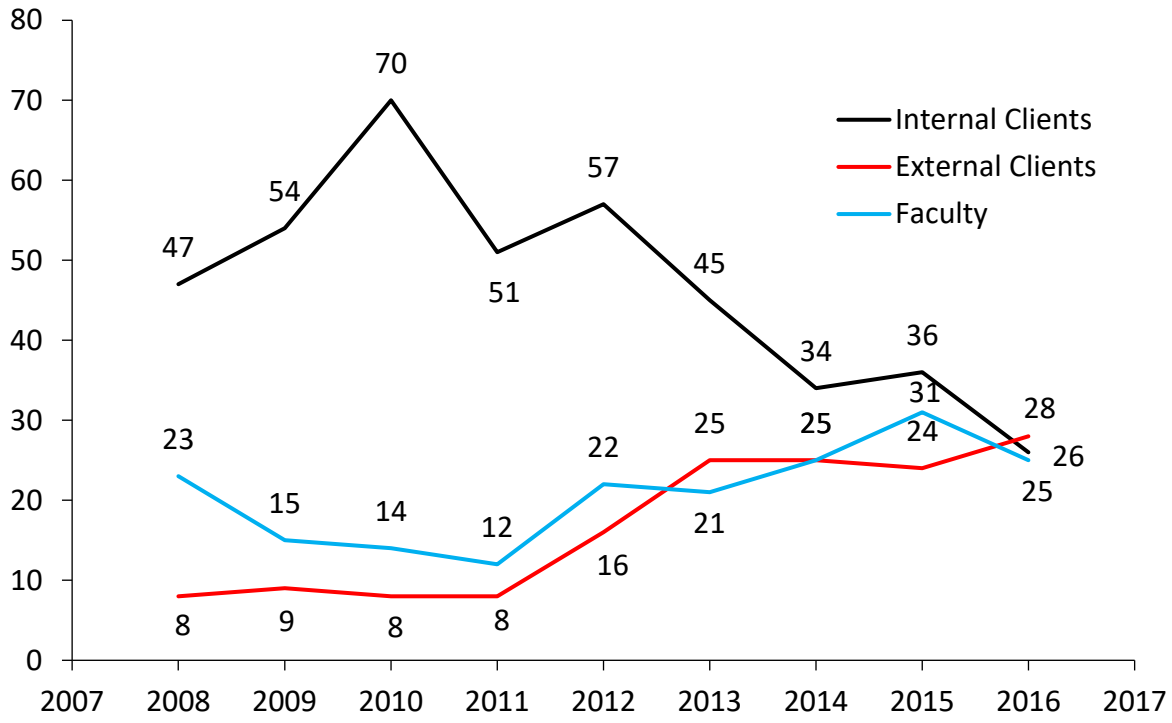


Figure 5. Historical data of clients utilizing the MNTC.

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Appendix A: Equipment

The MNTC has many capabilities for clients to perform their research in the facility. The following is a listing showing the equipment by category.

Photolithography

Photomasks and Direct Write:
A Heidelberg DWL 66FS UV laser patterning system for the generation of photomasks and direct write onto substrates, such as wafers or individual die. The Heidelberg can provide write resolution capabilities down to 600 nm for substrates up to 9" square. Additionally, it can perform direct write on wafers or individual die and write 128 levels of grayscale.

Contact Photolithography: Suss MA6 and AB-M mask aligners provide front and backside alignment capabilities. Alignment can be performed on individual die up to 6" wafers.

Image Reversal: An ammonia based photoresist image reversal systems by YES that can also perform HMDS vapor prime.

Thin Film Deposition

Plasma Enhanced Chemical Vapor Deposition system: Oxford PECVD system capable of depositing silicon nitride, silicon dioxide, oxynitride, amorphous silicon (undoped/doped), polycrystalline silicon (undoped/doped), silicon carbide, silicon nanowires and generation of carbon nanotubes. The Oxford tool includes a 700°C high temperature chuck and a TEOS delivery system.

Sputtering: Lesker PVD 75 three source tool and Technics two source system for deposition of both metals and dielectrics. The PVD 75 features RF, DC, RF/DC stacking and ion beam assisted sputtering, which includes throttled pressure control and reactive gas mixing.

Electron Beam and Thermal Evaporation: A Lesker electron beam and a Denton thermal evaporation system for depositing a variety of thin films on substrates up to 6".

Parylene Coating: An SCS vapor deposition tool for Parylene C and Parylene N.

Molecular Vapor Deposition: An Applied MST MVD system for the conformal deposition of hydrophobic coatings for lubricants, anti-stiction layers, molecular glues, reactive adhesion layers, or to change the surface contact angle.

Electroplating: Pulse or continuous DC electroplating systems for Au, Cu and Ni processing using high aspect ratio photoresists.

Atomic Layer Deposition: A Beneq ALD system for the deposition of alumina (Al_2O_3), zinc oxide (ZnO) and titanium dioxide (TiO_2) films.

Thermal Processing

Oxidation, Diffusion & Annealing: Multiple tube furnaces for thermal processes include wet/dry oxidation, high temperature annealing and boron/phosphorous diffusion.

Rapid Thermal Processes: An RTP system for silicon based gate oxide growth and rapid thermal annealing of implanted layers. Additionally, an RTA system for annealing of metal contact layers.

LPCVD Furnace: Low pressure chemical vapor deposition of polysilicon for 4"and 6" wafers.

Vacuum Cure Oven: Multiple programmable vacuum ovens capable of heating to 400°C.

Etching, Machining and Bonding

Deep Reactive Ion Etch (Silicon): An STS DRIE tool for anisotropic (vertical only) silicon deep trench etching using the Bosch process. This tool has a pulsed plate bias to minimize "footing" at oxide etch stops.

Anisotropic Silicon Wet Etching: KOH and TMAH wet etchants for silicon substrates.

Plasma Etching: Multiple reactive ion etching (RIE) and oxygen/plasma based systems capable of providing selective silicon, SiO2 and Si_3N_4 etching and oxygen plasma ashing.

Trion Phantom III Reactive Ion Etch System: A Trion ICP Phantom Minilock III Etcher for etching nitrides, oxides, polymers, metal, compound semiconductor and other materials using fluorine (CHF_3, SF_6, CF_4), oxygen and corrosive (Cl_2 and BCl_3) chemistries.

Xenon Di-Fluoride Etching: A Xactix XeF_2 system for isotropic (vertical and lateral) dry etching of silicon microstructures prone to stiction.

Wafer Level Bonding: A Suss SB6e for wafer level bonding of silicon/glass anodic bonding, glass/glass or gold/gold thermal compression bonding and Si/Si fusion bonding. All processes are capable of a 5 micron alignment with the adjacent Suss MA6 mask aligner.

Ion Milling: A two source ion beam based etching system capable of nanometer scale etching.

Critical Point Dryer: A critical point CO_2 dryer for drying substrates, where stiction needs to be avoided.

Packaging

Dicing: A Disco programmable saw for dicing silicon, glass and alternative substrates up to a 6" diameter.

Wire Bonding: Multiple Kulicke & Soffa wedge, ball and deep access wire bonders for aluminum and gold 1-mil wire bonding.

Flip Chip Packaging: A Finetech Fineplacer “Pico” system for flip chip die placement accuracy up to 5 microns. This tool can accommodate surface-mount components SMCs with a side length up to 17 mm.

Metrology & Testing

Thin Film Stress Measurement: A Toho thin film stress measurement system using non-contact multi-wavelength surface flatness techniques for evaluating thin film stresses from room temperature to 500°C.

3-D Contact Profiling: A Veeco contact profilometer that can provide down to a 7.5 angstrom step height measurement with a vertical range up to 1 mm and a maximum scan length of 200 mm. The low stylus force allows scratch-free measurement of soft materials.

Non-contact 3D Optical Profiler: A Zygo non-contact profilometer that is capable of measuring surface topology of micro scale systems. Its capabilities include field stitching and dynamic module for measuring MEMS devices during actuation.

Mid-wave Thermal Imaging System: A Quantum Focus Instruments (QFI) thermal imaging system for capturing thermal images and video of devices featuring 0.1°C temperature and 5 μm spatial resolutions.

Filmetrics systems for non-contact thin film thickness measurements and determining optical constants of single and multilayer films.

Testing: Veeco FPP-5000 Four-point Probe and suite of probe stations and electronic test instruments for measuring sheet resistance, TCR, I-V curves, C-V curves and device performance.

Design, Layout and Modeling

A full suite of computer-based tools for photo mask layout, custom analog and digital IC design, micro-scale tooling, and 2D/3D finite element models for virtual device evaluation. Software packages include: Tanner EDA, Silvaco TCAD, CoventorWare®, Solid Edge. These packages are available for academic purposes only.

Appendix B: MNTC Facilities

The MNTC is located throughout the Shumaker Research Building. Some locations are solely used by MNTC or other areas contain infrastructure that are maintained by physical plant. The following is list of locations and major uses of these locations:

SRB 121: Cleanroom & Chase Areas- The cleanroom is a 10,000 ft^2 class 100/1000 facility that houses multiple pieces of equipment available to clients. Chase areas are corridors adjacent to the open bay areas of the cleanroom and along the exterior wall of the cleanroom. This space is used for return air from the cleanroom, various utilities, location of chillers, pumps and other auxiliary equipment, storage for supplies and chemicals, gas cabinets, and transport of equipment and supplies in and out of the cleanroom.

SRB 119A: Hazardous Production Materials (HPM) Room – This explosion proof room contains chemical storage cabinets for chemicals waiting to be transferred to the service corridor, gas cabinets for pyrophoric and toxic gases with an associated scrubber and several inert cylinders that supply the cleanroom.

SRB 119: Loading Dock - This room is adjacent to the HPM room, service corridor and outdoor loading dock. The area is utilized to move equipment in and out of the cleanroom and is location of the primary DI water tank and pumping station that supplies the cleanroom. The location also serves as the 90 day satellite location for the pickup of non-hazardous or hazardous waste for DEHS.

SRB 199J: Service Corridor – This backside hallway allows for entry chemical storage, movement of supplies and tools into the cleanroom, gas cabinets, utilities and fire exits.

SRB 111: Machine Shop - This dirty space is utilized for repair of equipment and sandblasting of components from the cleanroom to remove deposition buildup.

SRB 113B – DI Water Filtration Station – This small room houses the primary and secondary filter banks for DI water provided to the cleanroom.

SRB142 – Interstitial Space - This door provides access to the elevated catwalk above the cleanroom, which house fourteen air handlers to receive and circulate incoming air from the air make up handler in the penthouse and chase areas in the cleanroom. The air handlers discharge filtered air through the HEPA filters.

SRB 139B: Fire Command Center – This small room houses the TGM server and fire command center.

SRB 213: Packaging Lab - This room contains packaging equipment for wirebonding, Parylene C deposition, thermal imaging, lapping and polishing and a variety of bench top test equipment.

SRB 226: TCAD Lab - This room contains computer workstations for performing simulations and developing CAD drawings for photomasks.

SRB Liquid Nitrogen Cage – This caged and enclosed area contains the 6,000 gallon liquid nitrogen tank and liquid to gas expansion system that supplies the cleanroom. A fill area is adjacent to the tank that allows clients to refill LN_2 dewars. This area also serves as the outdoor bunker for the 5% and 100% Silane gas cabinets.

SRB Basement: The basement contains the cleanroom's vacuum and compressed air systems, chiller for its dedicated air makeup handler in the penthouse, RO water filtration and pumping system and acid waste neutralization (AWN) system and back-up generator. This space is serviced by Physical Plant with exception to the AWN system.

SRB Penthouse: The MNTC's dedicated air makeup handler and three exhaust systems (acid/caustic, solvent and silane) are located in this area. This space is serviced by physical plant, but expense and labor are paid by the MNTC.

Appendix C: Rate Structure

The document with the current rate structure is shown on the next three pages.

UNIVERSITY OF LOUISVILLE
MICRO/NANO TECHNOLOGY CENTER RATES
(as of 11/10/2015)

http://louisville.edu/micronano

Go to the link below to learn how to gain access to the cleanroom.

http://louisville.edu/micronano/users/how-to-become-a-cleanroom-user

UNIVERSITY OF LOUISVILLE
Micro/Nano Technology Center

Clients of the MNTC will be charged a daily cleanroom access fee and associated equipment fees. All users will be charged including faculty.

Daily Access Fee for the Cleanroom: **Internal User:** $25/day
External User: $34/day

Equipment Usage Fee: The usage rates are defined below for internal users, external users and services. A cap of **$1,500** per month per researcher will be implemented for equipment usage, access fees and training for internal users only. This cap does not include consumables (wafers, wafer containers, tweezers, etc.) or services performed by the MNTC staff (i.e. dicing and photomasks). **A cap is not instituted for external users.**

Equipment	Internal Rate	External Rate	Service Center Rate
Flip Chip Bonder	$0.50/min	$0.75/min	$60/hour + Internal or External Rate
QFI Thermal Imaging System	$0.50/min	$0.75/min	
YES Image Reversal Oven	$0.50/min	$0.75/min	
Zygo Optical Laser Profilometer	$0.50/min	$0.75/min	
Critical Point Dryer	$0.50/min	$0.75/min	
Ball /Wedge Bonder	$0.60/min	$0.90/min	$60/hour + Internal or External Rate
Hi-Speed Camera	$0.60/min	$0.90/min	
March RIE	$0.60/min	$0.90/min	
Rapid Temperature Processing (RTP/RTA)	$0.60/min	$0.90/min	
ABM Aligner	$0.70/min	$1.05/min	$60/hour + Internal or External Rate
Beneq ALD	$0.70/min	$1.05/min	
DRIE	$0.70/min	$1.05/min	
E-beam Evaporator	$0.70/min	$1.05/min	
Molecular Vapor Deposition (MVD)	$0.70/min	$1.05/min	
Oxford PECVD	$0.70/min	$1.05/min	
Lesker PVD 75 (**extra for Au and Pt)	$0.70/min	$1.05/min	
Denton Thermal Evaporator	$0.70/min	$1.05/min	
Suss Aligner	$0.70/min	$1.05/min	
Suss Bonder	$0.70/min	$1.05/min	
Technics Sputterer	$0.70/min	$1.05/min	
Photoresist Spinners	$0.70/min	$1.05/min	
Trion Metal Etcher	$0.70/min	$1.05/min	
Xactix XeF_2 Isotropic Etching	$0.70/min	$1.05/min	
Hitachi SEM	$1.00/min	$1.50/min	$60/hour + Internal or External Rate

Equipment	Internal Rate	External Rate	Service Center Rate
Intelligent Micro-Patterning System (IMP)	$30/sample	$41/sample	$60/hour + Internal or External Rate
HF-8 Axic Barrel Asher	$30/batch	$41/batch	
Reynolds Electroplating Bench	$30/batch	$41/batch	
Tube Furnaces	$40/batch	$54/batch	
LF-8 2 RCA Clean Hood (RCA Cleaning)	$40/batch	$54/batch	
305 Acid Hood (Nanostrip, Aluminum Etch, Chrome Etch, BOE)	$40/batch	$54/batch	
307 Base Hood (KOH, TMAH)	$40/batch	$54/batch	
308 EDP Etch Hood (Gold Etch, Copper Etch)	$40/batch	$54/batch	
YES Polyimide Oven	$45/batch	$65/batch	
Parylene Deposition System	$45/batch	$65/batch	

Additional Fees	Internal Users	External Users
Training	$60/hour and is not included with tool usage fee	
**Gold/Platinum Deposition	$20/0.10 gram	$30/0.10 gram
Dicing (*Process performed by MNTC staff ONLY, Service fee included*)	$60/1st hour flat rate $1/minute after 1st hour	$85/1st hour flat rate $1/minute after 1st hour
Photomasks, Greyscale Photomasks (*Process performed by MNTC staff ONLY, Service fee included*)	$100/1st hour flat rate $40/hour after 1st hour	$136/1st hour flat rate $54/hour after 1st hour
Dewar Fill	$45/fill	N/A

Consumables/Supplies

Wafers	Internal Rate	External Rate
4"Non-Oxidized Prime SSP Wafers	$25/wafer	$34/wafer
4"Oxidized Prime SSP Wafers	$35/wafer	$48/wafer
4"Non-Oxidized Prime DSP Wafers	$35/wafer	$48/wafer
4"Oxidized Prime DSP Wafers	$45/wafer	$61/wafer
6"Non-Oxidized Wafers	$35/wafer	$43/wafer
4"Borosilicate Glass Wafers	$25/wafer	$34/wafer

General Cleanroom Supplies	Internal Rate	External Rate
4"Wafer Container	$4/each	$5.44/each
4"Wafer Container Lid	$4/each	$5.44/each
8.5"×11" Cleanroom Notebook	$12/each	$16.32/each
Metal Tipped Wafer Tweezers	$50/each	$68.00/each
Plastic Tipped Wafer Tweezers	$50/each	$68.00/each
Petri Dishes	$3/each	$4.08/each
Microscope Slides	$5/box	$6.80/box

Usage fee are not assessed on these items, but does not exclude MNTC labor fee:

Equipment
Dektak Profilometer
Filmetrics
Optical Microscopes
Stereoscopes
Toho Thin Film Stress Measurement System
Solvent Wet Bench
Spin Rinse Dryers
Vacuum Ovens
Spinners
Developer Wet Bench (LF8-1A Solvent Develop Hood)
Developer Wet Bench (115X Base Develop Hood)
Spinner Benches (153X Hot Plate Spinner Combo)
Solvent Bench (301 Solvent MEMS in wet etch bay)