



UNIVERSITY OF  
**LOUISVILLE**®

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MICRO/NANO TECHNOLOGY CENTER

**FY19**  
**Annual Report**

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**MNTC Personnel**



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Administrative Specialist**



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## **Executive Summary**

This document serves as the MNTC's official annual report for FY19 ending June 30, 2019. The University of Louisville's Micro/Nano Technology Center (MNTC) is a service center established in 2004 and consists of three facilities:

- The class 100/1000 \$30M 10,000 ft<sup>2</sup> cleanroom with processing equipment for the fabrication of novel thin film materials and devices.
- The Huson Imaging and Characterization Lab (HICL) is comprised of scanning electron microscopes (SEM), atomic force microscopes (AFM), mid-wave thermal imaging, Parylene C coater and wire bonding capabilities.
- The 300 ft<sup>2</sup> design/layout/simulation lab for MEMS and IC devices.

Together, these laboratories provide capabilities for researchers to perform a wide variety of micro and nanotechnology research. The University of Louisville faculty, academic institutions and external businesses utilize the facility for research, training and device prototyping.

## **Highlights:**

- \$19.6M funding utilized the MNTC for research.
- Overall revenue was \$282,867 for FY2019. External income was \$180,550 and \$102,317 for internal revenue.
- Both internal and external revenues dropped modestly of \$11,520 in comparison to FY18 (Internal revenue decreased \$8,185 and external revenue decreased \$3,335).
- The MNTC supported the 2018 KY Nano+AM Symposium held in July & August 2019.

## **Issues:**

- Infrastructure maintenance needs to be addressed. See below.
- Funding sources for staff need to be addressed.
- The MTNC would like to increase its user base. It has very limited control to do this activity for internal clients, but can has more latitude to pursue this activity for external users.
- SEM service contracts and replacement.
- DRIE imminent failure and replacement.

## Financials

The MNTC is utilized by both internal plus external clients and engineering personnel perform processing and characterization services as needed by clients. Figure 1 shows historical revenue data of the center since its inception in 2004. These data show a modest decline in overall revenue for the center, but growth of the center is still encouraging from a historical perspective.

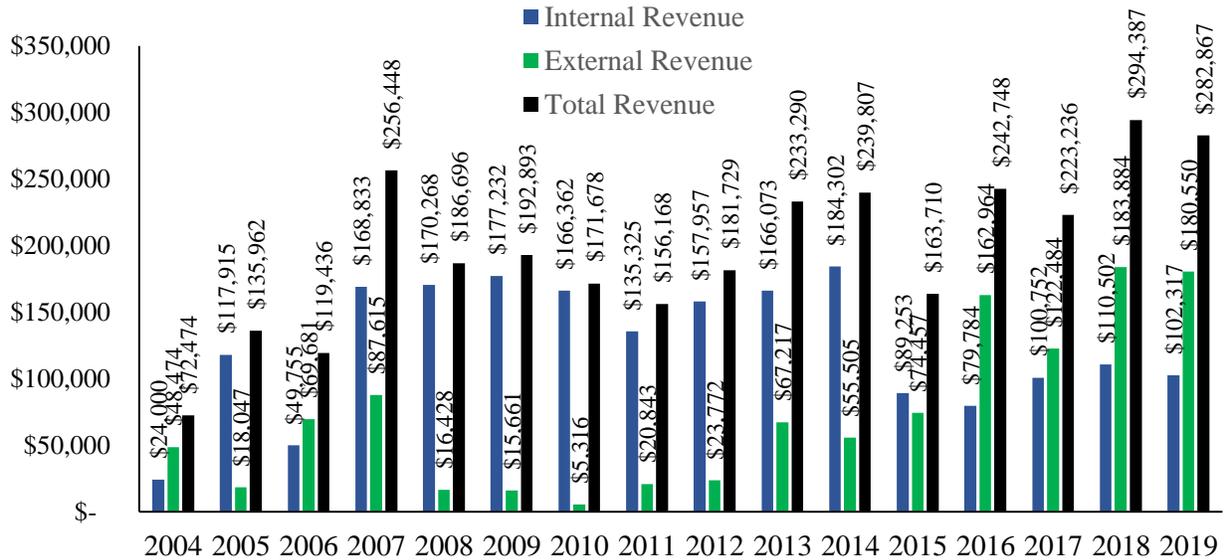


Figure 1. Internal and external revenue since the opening of the MNTC.

Figure 2 illustrates the percentage of internal versus external client revenue, which is similar to prior years. Partial reasoning for this difference are higher rates utilized by external clients and their tendency to utilize engineering personnel for service projects. The MNTC desires to achieve a closer percentage balance of 50% for each group and has made it an area of focus. Rates for the center are listed in the Appendix.

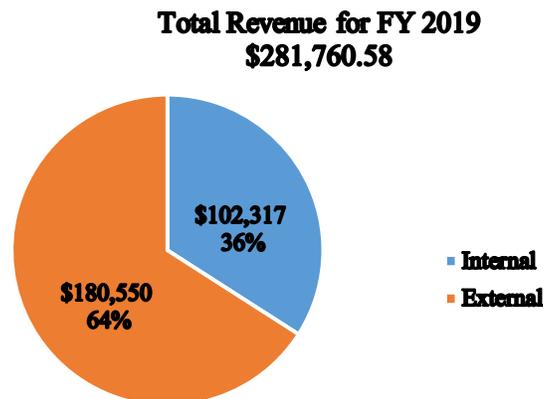


Figure 2. Total income from internal and external clients for FY 2019.

Tables 1 and 2 show an itemized breakdown of revenue for internal clients from the cleanroom and the Huson Imaging and characterization Laboratory, whereas a majority of revenue comes



Tables 3 and 4 are itemized listings of internal revenue categorized by department showing a large diverse group utilizing the center. The Electrical and Computer Engineering (ECE) Department was the largest contributing department at 30% of total percentage of internal revenue for both the cleanroom and the Huson Laboratory.

Table 3. Internal income for the Cleanroom FY 2019.

<b>TOTAL</b>	<b>84,701.21</b>	<b>100%</b>
BE	1,019.50	1%
BIO	180.00	0%
CHE	5,689.95	7%
CHEM	3,166.50	4%
CnCtr	256.50	5%
ECE	52,709.61	62%
CAP	3,000.00	53%
GAS	1,410.50	2%
IE	196.00	0%
ME	6,228.45	7%
Phy	355.50	0%
REU	10,488.70	12%

Table 4. Internal income for the Huson Laboratory FY 2019.

<b>TOTAL</b>	<b>16,509.87</b>	<b>100%</b>
BE	5,689.72	34%
BIO	271.00	2%
CHEM	1,214.50	7%
CHE	1,742.10	11%
ECE	4,960.00	30%
GAS	0.00	0%
ME	505.00	3%
CONN	400.00	2%
MISC	0.00	0%
PHY	307.25	2%
Pharm	0.00	0%
IE	0.00	0%
REU	1,420.30	9%

Table 6 displays revenue collected from external clients for both the cleanroom and the Huson Laboratory for a total of \$180,549.60. Company names have been removed to protect privacy.

Table 6. External clients for the cleanroom and Huson laboratory.

External Revenue	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	TOTALS
For Clients	10,758.73	11,436.33	16,213.49	26,927.87	8,638.58	16,866.40	33,087.85	5,449.45	24,067.52	15,941.89	(2,173.35)	13,334.84	180,549.60
xxx	1,691.20		1,357.75	1,243.60								352.10	4,644.65
xxx			3,915.00	4,735.75		7,830.00	11,745.00				7,830.00	3,915.00	39,970.75
xxx					199.50								199.50
xxx		200.00		1,190.00									1,390.00
xxx		1,845.60		5,135.25			8,623.42	474.00	3,718.50		3,689.85	1,305.00	24,791.62
xxx								39.60				50.00	89.60
xxx				3,499.00	625.88					(3,499.00)		4,157.64	4,783.52
xxx					200.00							775.00	975.00
xxx				836.00									836.00
xxx										589.00		2,281.10	2,870.10
xxx	1,900.00		1,500.00										3,400.00
xxx	1,849.35	1,892.38	1,327.05	1,312.00	121.60		3,063.43		950.16		3,324.29		13,840.26
xxx							1,015.45						1,015.45
xxx	68.00			136.00		102.00			34.00	68.00		34.00	442.00
xxx					2,209.00	2,944.00							5,153.00
xxx	3,947.00	3,001.85	3,031.20	1,921.40		1,655.10	2,492.55	134.00	1,867.60	407.10	372.00	270.00	19,099.80
xxx			2,585.25	3,314.25	4,487.50		1,952.55	195.00	1,514.13	1,548.13			15,596.81
xxx											244.50		244.50
xxx				1,582.38			600.00						2,182.38
xxx		4,163.50											4,163.50
xxx						500.00							500.00
xxx								633.38					633.38
xxx							115.50	166.50					282.00
xxx				300.00									300.00
xxx						500.00							500.00
xxx			474.24	722.24									1,196.48
xxx								185.68					185.68
xxx			400.00								241.75		641.75
xxx												195.00	195.00
xxx	390.00					195.00							585.00
xxx										200.00	370.00		570.00
xxx					795.10								795.10
xxx	2,073.18					1,851.60	2,583.15	3,618.68	5,474.13	3,812.26	1,972.26		21,385.26
xxx									400.00				400.00
xxx	(1,200.00)		1,250.00	1,000.00		1,288.70	896.80	2.61	10,109.00	12,816.40	(20,218.00)		5,945.51
xxx	40.00	333.00	373.00										746.00

**Facility Usage**

Previously mentioned the MNTC is utilized by both internal and external client users. Table 7 reflects entry into the cleanroom by clients and discipline with yellow highlights designated as external clients. The table does not include entries for services done by staff, camps, tours and other training where groups of students enter under a single instructor or TA. For FY 18 the total number of entries for the facility was 1,063 entries and shows a drop of 164 entries for FY 19. This would also support reasoning for why the amount of internal revenue dropped for FY 19.

Table 7. The number of entries into the cleanroom.

	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Total
EXT	2	2	4	2	1	1	2	2	1	1	2	1	21
EXT	4	3				1	2	1				3	14
ECE	9	3	3	7	11	10	13	4	3	2	2		67
EXT	6	16	3	17	32	14	12	11	6			5	122
CONN													0
ME	7		1	1						20			29
ECE									8				8
EXT							1				1	3	5
EXT	7	1			8			6	4	7	12		45
CHEM			2			1	1		1				5
ECE		8	1	9	10	3	6	3	8	10	2	2	62
CH	7	4	3	1		2		2	6	3	16	8	52
ECE	3	7	12	12	11				6	9			60
EXT	19	16	14	14	14	1		8	8	5	15	11	125
EXT											1		1
ECE	11	2	2	1			5	9	11	10	1	10	62
PHY													0
REU	38	2	2					2	13	22	23	29	131
ECE													0
BE	2			1									3
EXT	1	2	8	4		7	18			6	14	8	68
EXT											1		1
BE									1	2	1		4
EXT		1											1
ME	5		1	1	3			1					11
ECE							2						2
	121	67	56	70	90	40	62	49	76	97	91	80	899

Figure 3 shows the historical number of internal clients, faculty and external clients since opening of the facility. The primary indicator of this data is that while the number of clients increased overall in all categories, revenue did not increase proportionately as per the cleanroom entries listed in Table 7.

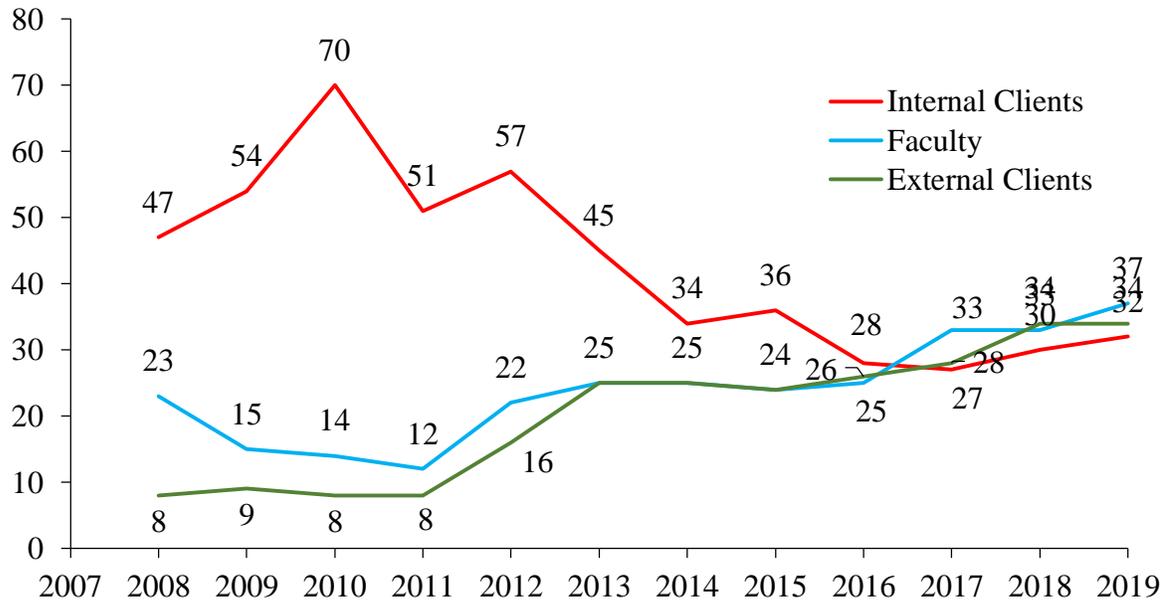


Figure 3. A tally of the number of internal users, faculty and external clients that utilized the MNTC.

Tool Usage is tabulated monthly for both the Huson Laboratory, Figure 4, and the Cleanroom, Figure 5. Other tools are utilized within both facilities, but are not connected to the FOM System to record the usage and is not captured. Work horse equipment from both facilities are the Supra SEM, Dektak Profilometer, DRIE, Lesker PVD 75 Sputterer, March RIE, Photoresist Spinners and Suss Mask Aligner. Service contracts exist on both SEMs while a 3<sup>rd</sup> party vendor services the Suss Mask Aligner each year.

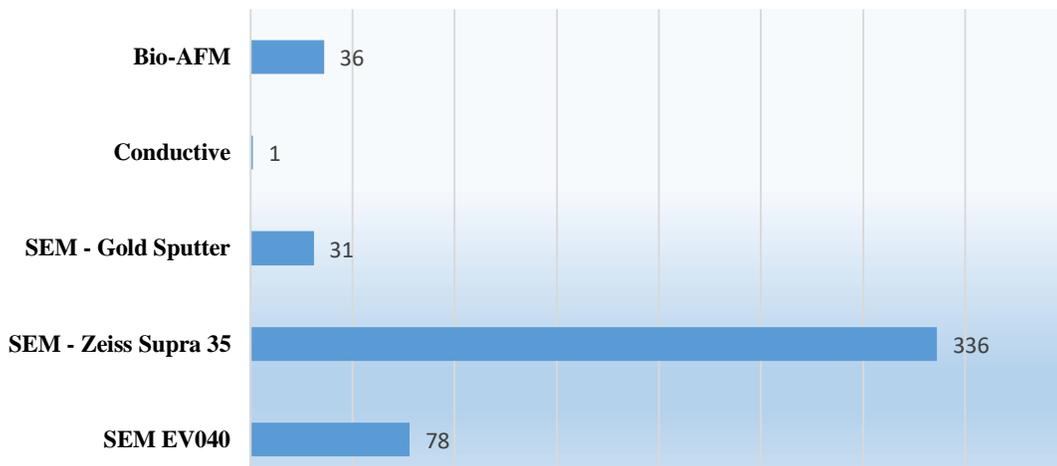


Figure 4. Huson laboratory tool usage for FY 2019.

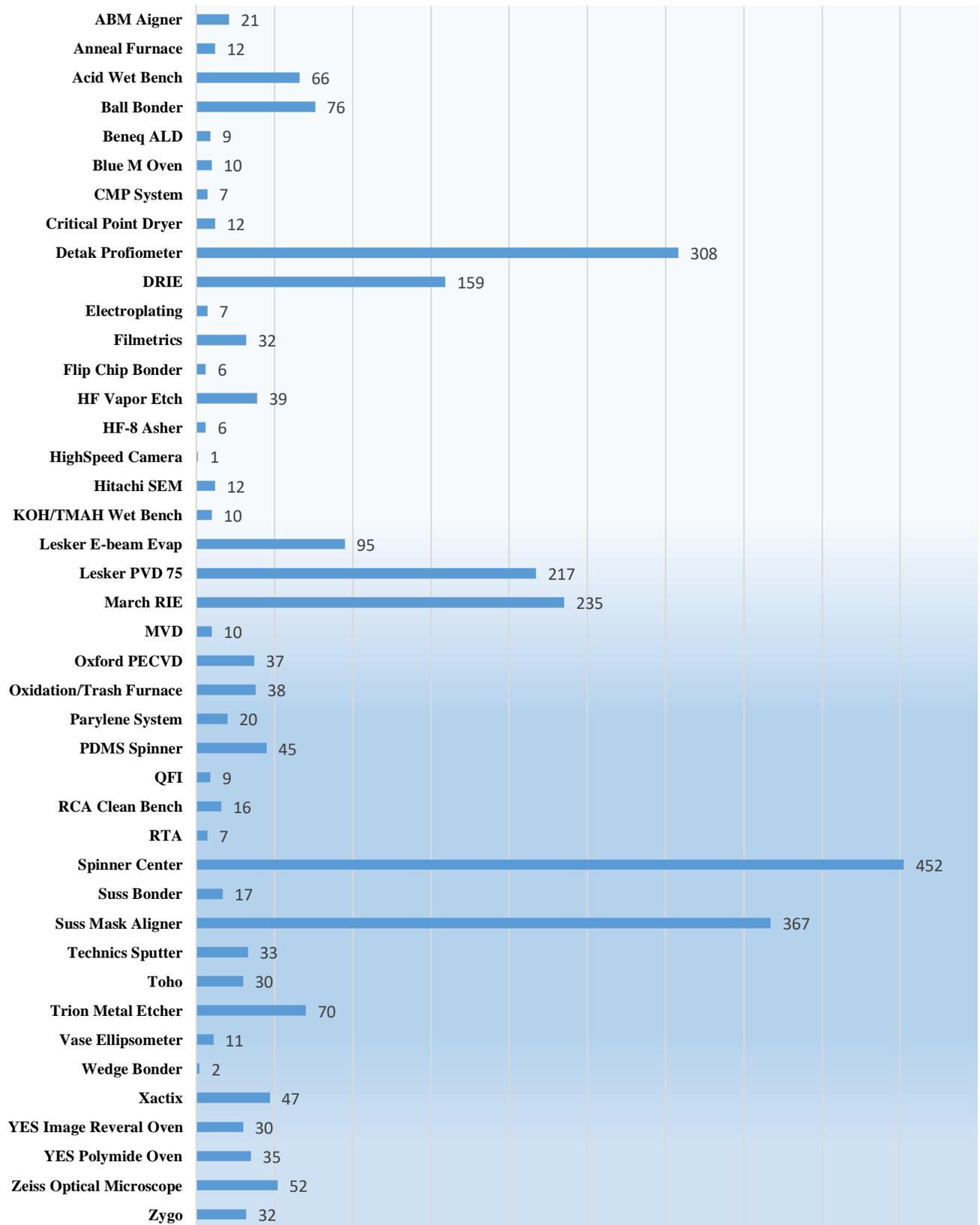


Figure 5. Cleanroom tool usage for FY 2019.

Table 8 is a compilation of grants and contracts utilized by faculty to conduct research that pays for access, service and equipment fees. Equipment fees are listed in the Appendix. These fees are used to maintain operations of the facility and its infrastructure. Not listed within the table are other funding sources that are not grants and contracts. Most of these awards were based upon availability of the MNTC that helped to award their proposals. Revenue collected for the center in comparison to award totals shows a leverage of 279%.

Table 8. Grants and contracts utilized by faculty in FY19.

<b>Speedtype</b>	<b>PI Name</b>	<b>Grant Amt.</b>	<b>MNTC Exp</b>
GB140779	Alphenaar	1,050,000.00	<b>14,642.35</b>
GB140348	Berfield	332,757.00	<b>1,909.10</b>
OICN130662	Dr. Abell (Doug Jackson)	511,000.00	<b>1,072.50</b>
GB140142D1	Sunkara - Druffel	1,392,500.00	<b>400.00</b>
GB161177J2	Srivastava	321,027.00	<b>597.75</b>
GB180260	Fu-Morris CR	226,587.00	<b>2,359.40</b>
CCDB151153	Fu-Zhenzhen	200,000.00	<b>3,342.60</b>
GB170358	Grapperhaus	450,000.00	<b>675.00</b>
GB160740	Harnett- CR	450,000.00	<b>5,400.75</b>
GB180796	Popa	1,530,219.00	<b>1,767.65</b>
GB140142C1	Harnett-Islam HL	508,874.00	<b>1,895.50</b>
GB160232	Walsh	374,398.00	<b>9,868.90</b>
GB180776	Kopechek SR	750,000.00	<b>676.00</b>
GB160493	Maurer HL	540,913.75	<b>463.50</b>
GB180776	Menze-Janis HL	750,000.00	<b>121.00</b>
GB140162	O'Toole HL	1,047,933.00	<b>2,223.02</b>
OIEN190151	O'Toole-Rajat HL	348,000.00	<b>1,335.00</b>
GB180796	Popa-Sherehiy HL	1,530,219.00	<b>853.50</b>
GB160972	Popa-Wei	863,232.00	<b>605.20</b>
GB170954	Popa-Zhong	747,259.00	<b>6,238.43</b>
GB170955	Popa-Zhong	1,530,219.00	<b>280.00</b>
GB131493D1	Running - Bao HL	60,000.00	<b>15.00</b>
OIEB171329	Starr-Vunnam HL	299,628.00	<b>962.50</b>
GB180729H2	Steinbach-Mahmoud HL	202,447.00	<b>178.20</b>
GB160042	Steinbach-Mohamed HL	423,500.00	<b>1,452.50</b>
GB151257	Walsh	1,272,164.00	<b>5,267.10</b>
GB140315A	Williams SR	225,000.00	<b>858.00</b>
GB151393	Williams-Rashed HL	253,500.00	<b>2,304.35</b>
GB150568	Worley-Gopinath LN	450,000.00	<b>135.00</b>
OIEB181307	Yang	36,986.00	<b>196.00</b>
GB170485	Yang-Yan HL	45,430.00	<b>205.00</b>
GB171268	Yoder-Himes LN	53,609.00	<b>90.00</b>
GB160551	Zamborini -HL	438,605.00	<b>1,513.50</b>
GB130558	Zamborini-Hkaul HL	390,000.00	<b>389.50</b>
		<b>19,606,006.75</b>	<b>70,293.80</b>

Figure 8 is a historical account of operating expenses of the facility since opening in 2004. Expenses for the fiscal year were second highest primarily due to purchase of a spare parts DRIE system from Case Western Reserve University for \$40,000. This was necessary since the existing DRIE system it is no longer supported by the vendor and critical spare parts are no longer available.

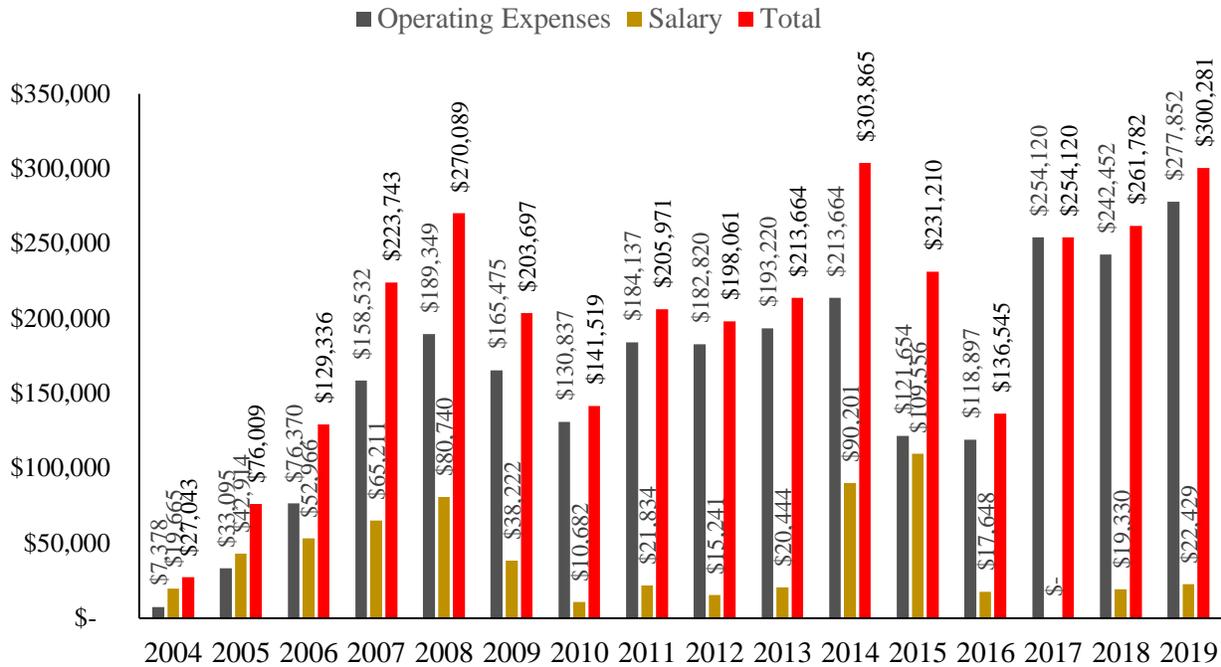


Figure 8. Operating and salary expenses since the since the opening of the MNTC.

Figure 9 is an itemized listing of expenses accumulated by category for FY19. As noted previously the \$40,000 acquisition of the DRIE system from Case Western Reserve University increased expenditures beyond typical expenses for the year. Without this expenditure the overall total would have been \$260,281 and typical of costs seen in FY17 and FY18. Of similar note, the Center’s salary expenses are were slightly increased from FY18.

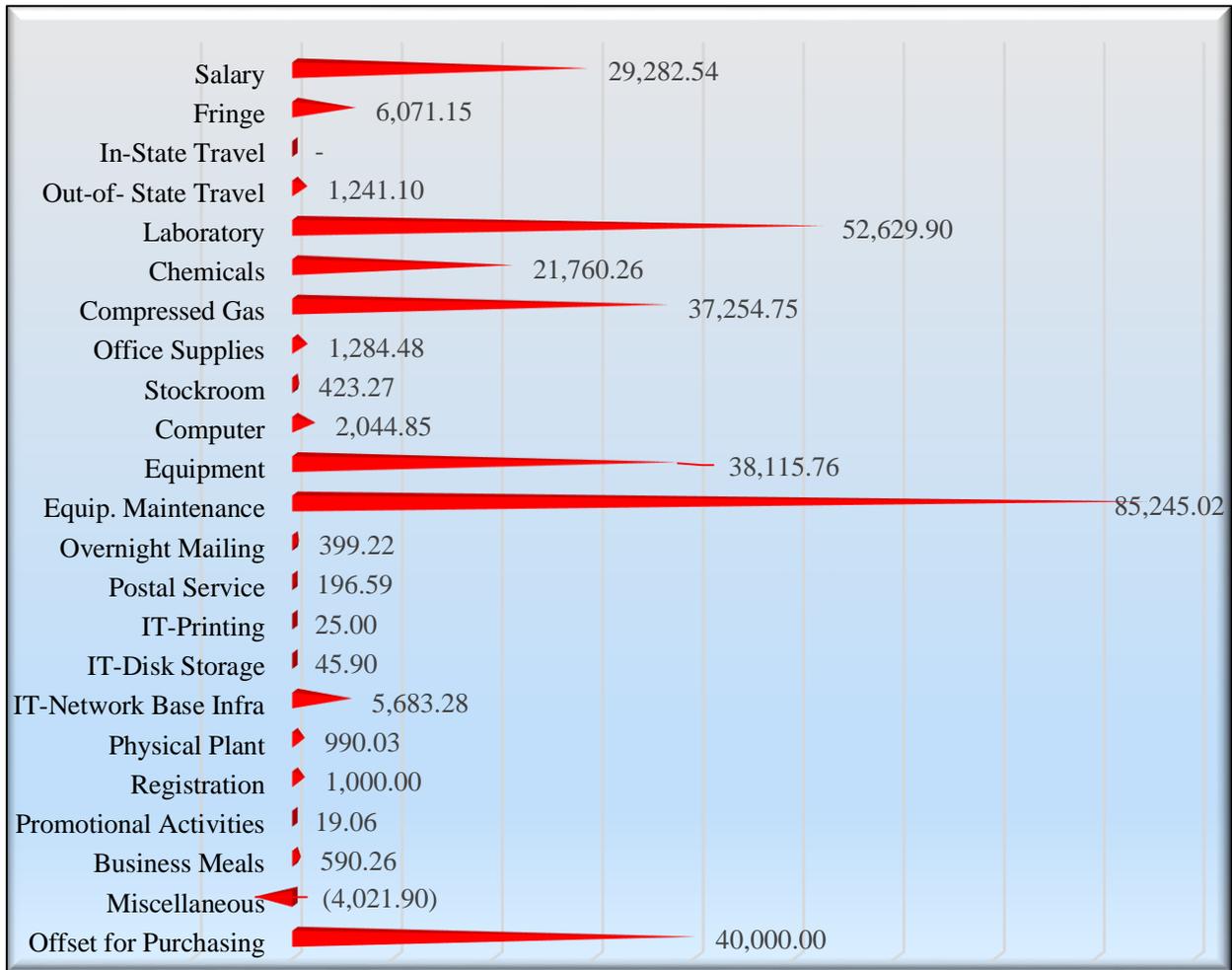


Figure 9. Operating and salary expenses of the MNCT for FY 19.

MNTC also supports work study students as it has for multiple years. Work study is a federal financial aid program that offers hourly employment to eligible students. This program helps students make connections gain valuable work experience, while pursuing a college degree. Each semester the MNTC requests three work study students to cover two positions within the cleanroom and one for administrative support. Students are trained in chemical safety, equipment maintenance and perform simple procedures on systems in the cleanroom. Work studies usually commit five to ten hours per week each semester and alternate semesters based upon co-op schedules. Experience gained by work studies in the MNTC is valuable in that it can assist their future endeavors. Work studies are not a financial responsibility on the MNTC and are thankfully provided by the University.

### **Ongoing Issues and Future Directions**

As the center ages its infrastructure costs continue to increase. Examples are the deionized water and filtration systems, air handling and exhaust systems, toxic gas monitoring and acid waste neutralization system. Each of these critical components keep the center operational and safe. As a result, additional funds were requested from the Deans' Office to help defer maintenance costs

for these systems along with other expenses. Discussions with the Dean's office brought fruitful fiscal assistance to keep these systems operational, of which the MNTC is grateful. However, it has been communicated that these expenses will continue to rise as the systems age and maintenance costs increase.

An additional item of ongoing concern is salary funding for engineering personnel. Each year the burden of providing salary assistance for existing staff continues to grow. It is preferred to return to the model where salary and fringe benefits were covered by the Dean's Office. Therefore, continuing discussions are ongoing as fiscal opportunities become open.

In order to help with increased utilization of the facility the MTNC would like to increase its user base. The Center has very limited control to expand its internal clients, but has more latitude to pursue this activity for external users. As a result, Customer Relationship Management (CRM) will be investigated to expand the external client base.

For equipment, plans for FY20 are to replace both SEMs in the Huson Laboratory due to the notification by the vendor to cease service contract offerings for both tools. Additionally, an NSF MRI proposal will be submitted to purchase a new DRIE in FY19 to avoid catastrophic consequences if the existing system fails again.



Hitachi SEM	\$1.00/min	\$1.50/min		
Xactix XeF <sub>2</sub> Isotropic Etching	\$1.00/min	\$1.60/min		
HF Vapor Etcher	\$1.00/min	\$1.60/min		
Beneq ALD	\$1.00/min	\$1.60/min		

	Equipment	Internal Rate	External Rate	Service Center Rate Internal	Service Center Rate External
	HF-8 Axic Barrel Asher	\$30/batch	\$45/batch	\$60/hour for training and labor (does not include tool rate)	\$100/hour for training and labor (does not include tool rate)
	Reynolds Electroplating Bench	\$30/batch	\$45/batch		
	Tube Furnace (Anneal, Oxidation, Diffusion)	\$40/batch	\$60/batch		
Wet benches	RCA Clean Hood (RCA Cleaning)	\$40/batch	\$60/batch		
	305 Acid Hood (Nanostrip, Aluminum Etch, Chrome Etch, BOE)	\$40/batch	\$60/batch		
	307 Base Hood (KOH, TMAH)	\$40/batch	\$60/batch		
	308 EDP Etch Hood (Gold Etch, Copper Etch)	\$40/batch	\$60/batch		
	YES Polyimide Oven	\$45/batch	\$70/batch		
	YES Image Reversal Oven	\$45/batch	\$70/batch		
	Parylene Deposition System	\$45/batch	\$70/batch		

### ADDITIONAL FEES

Fees	Internal Users	External Users
Training	\$60/hour	\$100/hour
Gold/Platinum Deposition	\$20/0.10 gram	\$35/0.10 gram
Dicing ( <i>Process performed by MNTC staff ONLY, Service fee included</i> )	\$60/1 <sup>st</sup> -hr flat rate \$1/minute after 1 <sup>st</sup> hour	\$100/1 <sup>st</sup> -hour flat rate \$1/minute after 1 <sup>st</sup> hour
Dewar Fill (LN <sub>2</sub> )	\$45/fill	N/A

Photomasks ( <i>Process performed by MNTC staff ONLY. Service fee is included.</i> )	Internal Users	External Users
4" substrates Resolution 6 um and larger	\$125	\$200
6" substrates Resolution 6 um and larger	\$225	\$300
CAD File Development	\$100/hour	

Usage fees are not assessed on these items.

Spin Rinse Dryers, Vacuum Ovens, Four Point Probe, Probe Station, Solvent Wet Bench, Developer Wet Bench (LF8-1A Solvent Develop Hood), Developer Wet Bench (115X Base Develop Hood), Spinner Benches (153X Hot Plate Spinner Combo), PDMS Spinner and Blue M Vacuum Ovens.

**HUSON IMAGING & CHARACTERIZATION LABORATORY (HICL)**

Equipment	Internal Rates		External Rates
SEM's (Supra and EVO)	\$50/hour	OR Monthly cap of \$500/month for each user	\$100/hour
AFM's (Bio and Conductive)	\$25/hour		\$40/hour
SEM Sputter Coater** **Doesn't included in the monthly cap	\$0.70/min		\$1.05/min
Training & Labor	\$60/hour for training and labor (does not include tool rate)		\$100/hour for training and labor (does not include tool rate)

**CONSUMABLES/SUPPLIES**

Item	Internal Rate	External Rate
Photoresist S1805, bottle 50 g	\$38	\$60
Photoresist S1805, bottle 100 g	\$53	\$80
Photoresist S1813, bottle 50 g	\$40	\$60
Photoresist S1813, bottle 100 g	\$56	\$85
Photoresist S1827, bottle 50 g	\$56	\$85
Photoresist S1827, bottle 100 g	\$78	\$120
Photoresist SPR 220-3.0, bottle 50 g	\$58	\$90
Photoresist SPR 220-3.0, bottle 100 g	\$81	\$125
Photoresist SPR 220-7.0, bottle 50 g	\$60	\$90
Photoresist SPR 220-7.0, bottle 100 g	\$84	\$130
Photoresist AZ4620, bottle 50 g	\$60	\$90
Photoresist AZ4620, bottle 100 g	\$84	\$130
Polyimide 2611, bottle 50 g	\$56	\$85
Polyimide 2611, bottle 100 g	\$78	\$120
4"Non-Oxidized Prime SSP Wafers	\$25/wafer	\$35/wafer
4"Oxidized Prime SSP Wafers	\$35/wafer	\$50/wafer
4"Non-Oxidized Prime DSP Wafers	\$35/wafer	\$50/wafer
4"Oxidized Prime DSP Wafers	\$45/wafer	\$63/wafer
6"Non-Oxidized Wafers	\$35/wafer	\$45/wafer
4"Bonafloat 33 Wafers	\$25/wafer	\$35/wafer
4"Wafer Container	\$4/each	\$6/each
4"Wafer Container Lid	\$4/each	\$6/each
Cleanroom Notebook	\$12/each	\$17/each
Metal Tipped Wafer Tweezers	\$50/each	\$70/each

Plastic Tipped Wafer Tweezers	\$50/each	\$70/each
Petri Dishes	\$3/each	\$5/each
Gel pack	\$8/each	\$12/each
Microscope Slides	\$5/box	\$7/box