Nanotools MicroFabrication Facility
Annual Report
June 2009 – May 2010

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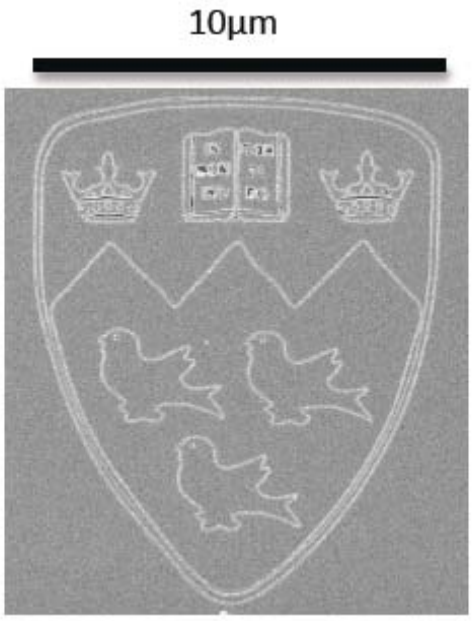
Prof. P. Grutter
Director,
Nanotools MicroFabrication Facility



Content

Executive Summary

In the fiscal year 2009-2010, usage and associated income is up (6600h, an increase of 52% with a user fee generated income of more than $142,000 – an increase of 82% !). For the first time since inception the McGill Nanotools Microfab is (barely) recovering operating expenses from user fees. The University continues to support the cost of manpower at 100%. The number of 'large' PIs (defined as PIs using the fab more than 100h per year) is dramatically up compared to last year, as are the number of publications (41 peer reviewed papers and 2 patents), industrially linked research grants (8) and graduated students with fab experience (28). The PIs acquired a total sum of more than 1.3 M$ in *new* grants and contracts directly linked to the fab in 2009/10! Particularly noteworthy is the NSERC CREATE in Integrated Sensor Systems (A. Kirk (PI) and 9 others), worth $1,650,000 (2010-2016).

This all points to a more intensive use of the McGill Nanotools Microfab, which is clearly becoming central to many, mainly recently hired, faculty in Engineering, Science and Medicine. Our outside user basis has also grown dramatically (+369%). The collected data presented in this report shows that we also have many old and new companies using the McGill Nanotools Microfab. One start-up resulted from work performed in the fab, a total of eight new companies are using the McGill Nanotools Microfab. What is interesting to note is that these companies access the McGill Nanotools Microfab via collaborative mechanisms such as NSERC Strategic projects or in other partnership agreements with McGill researchers. We conclude that companies are interested in the whole 'package': PI, HQP and access to excellent facilities. In 2009/10 the McGill Nanotools Microfab has upgraded its equipment with the addition of:

- A Deep Reactive Ion Etcher (Tegal SDE110)
- New set of wet benches (5) (SIC Bromont)
- An Ebeam Evaporator (Temescal BDJ1800)
- A spraycoater equipped with an additional EBR head and a non contact wafer chuck(EVG101)
- A variable angle spectroscopic ellipsometer (SOPRA GES5)
- A parylene coater (Specialty Coating Systems – Lab Coater)
- A vacuum oven for wafer priming and image reversal processes (Yield Engineering Systems)
- A contact aligner (OAI 200)
- A rapid thermal annealing oven (AGA Heatpulse 410)
- A probe station with 4 micromanipulators

From an operational point of view, the position of an Academic Fab Director was created with responsibilities for the overall strategy, oversight, and development of policies governing user access and fees. The day-to-day operation of the McGill Nanotools Microfab remains the responsibility of the fab manager. Prof. Peter Grutter (Assoc. Dean, Res. & Grad. Education, Faculty of Science) started this new position as Academic Fab Director in November 2009. He is supported by an Advisory Committee (Profs. D. Juncker (Medicine), Th. Skopek (ECE), S. Vengallatore (Mech. Eng) and Dr. M. Nannini (Fab

manager)). An external consultant analyzed the financial viability of the fab at the beginning of the fiscal year 2009-10. After a consultation process with all users, the adapted recommendations were successfully implemented.

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A clear trend is observable in all the data: the majority of users are from engineering, as is the research output. As an example, of the 23 fab graduates, 20 are engineers. This is a reflection of the fact that only engineering has faculty members with an exclusive, major focus on microfabrication. For science and medicine faculty members access to the fab is important and is in many cases crucial for their research, however they are not major users in terms of time or money spent in the fab. Also, often, life science related projects are performed in collaboration, where engineers are responsible for the microfabricated device. The microfab is thus a focal point bringing together various disciplines – a 'watering hole' as envisioned in the original CFI Nanotools application in 1999.

Organization

Academic Oversight

In November 2009, the position of Academic fab director was created. The academic fab director is responsible for:

- updating or creating policies
- supporting training and teaching opportunities
- enabling scientific and technological development
    1. Taking advantage of available expertise and capabilities (active/passive 'matchmaking')
    2. Identification of needs and what to do about it
    3. Coordination of capital equipment grants (CFI)
- developing in- and outreach initiatives
- ensuring financial stability of the fab
- evaluation of fab personal
- receiving and following up on suggestions and complaints about fab operations
- generate an annual report (accountability, transparency and information)

To achieve these goals, the academic director is supported by an Advisory Committee (AC). The AC provides feedback to the fab director, but has no executive decision power, which rests with the fab director.

Academic fab director:	Prof. Peter Grutter, Assoc. Dean of Res. & Grad. Ed. (Faculty of Science).
Advisory Committee:	Prof. David Juncker (Medicine)
	Prof. Thomas Skopek (ECE)
	Prof. Srikar Vengallatore (Mech. Eng)
	Dr. M. Nannini (Fab manager)

Achievements

Following a list of activities initiated by the fab director. These initiatives were identified by a selection of major fab users as priorities and as a consequence led to the establishment of the position of Academic fab director. The general philosophy guiding these initiatives and policies is to provide transparent and fair access to all users (major and casual, academic and industrial) and to nurture the vision of a shared fab community where all users share responsibility, information and training.

In the following a list of achievements accomplished in 2009/10

1. Organized annual fab user meeting, held 22.2.2010 with more than 50 participants.

The aim of these meetings is to build and sustain the fab community, facilitate personal interactions, enable the exchange of information, and provide a forum for consultation between the fab team and users. Policies and procedures were discussed (and if necessary adapted).

The first meeting was a combination of posters by students, talks by Dave Danovitch (IBM Bromont), Mourad El-Gamal (McGill University, ECE) and David Juncker (McGill University, Biomed. Eng.) as well as a information/discussion forum to present the new fab management structure as well as inform about the change in user fee structure.

2. The following policies were developed, communicated and implemented :
    - New user fee structure
    - Consequences for major misbehaving in fab (e.g. leaving the workplace in a mess, not reserving equipment, etc.)
    - After hour access to fab (buddy system, no HF, OK from fab staff)
    - Getting rid of obsolete equipment in the fab
    - New equipment in the fab
    - Glassware in the fab

3. Annual evaluation of all fab staff:
    1. auto evaluation
    2. evaluation by supervisor according to job description

All these initiatives were a joint effort by the AC and the fab operation staff, in particular the fab manager. In addition, a new web site was implemented by the fab team.

Major new policies

1. Obsolete and new tools:

The fab and the needs of users continuously evolve. One needs to establish policies for the removal of obsolete tools and the selection and incorporation of new tools. The guiding philosophy is:

- maximize usage and impact of tools in fab
- minimize operating costs (new equipment expected to be at least cost neutral)
- attempt to generate reasonable revenues for fab when disposing of unused equipment

The Academic Fab director makes the final decision of what new equipment goes into the fab after consultation with the users, the AC and fab staff.

Following a summary of the relevant policies:

1. Obsolete tools – or how to determine what one can get rid of:

1. What was tool usage in past 2 years? -> identifies equipment not used, but taking up resources.
2. Inform of potential removal of tool. Get feedback from users (PIs) at 2 fab meetings and by email. This allows us to evaluate future anticipated usage and gives a buffer of 1 year before a tool is finally removed.
3. The removed tools are disposed of according to regular McGill policy.

2. New equipment policy:

Before the bi-annual fab user meeting users are asked to submit any indication if one is planning on new equipment that should go into the fab, planning on new hires in departments, etc. At the user meeting all users and fab staff discuss what needs to go in the fab, what should go in a 'private' lab. This process is necessary as the fab floor space is used to capacity, new equipment can only be brought in if an obsolete tool is first removed.

Equipment in the fab belongs to the fab. PIs who generated the grants for the equipment will not receive an extra deal in terms of access or user fees; they pay regular user fees. Benefit to the PI who brings in new equipment is free maintenance of the equipment and training by fab staff.

2. Fee structure:

The details of the new pricing structure, implemented on Feb 1st, 2010, are the following:

1. The **Facility Fee will be set at a base-rate of $40/hour starting on February 1, 2010.** It will then increased to **50 $/hour on June 1, 2010**.

2. A 15% consumable surcharge will be added to Facility Fees **on equipment requiring consumables**. (e.g. TMAH etching, photo resist, sputtering tool, etc).

3. **$ 0.50 per nm of deposited precious metal** (Au, Pd, Pt) is charged instead of the 15%. This applies to the ebeam evaporator and the sputterer.

4. Soft Cap:
The new pricing structure is based on a single hourly base-rate per student:

1. **Single PI/ 1-3 students** –For each student (1-3), the PI will be charged the full Facility Fee for the first 25 hours of the month. For subsequent use, each hour will be charged at 25% of the Facility Fee for the remainder of the month.
2. **Single PI / 4 students or more** - For PIs with 4 or more students working in the fab the PI will be charged the full Facility Fee for the first 50 hours logged collectively by all his/her students per month. For subsequent use, each hour will be charged at 25% of the Facility Fee for the remainder of the month.

Note that the number of students per PI is defined as the number of students who used the fab in a given month.

5. Industrial users:
The Facility Fee for **industrial users** will be $100/hour plus consumables and the McGill overhead charges.

As in the past, we will have to continue to charge a 1.5% overhead on all bills (this is clawed back by the Provost).

Billing periods:
There will be four billing periods per year (three months each). We will make the exception that the first two months (Feb and Mar 2010) will be billed per month to monitor changes in individual bills.

The February 1st change will allow us to recuperate about 40% of the cost of operating the fab, the June 1st increase will increase this to a 50%. We need this level of user support to convince the University to continuing supporting the fab at the current level of $260,000 p.a.

The new pricing applies to all academic users (McGill or non-McGill). Any other additional service such as technical support, engineering etc. is invoiced at an hourly rate of $60.

We have run simulations of the consequences of these new fees based on historic usage. After June 1st the major users will see fees increase by approximately 50% (or roughly $5,500 for the top major user). While this is a significant increase, the additional revenues will help sustain the overall financial viability of the facility.

3. Fab misuse – penalties for breaking the rules:

With increased usage a policy with respect to non-adherence to rules pertaining to safety, environment, tool mistreatment or usage of tools without reservation (upon which billing is based) needed to be developed. Observed infractions include equipment mishandling (e.g. leaving resist residues in the spin coater or ramping up the voltage too fast on the ebeam writer), safety (e.g. safety equipment not worn or bottles not labeled), environment (disposal of acids and solvents!) or after-hours usage of equipment.

If a serious rule infraction is discovered, the fab manager discusses the issue with the users and his supervisor. The aim is to initiate a change of behavior. In addition, the following rules apply without exception:

- 2 weeks for 'basic' infractions, decided by Fab. Director (after talking to the parties involved).
- 4 weeks if there is a major impact for other users (e.g. down time of a crucial tool). In 'major' cases it is the committee that makes the decision after due process (i.e. talking to all parties involved with the aim of ensuring that the rule breaker was correctly identified). Safety and environment are major offenses.
- Repeat offense double time.
- Public announcement of penalty for offense as deterrent. (posted at tool without name of offender)

Update on Manpower and Equipment

Operation Staff

Fab Manager: Dr. Matthieu Nannini

Technologist: Don Berry

Pierre Huet (not renewed end of June, 2010)

Equipment technologist

John Li (hired in June 2010)

Changes in Tools

The following pieces of equipment were deemed obsolete by the community and are in the process of being removed:

- Laminar flow hood (still looking for new home)
- X-ray fluoroscope (given to undergrad lab in physics)
- Stepper (after intensive efforts no buyer was found, dismantled August 2010)

The following pieces of new equipment were purchased and commissioned in 2009-2010:

- A Deep Reactive Ion Etcher (Tegal SDE110) - commissioned
- New set of wet benches (5) (SIC Bromont) – commissioned
- An Ebeam Evaporator (Temescal BDJ1800) – commissioned
- A spraycoater equipped with an additional EBR head and a non contact wafer chuck(EVG101) – commissioned
- A variable angle spectroscopic ellipsometer (SOPRA GES5) – commissioned
- A rapid thermal annealing oven (AGA Heatpulse 410) – commissioned
- A parylene coater (Specialty Coating Systems – Lab Coater) – Installation in progress
- A vacuum oven for wafer priming and image reversal processes (Yield Engineering Systems) – Installation in progress
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- A probe station with 4 micromanipulators– Installation in progress

Outcomes: Publications, HQP and Grants

Summary

Nearly all outputs quantifiable with reasonable effort show a dramatic increase as compared to 2008/09. 41 publications (21 in 2008/09), 2 patents (7), 28 HQP graduated with a project that had a major fab component (data not available in 2008/09) and 8 companies (3).

Publications (including Patents and Disclosures)

In 2009/10 at least 41 peer reviewed publications and 2 issued patents resulted from work with an intensive fab component (some of the minor fab users did not provide an annual report). At least 31-5-5 is the distribution among Engineering-Science and Medicine. This is a substantial increase compared to 2008/09 (21 publications, with a 18-1-2 distribution in 2008/09). Appendix A gives the detailed titles, authors and references.

Graduated HQP

The total number of HQP trained in the fab has increased from 57 (2008/09) to 64 in 2009/10. What is remarkable is the large number of students who graduated with a major component of their work being performed in the fab (see appendix for details). Again, these numbers are underestimates, as not all PIs provided a report. In the following the numbers in brackets indicate the distribution across engineering-science and medicine. Undergraduates: 5(5-0-0), Masters: 10(8-2-0), Ph.D.: 6 (6-0-0), PDF: 2 (1-1-0).

Research Grants acquired due to access to fab

The total of ***new*** grants and contracts directly linked to the fab had a value of **$ 1,339,826 in 2009-10.** In 2009/10 the PIs of these grants were almost exclusively from the faculty of engineering, although several were in collaboration with science or medicine.

The biggest and most important success for the fab was the NSERC CREATE in Integrated Sensor Systems, PI-ed by A. Kirk and 9 others, including members from INRS, Ecole Polytechnique and Sherbrooke. This training grant is worth $1,650,000 (2010-2016) and is expected to fund graduate students starting fall 2010.

Budgetary report

Fiscal year 2010: June, 1st 2009 to May 31st 2010

Summary

Total expenses	Total invoiced	Difference
147 748,18 $	142 049,87 $	- 5 696,31 $

History

	Total expenses	Total invoiced	Difference
FY08	137 038,35 $	83 184,13 $	- 53 854,22 $
FY09	115 529,12 $	77 432,85 $	- 38 096,19 $
FY10	147 748,18 $	142 049,87 $	- 5 696,31 $

Expenses Details for FY10

	FY10	FY10	FY09	FY08
PM-Repair: includes equipment and facilities repair expenses	20 192,53 $	14%	18.3%	41.3%
Consumables: includes chemicals (acids, solvents, litho…), materials, substrates, N2 (25k) …	56 197,88 $	38%	40.5%	25.6%
External: includes mainly shipment to other univ.	1 028,48 $	1%	0.3%	1.6%
Office: includes NCS charges, computer and office supplies	14 285,75 $	10%	5.3%	2.5%
CRMaint.: includes cleanroom cleaning, laundry, supplies and DI Water maintenance.	41 018,51 $	28%	33.5%	19.6%
Clients: includes expenses for clients when subcontracting is needed	5 203,45 $	4%	0.3%	0%
MDEIE: expenses related to MDEIE equipment installations	7 425,20 $	5%	-	-
Facilities Eq. purchases: includes pieces of equipment bought from operating funds to be used in the service area	244,10 $	0%	1.8%	8.8%
Travel	1 804,22 $	1%	0%	0%
Uncategorized	348,06 $	0%	0%	0%

Comments:

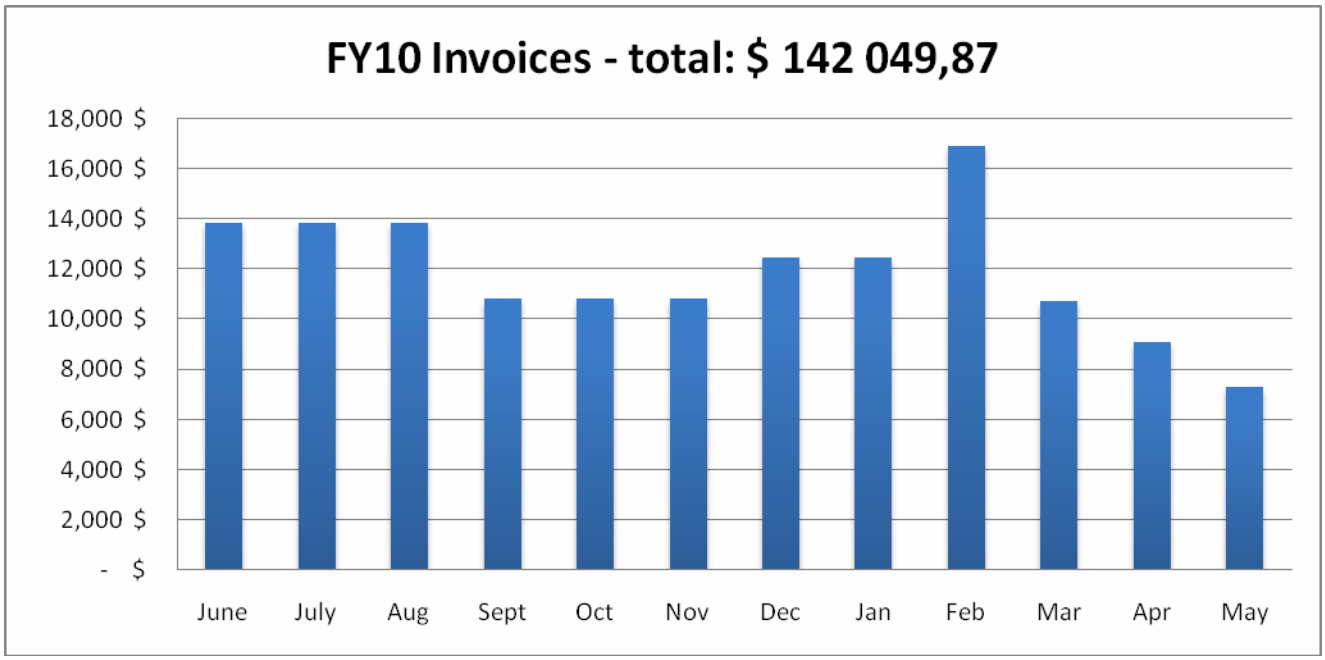
- The MDEIE expenses category relates to all extra expenses that were necessary for the installation of all equipments purchased with the MDEIE fund. This might explain the 7 000$ negative balance at the end of fiscal year 2010. This number is more than likely underestimated as not all minor expenses where tracked and ended up being accounting for in the PM-Repair category.

Revenues

Reminder: as of February 1st, 2010, fab fees were set to 40$/h regardless of equipment used. This will be increased to 50$/h starting June 1st of the same year. In addition, a soft cap (instead of the previous hard cap) was implemented.

Details @ http://miam2.physics.mcgill.ca/?q=content/rates

The following chart summarizes revenues for FY10:



Comments

A quick look at the graph reveals a steep decrease in fees starting in March. This could be attributed to the Electron Beam Writer which was down since February (power supply/climate control issue).

Usage

In 2009/10 the microfab generated more than 6600h billable hours – an increase of more than 2300 h (+52%) compared to 2008/09 period! A very positive development is the increase in major users (defined as PIs who use the fab more than 100 h per year). We now have 14 major users, including 3 users with more than 1000h! This demonstrates that the user basis of the fab is now much broader and thus more sustainable than in previous years. These PIs sent a total of 64 HQP to work in the fab, up from 57 (+12%) in FY 2008/09. One can conclude that the time spent per HQP in the fab has increased (on average) from 75h to 103h, thus graduating HQP with more fab intensive experience.

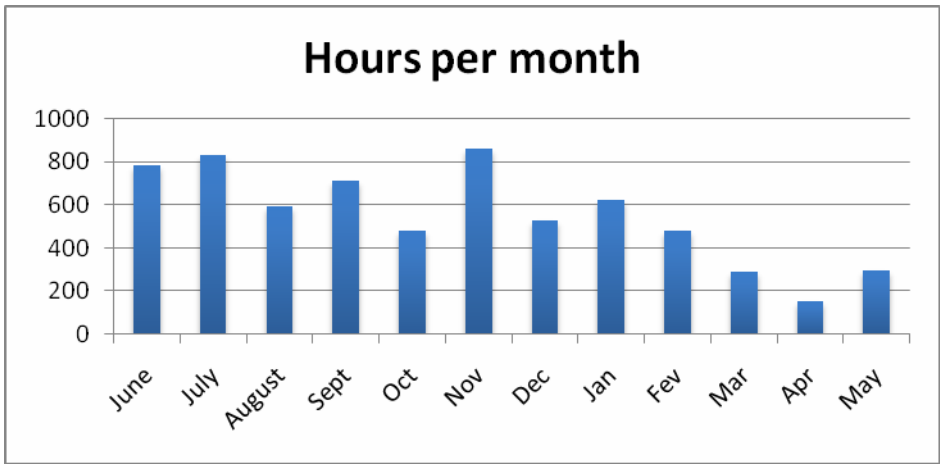


Figure 1 Billed hours per month in FY 2009/10. The decrease starting in March is due to the downtime of the ebeam writer.

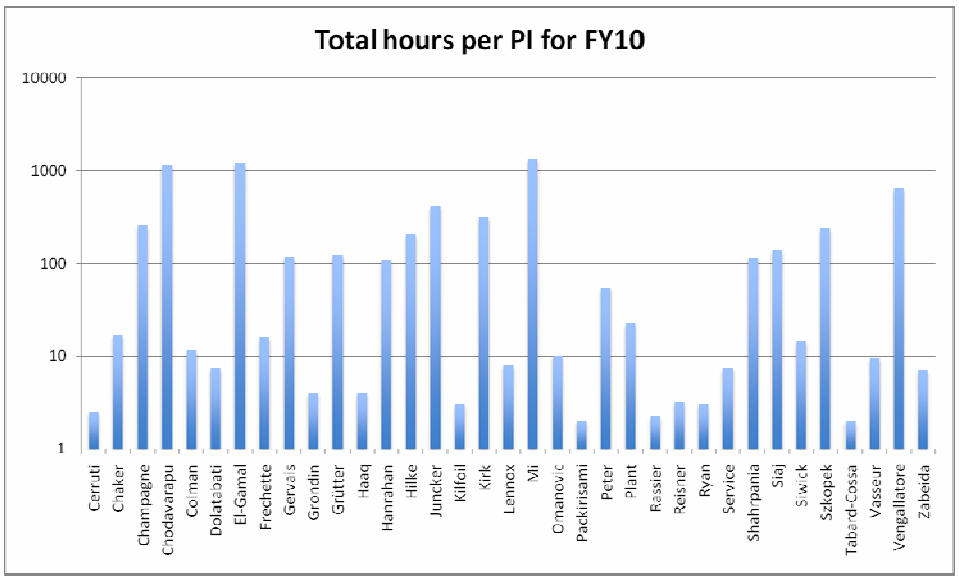
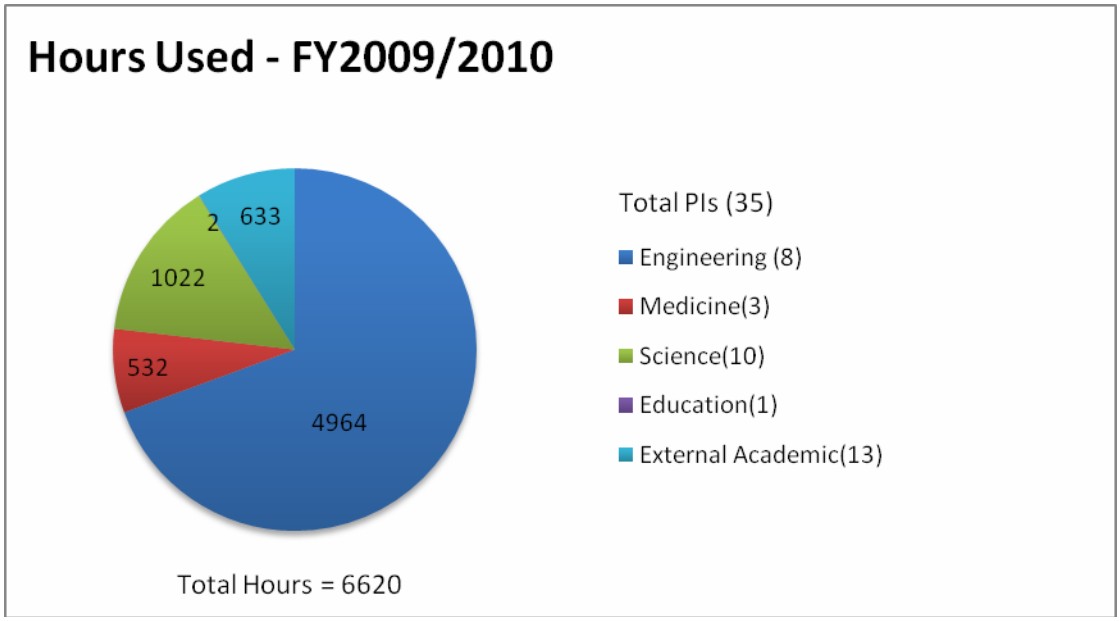


Figure 2 Total hours per PI for FY 2009/10. Note the broad, sustainable basis of major users with more than 100h.

Usage breakdown according to faculties:

The major user in terms of hours is the faculty of Engineering. Medicine, Science and external users are similar, each about 10-20% compared to engineering. Major increases in usage were observed for Engineering (+2158h, +77%), Science (+225h, +85%) and external users (+498h, +369%). The usage by medicine has dropped substantially (-564h, -51%), in part due to collaborations with Engineering and Science PIs. The total number of PIs has not changed significantly.



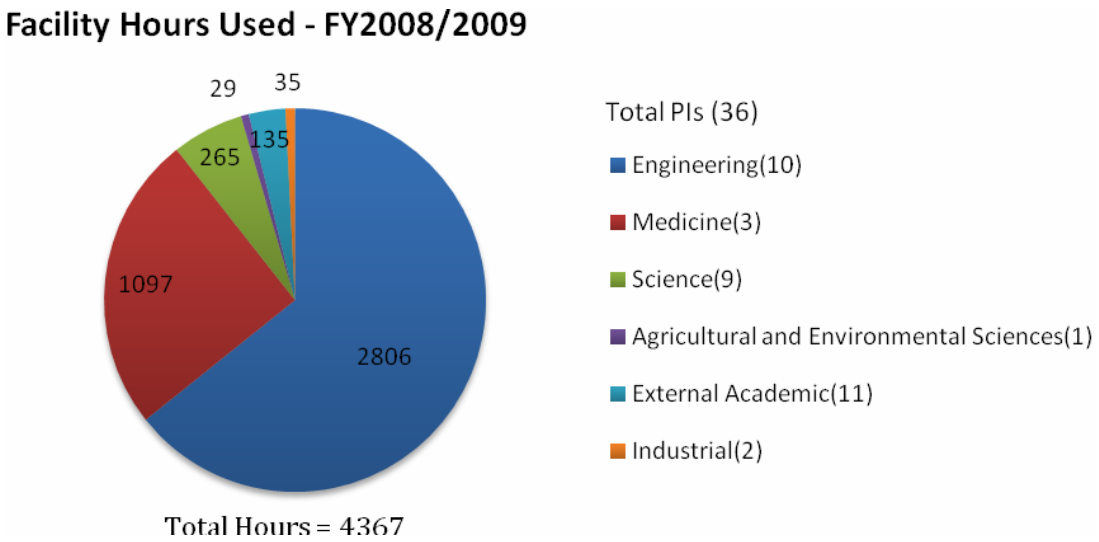
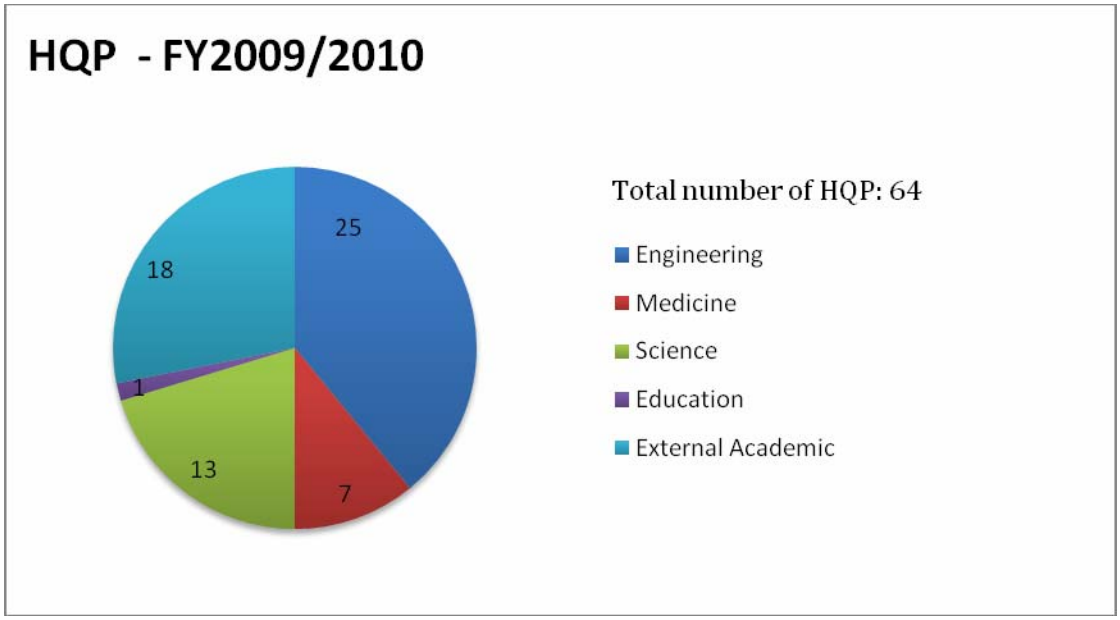


Figure 3: Breakdown of hours of Fab facility usage for fiscal years 2008/2009 and 2009/2010. The number of principal investigators (PIs) for each category is also given in brackets. PIs affiliated with the Faculties of Engineering are major users, with Medicine, Science and external usage also noteworthy.



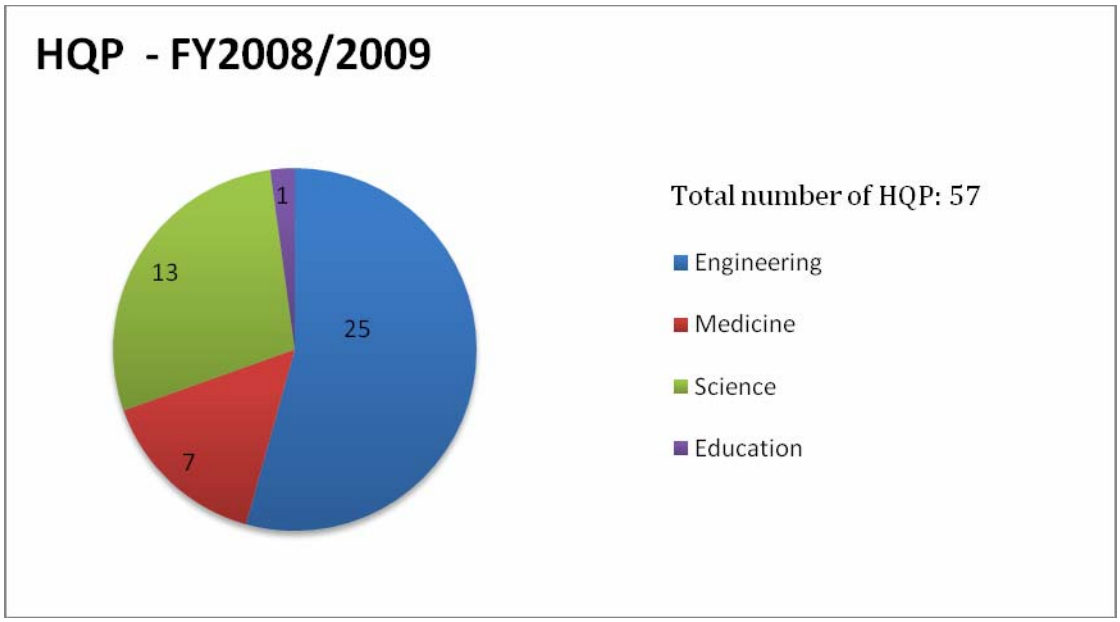


Figure 4: Number of HQP using the Fab for fiscal years 2008/2009 and 2009/2010, broken down by Faculty affiliation. There has been a 12% increase in HQP using the Fab in the last fiscal year.

Industrial Usage:

We observed that companies are not very interested in directly accessing the fab. A strong increase in academia-industry collaborations and partnerships leads to the conclusion that companies prefer to access the McGill Nanotools Microfab via collaborative mechanisms such as NSERC Strategic projects or in other partnership agreements with McGill researchers instead of directly using it. This is corroborated by informal and non-representative discussions with several companies: they are interested in the whole 'package': PI, HQP and access to excellent facilities. In one case (Boston Microsystems) the attractive cost structure as compared to fabs in the Boston area was an important factor in deciding to engage in a collaboration at McGill.

The following companies have used the fab in 2009/10: (collaborating PI indicated in brackets)

MEMS-Vision Inc. is a spin-off company from McGill (Mourad El-Gamal).

Boston Microsystems (Research collaboration, Srikar Vengallatore, Mourad El-Gamal)

General Motors of Canada, Inc. (Strategic Grant and Collaborative Research Grant, both S. Vengallatore in collaboration with Prof. Luc Frechette at Universite de Sherbrooke. The combined value of these grants is about $1 million over four years (2008-2011)

Bombardier and Thales (industrial sponsors of a CRIAQ project entitled "Data Networks and Smart Sensors for Safety-Critical Avionics Applications". Mourad El-Gamal)

Reflex Photonics Inc. (Montreal) committed in-kind support for NSERC Strategic grant entitled 'Direct integration of microtube lasers on silicon ' (PI Andrew Kirk, with Z Mi and D.V. Plant), $136,000 per year of funding from NSERC (2009-2011)

DALSA Semiconductor (Bromont) has committed $20,000 per year of funding as part of a NanoQuebec project entitled 'Integrated polymer electro-optic switches', (PI Andrew Kirk, with Mark Andrews), leveraging $66,667 per year of funding from NanoQuebec (2010-2012)

ICP Solar Technologies and Silonex Inc.
Full-Solar-Spectrum InGaN Tandem Solar Cells on Si (Z. Mi)

DNA LandMarks Inc.
Ultrasensitive InN Nanowire Biosensors (Z. Mi, P. Grutter, R. Sladek)

Organizations with which the fab has had service agreements in the past 2 years are:

INO (Quebec City), Semiconductor Insights (Ottawa), Microbridge (Ottawa), Reflex Photonics (Montreal), Acculine Micro (Vermont). The fab was used mainly for proof of principle demonstration. Once established, processes were transferred to the clients, usually by the clients.

Appendices

Papers 2009-2010 that used some aspect of the McGill Microfab:

1. L. Yao, K. Y. Yung, R. Khan, V. P. Chodavarapu, F. V. Bright,
   "CMOS Imaging of Pin-Printed Xerogel based Luminescent Sensor Microarrays,
   In Press, IEEE Sensors Journal, 2010.
2. M. Hajj-Hassan, M. C. Cheung, V. P. Chodavarapu,
   "Dry Etch Fabrication of Porous Silicon using Xenon Difluoride",
   Micro & Nano Letters, Vol. 5, pp. 63-69, 2010.
3. Neutron powder diffraction determination of the magnetic structure of Gd_3Ag_4Sn4 J.M. Cadogan, D.H. Ryan, M. Napoletano, P. Riani and L.M.D. Cranswick, J. Phys.: CM **21** (2009), 124201(8)
4. Coexistence of long-ranged magnetic order and superconductivity in the pnictide superconductor $SmFeAsO_{1-x}F_x$ (x=0, 0.15) D.H. Ryan, J.M. Cadogan, C. Ritter, F. Canepa, A. Palenzona and M. Putti, Phys. Rev. B**80** (2009), 220503(R)
5. M. Hajj-Hassan, S. J. Kim, M. C. Cheung, L. Yao, V. P. Chodavarapu, A. N. Cartwright,
   "Porous Silicon and Porous Polymer Substrates for Optical Chemical Sensors",
   In Press, SPIE Journal of Nanophotonics, 2010.
6. M. Hajj-Hassan, V. P. Chodavarapu, S. Musallam,
   "Reinforced Silicon Neural Microelectrode Array Fabricated using Commercial MEMS process",
   SPIE Journal of Micro/Nanolithography, MEMS, and MOEMS, vol. 8, 033011, 2009. (Selected for Virtual Journal of Biological Physics Research, vol. 18, iss. 3, August 2009)
7. S. Prabhakar, F. Nabki, M. El-Gamal and S. Vengallatore,
   "Measurement and analysis of structural damping in silicon carbide microresonators,"
   Materials Research Society Symposium Proceedings, vol. 1139, pp. 47-52 (2009)
8. S. Ibasco, F. Tamimi, R. Meszaros, D. Le Nihouannen, S. Vengallatore, E. Harvey, and J. E. Barralet
   "Magnesium-sputtered titanium for the formation of bioactive coatings,"
   Acta Biomaterialia, vol. 5, pp. 2338-2347 (2009)
9. G. Sosale, S. Prabhakar, L. Frechette and S. Vengallatore ,
   "Effect of thin aluminum coatings on structural damping of silicon microresonators,"
   Materials Research Society Symposium Proceedings, vol. 1222, article DD01 (2010)
10. H. S. Skulason, P. E. Gaskell and T. Szkopek,
    ``Optical reflection and transmission properties of exfoliated graphite versus thickness from a graphene monolayer to several hundred graphene layers'',
    to appear in Nanotechnology
11. E. Ledwosinska and T. Szkopek, `
    `A floating gate double-quantum well far-infrared photoconductor'',
    Proc. SPIE, vol. 7601, January 2010.

12. S. A. Imam, S. Sabri and T. Szkopek,
``Low-frequency noise and hysteresis in graphene field-effect transistors on oxide'',
Micro and Nano Letters **5**, 37 (2010).
Selected as the featured article of Micro and Nano Letters in month of publication.

13. S. Sabri, P. Lévesque, C.M. Aguirre, J. Guillemette, R. Martel and T. Szkopek,
``Graphene Field Effect Transistors with Parylene Dielectric'',
Appl. Phys. Lett. **95**, 242104 (2009).
Tenth most downloaded Appl. Phys. Lett. in month of publication.

14. M. A. Taghvaei, P.-V. Cicek, K. Allidina, F. Nabki, and M. N. El-Gamal,
"A MEMS-based temperature compensated vacuum sensor for low-power monolithic integration,"
IEEE International Symposium on Circuits and Systems (ISCAS 2010), Paris, France, May 2010.

15. F. Nabki, K. Allidina, F. Ahmad, P.-V. Cicek, and M. N. El-Gamal,
"A highly integrated 1.8 GHz frequency synthesizer based on a MEMS resonator,"
IEEE Journal of Solid-State Circuits, pp. 2154 - 2168, August 2009.

16. P.-V. Cicek, S. Mahdavi, F. Nabki, and M. N. El-Gamal,
"Low actuation voltage silicon carbide RF switches for MEMS above IC,"
IEEE 16th International Conference on Electronics, Circuits, and Systems (ICECS'09), Dec. 2009.

17. Allidina, M. A. Taghvaei, F. Nabki, P.-V. Cicek, and M. N. El-Gamal,
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41. Invited: Z. Mi and Y.-L. Chang,
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Patents:

1. Localized Multiple Measurand Solid State Brain Probe,
M. Hajj-Hassan, V. P. Chodavarapu, and S. Musallam,
United States Provisional Patent 61/222,525. Filed July 2, 2009.

2. Low Temperature Ceramic Microelectromechanical Structures
Mourad El-Gamal
- US Provisional Patent Application 61/129,644, July 9, 2008.
- PCT International Patent Application PCT/CA2009/000931, July 8, 2009.

Graduated HQP:

Undergraduates:

1. Josue Robinson (ECE)
2. Ahmed Korayem (ECE)
3. Tanmoy Saha (ECE)
4. Ali Akeel (ECE)
5. Hamza Bari (ECE)

M.Sc/M.Eng:

1. Amir Mohsen Aliakbar ECE
2. P. Gaskell (ECE)
3. E. Ledwosinska (ECE)
4. Hassan Shahriar (Mech)
5. S. Sabri (ECE)
6. H. Skulason (ECE)
7. Dominique Lemoine (ECE)
8. Shona McGowan (Physics)
9. Victor Yu (Physics)
10. Yi-Lu Chang (Mech)

Ph.D:

1. Alleyne, Colin (ECE)
2. Mohamad Hajj-Hassan (ECE)
3. Menard, Michael (ECE, awarded NSERC Post-doctoral fellowship on graduation)
4. Hoa, Xuyen (ECE)
5. Sairam Prabhakar (Mech)
6. Frederic Nabki (ECE)

PDF:

1. Ebrahim Ghafer-Zadeh (ECE)
2. Peter Thostrup (Physics)

Grants and contracts:

The total of ***new*** grants and contracts directly linked to the fab had a value of **$ 1,339,826 in 2009-10**
Note: all $ values indicated are per year.

NSERC

A. Kirk (PI) and 9 others,
NSERC CREATE in Integrated Sensor Systems.
$275,000 (2010-2016)

(PI Andrew Kirk, with Z Mi and D.V. Plant)
Strategic grant entitled 'Direct integration of microtube lasers on silicon,
$136,000 (2009-11)

S. Vengallatore in collaboration with Prof. Luc Frechette (Universite de Sherbrooke).
Strategic Grant and Collaborative Research Grant,
$250,000 (combined) (2008-2011)

B. Siwick
Radio-frequency electron pulse compression for ultrafast electron diffraction
$149,039 (2010)

FQRNT:

V. P. Chodavarapu (PI) and 1 other,
Genetically Engineered Highly Selective and Sensitive Biosensors.
$146,220 (2009-2012)

S. Musallam (PI) and 2 others,
Hybrid Silicon Sensory Neural Electrodes: Simultaneous Recording of Oxygen and Electrical Activity from the Brain.
$168,000 (2010-2013)

NanoQuebec and Canada Space Agency:

V. P. Chodavarapu (PI) and 3 others,
CMOS Integrated Nitride Nanowire Array based Bacterial Biosensors.
$87,000 (2009-2011)

Andrew Kirk (PI) with Mark Andrews
Integrated polymer electro-optic switches',
$66,667 (2010-2012)

Canadian Institute for Photonic Innovations:

V.P. Chodavarapu (PI) and 1 other,
Nanoporous silicon catheter device with real-time optical monitoring of bacterial contaminants during hemodialysis.
$31,900 (2009-2010)

Ministry of Economic Development, Innovation and Export (MDEIE, Quebec)
B. Siwick
Radio-frequency electron pulse compression for ultrafast electron diffraction
$30,000 (2009 – 2012)