

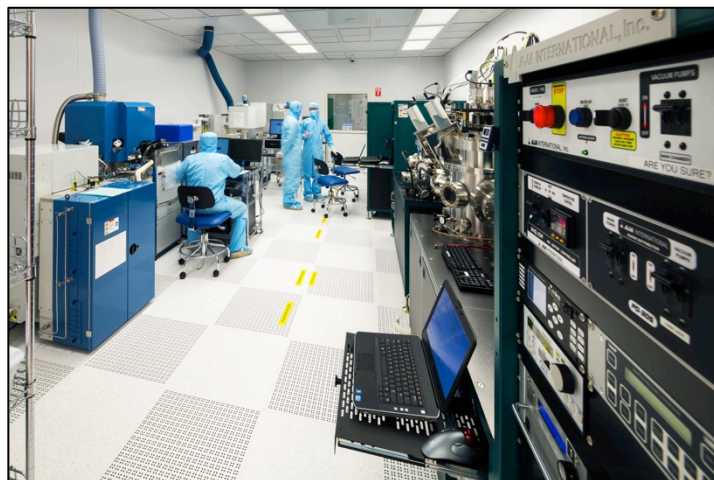
Quantum NanoFab Core Facility

Annual Report
2014/15

Covering period May 1, 2014 to April 30, 2015

Vito Logiudice

4/27/2016



**Quantum NanoFab Dry Etch & ALD/PECVD/PVD
Deposition Bay**

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SPECIAL THANKS

We remain deeply indebted to:

Mike and Ophelia Lazaridis

The University of Waterloo

Canada Foundation for Innovation

Ontario Ministry of Economic Development and Innovation

Industry Canada

We are grateful to **Ian Orchard, Vice-President Academic & Provost**, for covering the substantial nitrogen gas consumption costs incurred in FY2014/15.

We are also grateful to **Scott Nicoll, Manager, Space Planning**, and **Beth Jewkes, Associate Provost, Resources**, for having managed the bulk nitrogen supply to the entire Lazaridis Quantum-Nano Centre complex since the start of QNC operations, and for having carried these substantial costs for the first two years of these operations.

Special thanks to **Rick Zalagenas, Director, Maintenance & Utilities**, and the entire **Plant Operations Maintenance Group** for having done an excellent job of fine tuning and maintaining many services critical to cleanroom operations.

Special thanks as well to our two faculty members on the Quantum NanoFab Management Team, **David Cory, Scientific Director (IQC)**, and **Tong Leung, Scientific Director (WIN)**, for their continued excellent guidance in support of the Quantum NanoFab's vision of enabling world-class research via state-of-the-art facilities and professional operations.

Finally, special thanks to **IQC** for having initiated and funded the acquisition of the JEOL JBX-6300FS 100kV e-beam lithography system, an outstanding new capability to be installed in 2016 which will be of great benefit to the facility's broad and growing community of lab members.

1. EXECUTIVE SUMMARY

This report summarizes the operational activities and financial highlights of the Quantum-Nano fabrication core facility (*Quantum NanoFab*) for the period May 1, 2014 to April 30, 2015. There is some overlap between this report and the special 2-year annual report published in June 2015 that covered the period May 1, 2012 to August 31, 2014.

Quantum NanoFab Team: The team remained stable over the course of FY2014/15 with zero turnover amongst its membership. The team's dedication and work ethic continue to impress.

Several remaining issues related to the building and cleanroom infrastructure were successfully addressed. This included rendering several key systems fully operational such as the chilled water and humidification systems, and also included the successful resolution of a stubborn water infiltration issue. Cleanroom operations & safety were further enhanced by the creation & adoption of multiple new procedures. Several pieces of lab equipment were commissioned and placed into service and a key equipment highlight is the acquisition of a state-of-the-art 100kV e-beam lithography system expected in early 2016. A formal monthly invoicing mechanism was also implemented as was an online facility dashboard that provides a snapshot on fab operations and which can be publicly viewed from any computer or smartphone.

A total of 73 Lab Members under 28 Principal Investigators were registered with the facility as of April 30, 2015. Total equipment hours booked for the year fell to 1984 hours from a high of 6153 hours over the course of FY2012/13. This is due to the fact that the facility was in operation for only 8 of 12 months from Sept. '14 to April '15 and also due to the significant amount of new training required of existing and new lab members before being granted access to the newly commissioned QNC cleanroom.

Operating costs for FY2014/15 remained comparable with the previous year at \$771k. Of this figure 48% is attributable to direct salary costs, 39% to supplies, maintenance and consumables costs and 13% to bulk nitrogen. The University of Waterloo's Office of the Provost graciously covered this year's \$103k cost for the bulk nitrogen. Revenues for the year totaled just over \$80k, the full amount of which was poured back into the facility to defray a portion of the operating costs incurred over the course of the year.

Several key initiatives have been identified for FY2015/16. These include the hiring of additional personnel and the establishment of a strategy for covering the \$200k in utilities costs expected in the future under the university's new NRAM model. The Fab Team also aims to continue to improve Lab Member experience by accommodating several special user requests, augmenting equipment capabilities and installing the 100kV E-Beam Direct Write Lithography system ordered in March 2015.

2. GOVERNANCE

In October 2010 the facility's organizational structure and management plan received the approvals of Raymond Laflamme, Executive Director of IQC, and Arthur Carty, Executive Director of WIN. This organizational structure remains in place in its original form. The detailed plan may be viewed online: <https://fab.qnc.uwaterloo.ca/governance>

3. PEOPLE

The Quantum NanoFab Team remained stable over the course of 2014/15 with no new additions or departures. All team members remain dedicated to the success of the fab and its membership.

Quantum NanoFab Team:

Equipment Technologists

Brian Goddard

Rodello (Rod) Salandanan

Matthew (Matt) Scott

Process Engineering

Nathan Nelson-Fitzpatrick

Cleanroom Certification & Inventory Specialist

Mai-Britt R. G. Mogensen

Information Technology

Steve G. Weiss

Accounting

Mary Lyn Payerl

Director of Operations

Vito Logiudice

Management Team:

Faculty, Scientific Director (IQC)

David Cory

Faculty, Scientific Director (WIN)

Tong Leung

Director of Operations

Vito Logiudice

Leadership Team:

Executive Director, WIN

Arthur Carty

Executive Director, IQC

Raymond Laflamme

Faculty, Scientific Director (IQC)

David Cory

Faculty, Scientific Director (WIN)

Tong Leung

Director of Operations

Vito Logiudice

4. KEY ACTIVITIES & HIGHLIGHTS

This section presents a summary of the infrastructure and operational highlights over the period May 1, 2014 to April 30, 2015. The Quantum NanoFab was in operation for only eight of

twelve months over this period, with operations commencing in the Lazaridis Quantum-Nano Centre on Sept. 2, 2014.

4.1. BUILDING & CLEANROOM INFRASTRUCTURE

As detailed in the 2011/13 special report, some portions of the cleanroom and its satellite labs were not entirely ready for commencement of operations in September 2014. These elements were largely completed by May 2015 and included the following:

- Fandeck wall repairs to address water leaks from adjacent atrium skylight
- Modifications to gowning room main access door & sliding door assembly into central clean corridor
- Packaging Lab & Sample Prep Lab setups completed
- Process Chilled Water (PCW) resistivity set point adjusted & fixed to an acceptable value of 20 microsiemens/cm prior to powering up lab equipment with RF power supplies
- Tested, adjusted & enabled cleanroom “clean steam” humidification function

4.2. CLEANROOM OPERATIONS

Cleanroom operations & overall safety were further enhanced by multiple initiatives:

- Detailed protocol and schedule for laundering of cleanroom gowning gear
- Detailed protocol and schedule for ongoing cleaning of cleanroom walls, floors and ceilings as required to maintain ISO 5 & ISO 6 certifications
- Rolled out mechanism for generating and managing new user ID badges and access FOB's
- With approval from the *University Secretariat & Office of General Counsel*, expanded facility access policies to allow non-UWaterloo user access (including non-UW academic and private sector applicants)
- Established temporary monthly invoicing mechanism via support from *Badger*
- Rolled out *Badger Dashboard* on fab website that provides a snapshot of fab operations and which can be publicly viewed from any computer/smartphone: <http://uwaterloo.badgerlms.com/badger/DashboardQNCFAB-1.html>
- Implemented protocols for annual verification of fume hood face velocities, and monthly inspections of fire extinguishers and emergency safety showers
- Established detailed procedures for safely charging toxic & corrosive gas lines
- Established a monthly safety inspection plan with formal inspections commencing in September 2014 (performed on the last Friday of every month)

- Acquired additional chemical spill kits
- Established presentation and online quiz for “*HF Acid Handling Best Practices*” training module

4.3. LAB EQUIPMENT

- Completed all remaining equipment ESA (Electrical Safety Authority) certifications
- Commissioned all tools previously available in the RAC1 temporary facility on a priority basis soon after commencement of QNC operations These included:
 - *Oxford* silicon etcher (Si DRIE)
 - *Oxford* metal etcher (RIE for metals & III-V materials)
 - *Oxford* ALD/PECVD cluster deposition system
 - *YES* Oxygen plasma etch system
- Commissioned newly installed equipment including:
 - Rapid Thermal Processor
 - *AJA* Twin-chamber sputter
 - *AJA* Ion mill
 - Four-tube furnace stack (some processes not yet qualified)
 - Ellipsometers
 - Wet benches
 - Film stress measurement system
 - Packaging Lab equipment
- Went to tender for a new 100kV electron beam lithography system in January 2015. An order was placed for a JEOL JBX-6300FS on March 6, 2015. The \$3M system was acquired via IQC funding (see memo in Appendix A). IQC also provided funding for the associated installation and software acquisition costs. System delivery is expected in early 2016.

4.4. SAFETY

No injuries to report. One incidence of theft noted. On October 12, 2014 the extensive copper grounding system in support lab 1708 (flammable solvents storage room) was found to be missing along with six, 2' x 4' x ¼" stainless steel plates. The steel plates are used to protect the cleanroom raised access floor when rolling heavy equipment into the facility. UW Police Services was informed of the theft. It is suspected that someone employed during the cleanroom fit-out project might have defeated the lock on the emergency exit which leads from this room out to the loading dock. The person likely returned overnight at a later date to remove the hardware. The room was not yet in use at the time and it is thus possible that the missing components were only observed several days or weeks after the theft. The total cost for replacing the copper grounding bars

amounted to \$4400 + HST. This cost was absorbed by the building's base construction/fit-out budget (special thanks to Byron Murdock and Daniel Parent).

5. LAB MEMBERSHIP

Table 1 lists the names of the 28 Principal Investigators registered as Quantum NanoFab lab members at the end of the April 2015.

Table 1: Registered Principal Investigators as of April 30, 2015

Name	IQC	WIN	Other UW	Other
Hany Aziz		✓		
Michal Bajcsy	✓			
Dayan Ban		✓		
Jonathan Baugh	✓			
Raffi Budakian	✓			
David Cory	✓			
Bo Cui		✓		
Karim Karim		✓		
Andy Knights				Ranovus
Raymond Laflamme	✓			
Adrian Lupascu	✓			
Vivek Maheshwari				VELOCITY
Hamed Majedi		✓		
Vadim Makarov	✓			
Raafat Mansour		✓		
Matteo Mariantoni	✓			
Michael Mayer				Mech Eng
Guoxing Miao	✓			
Carolyn Ren				
Safieddin Safavi-Naeini			ECE	
German Sciaini		✓		
Simarjeet Saini		✓		
Grum Teklemariam				High Q
Zbig Wasilewski		✓		
Christopher Wilson	✓			
Amir Yacoby	✓			
Mustafa Yavuz		✓		
John Yeow		✓		
TOTAL:	11	12	1	4

Breakdown of Registered Principal Investigators

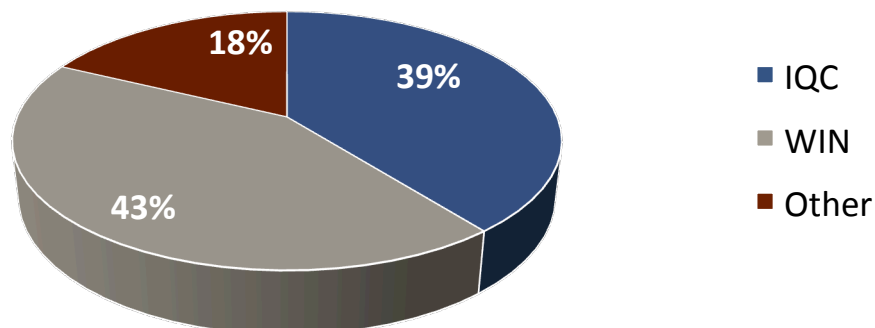
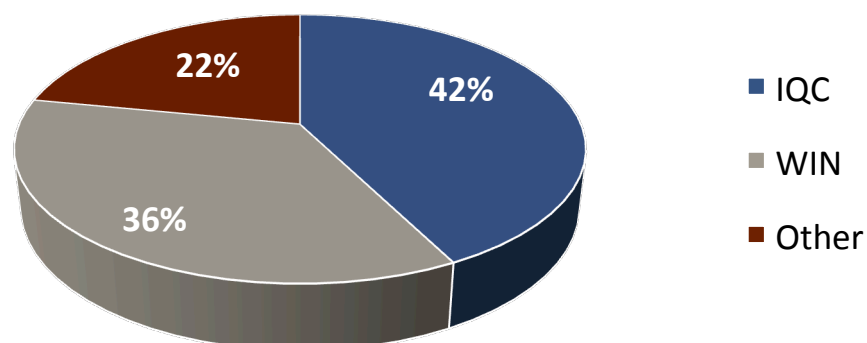


Table 2 shows the breakdown and total number of lab members (73) working under the 28 PI's listed in table 1.

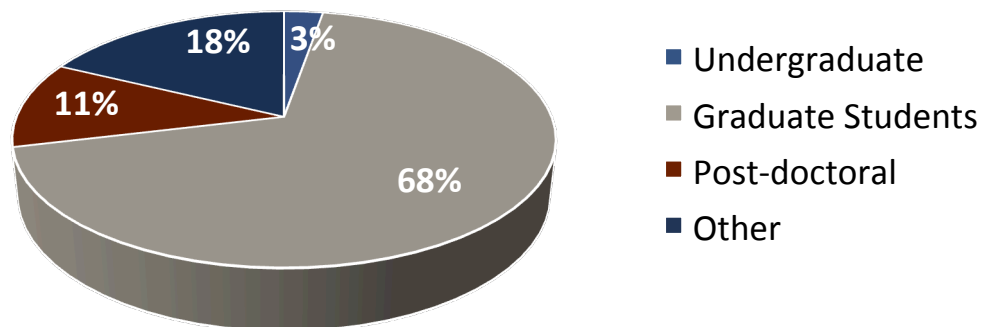
Table 2: Breakdown of Lab Members per Institute as of April 30, 2015

Category	IQC	WIN	Other	TOTAL
Co-op Students	0	0	0	0
Undergraduate Students	1	0	1	2
Graduate Students	20	21	9	50
Post-Doctoral Fellows	5	2	1	8
Other	5	3	5	13
TOTAL:	31	26	16	73

Breakdown of Registered Lab Members / Institute



Breakdown of Lab Member HQP Categories



6. EQUIPMENT BOOKINGS

Table 3 shows the annual trend of equipment hours booked in the Quantum NanoFab facility since operations first began in November, 2009 with the acquisition of the Raith 150TWO e-beam lithography system. The number of hours booked in FY2014/15 is lower than in previous years. This is largely due to the reduced number of months of operation (8 of 12 months only) and due to the significant amount of new training required of existing and new lab members before being granted access to the QNC cleanroom.

Trends noted at the time of publication of this document suggest that the previous record of 6153 hours in FY2012/13 will be exceeded in FY2015/16.

Table 3: User Equipment Bookings (total hours)

2009/10	2010/11	2011/12	2012/13	2013/14*	2014/15*	TOTAL (since start of operations)
235	1073	3551	6153	3985	1984	16981

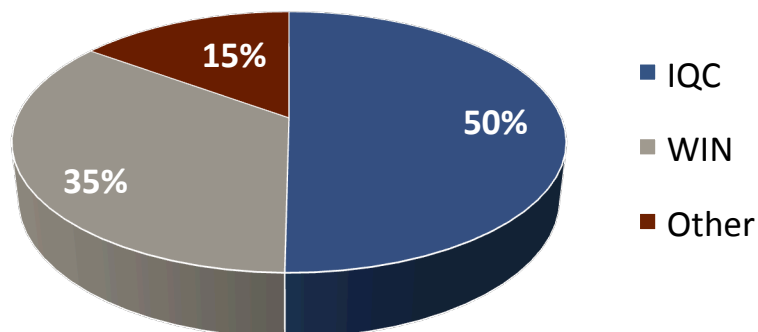
*Fab in operation for only 7 of 12 months during FY2013/14 and for 8 of 12 months during FY2014/15

Table 4 shows the number of equipment hours booked per research group over the course of FY2014/15.

Table 4: Equipment Hours Booked per Faculty Member in 2014/15

Name	IQC	WIN	Other
Hany Aziz		7	
Michal Bajcsy	73		
Dayan Ban		66	
Jonathan Baugh	245		
Raffi Budakian	6		
David Cory	243		
Bo Cui		138	
Karim Karim			
Andy Knights			
Raymond Laflamme			
Adrian Lupascu	21		
Vivek Maheshwari			
Hamed Majedi			
Vadim Makarov	7		
Raafat Mansour		13	
Matteo Mariantoni	204		
Michael Mayer			10
Guo-Xing Miao	3		
Carolyn Ren			
Safieddin Safavi-Naeini			287
German Sciaini		104	
Simarjeet Saini		240	
Grum Teklemariam			
Zbig Wasilewski			
Christopher Wilson	194		
Amir Yacoby			
Mustafa Yavuz		74	
John Yeow		48	
TOTAL	996	587	297

Equipment Hours Booked per Institute



7. EXPENSES & REVENUES

Expenses are divided into direct and indirect costs. Per previous verbal agreements between WIN and IQC, the indirect costs listed in Table 5 are to be equally shared by both institutes.

In FY2014/15, direct costs were paid for from a combination of CFI-IOF funds, revenues generated from access fees charged to lab members, funds provided by the University of Waterloo's Office of the Provost and, on an exceptional basis, IQC funds. Facility access fees were collected throughout this reporting period as a function of the fee schedule published on the public portal of the fab website: <https://fab.qnc.uwaterloo.ca/data/access/fees/doc>

7.1. INDIRECT COSTS

Table 5: Indirect Costs shared equally by IQC & WIN *

* These costs are not CFI-IOF admissible and are therefore equally borne by both institutes

Category	IQC	WIN
Salary & Benefits, Director of Operations	50%	50%
Salary & Benefits, Accounting Support ** ** 1 day per week	50%	50%
Salary & Benefits, Information Technology Support ** ** 1 day per week	50%	50%

7.2. DIRECT COSTS

A summary of the direct costs incurred over FY2014/15 is presented in Table 6.

The Salaries & Benefits total of \$365,712 was covered as follows: \$204,799 was paid for via IQC's Industry Canada fund, \$158,639 was paid for via the CFI-IOF grant associated with CFI project # 11544, and \$2,274 was paid for out of revenues generated from fab operations.

Of the \$302,379 total for Supplies, Maintenance & Repairs, \$160,789 was paid for out of the same CFI-IOF grant noted above with the balance paid for via fab revenues. The cost of the bulk nitrogen consumed over this period is estimated to be \$103,000. As detailed below, this amount was paid for by the *Office of the Vice President, Academic & Provost*.

The QNC cleanroom consumes significantly more bulk nitrogen than did the temporary cleanroom in RAC1. This is largely due to four main contributing factors:

- The installation of multiple new gas cabinets which house flammable & pyrophoric gases used by the *Tystar* 4-tube furnace stack. For safety reasons and as required by code, the control cabinets on these cabinets are purged on a 24/7 basis with a continuous flow of N₂ gas.
- The installation of several new fume hoods which are dedicated to the use of flammable solvents and/or highly corrosive solutions. For safety reasons and as required by code, the electrical control panels for these particular hoods must also be purged with N₂ gas on a 24/7 basis.
- The addition of several large vacuum pumps which convey pyrophoric or highly reactive and corrosive process gases. For safety reasons these pumps must remain under constant N₂ purge.
- The *Tystar* 4-tube furnace stack was first installed in QNC. This system is equipped with four independent process chambers (tubes). These tubes consume large quantities of high purity N₂ gas when in process and, in the case of the single atmospheric tube, when sitting idle between process runs.

Since the start of QNC operations, the cost of bulk nitrogen gas consumed by the Quantum NanoFab as well as by occupants of the Lazaridis Quantum-Nano Centre has been temporarily borne by the *Office of the Associate Provost, Resources*. Late in 2015, it was learned that the *Office of the Vice President, Academic & Provost* had agreed to cover the full cost of bulk nitrogen gas consumed since the start of QNC operations out to the end of FY2015/16. The Quantum NanoFab is grateful to Scott Nicoll, Manager, Space Planning, Beth Jewkes, Associate Provost, Resources, and Ian Orchard, Vice-President, Academic & Provost, for these substantial contributions.

Table 6: Breakdown of Direct Costs - FY2014/15

Category	Cost	
Salaries & Benefits: (Direct personnel only)	\$365,712	48%
Supplies, Maintenance & Repairs: cleanroom, chemicals, process gases, lab equipment repairs	\$302,379	39%
Supplies: Bulk nitrogen gas (estimate)	\$103,000	13%
TOTAL (\$):	\$771,091	

NOTE: On May 15, 2009, UW's *Office of Research* confirmed "there is no expiration date on the IOF, however funds are expected to be used"

within 5 years or “within reasonable life expectancy of the CFI equipment”.

IQC aims to preserve, as long as reasonably possible, the CFI-IOF funds allocated to the Quantum NanoFab. IQC has thus paid a significant portion of the Quantum NanoFab’s operating costs since FY2011/12 (year-by-year breakdown to end FY2014/15 included in Appendix B). IQC aims to initiate discussions with WIN to elaborate a plan for equitable sharing of these costs.

7.3. REVENUES

Invoices were issued on a monthly basis to each registered principal investigator over the entire fiscal year. The total amount invoiced for this period was \$80,817. This is lower than in previous years for the reasons mentioned in section 6 of this document.

A summary of total fab charges invoiced to each faculty member for this period is included in Appendix C.

Revenues are deposited in a fund 100 operating account dedicated to Quantum NanoFab operations. As detailed in section 7.2, this year’s revenues together with amounts left over from previous years were used to cover a portion of the direct operating costs. Thus, all revenues generated from the collection of facility access fees have been redirected back into fab operations to the collective benefit of the lab member community.

The remaining balance of the CFI-IOF funds granted against CFI project # 11544 continues to be dedicated to the operations of the two IQC & WIN jointly operated facilities. These include:

- The Quantum NanoFab
- The QNC Metrology Facility

These funds remain primarily earmarked for the salaries of technical staff dedicated to the operation & maintenance of both shared facilities.

8. ACCESS FEES FOR 2014/15

Access fees in effect for FY2014/15 remain consistent with the rates first established and published in September 2014. These are listed in Appendix D. Access fees remain highly subsidized by IQC, WIN, the University of Waterloo and the CFI-IOF operating fund associated with CFI project # 11544.

As has been the case since temporary operations first started in the RAC1 cleanroom in November 2009, a single access fee structure remains in place for all academic members, regardless of affiliation (IQC, WIN or other academic), and regardless of PI status (junior or senior faculty).

9. KEY OBJECTIVES & ACTIVITIES FOR FY2015/16

Key Fab Team objectives for FY2015/16 include:

People & Finances

- Hire *Accounting & Administration Assistant*. See related memo in Appendix E
- Create a third *Senior Equipment Technologist* position as needed to accommodate the significant growth in lab equipment available for use in QNC. See Appendix F for list of equipment currently available
- Establish a strategy for covering the estimated \$200k in annual lab utilities cost charges expected under the university's New Resource Allocation Model (NRAM)

Lab Member Experience & Outreach

- Establish lithography training modules to complement existing equipment training modules
- Raith qualification tests: allow users to perform their tests on their own devices
- Organize talks given by speakers with fabrication-related experience
- Accommodate IQC request for fab access for USEQIP participants (June 2015)
- Talks & updates:
 - Present at Core Facilities conference (Florida, May 5, 2015)
 - Present at Nano-Ontario workshop (QNC, May 13, 2015)
 - WIN BOD update (June 10, 2016)
 - Participate in Quantum Innovators conference (QNC, October, 2015)

Lab Equipment

- Complete remaining equipment startup & commissioning activities (including SOP's & training plans)
- Oxford ALD precursor cabinet upgrade
- Prepare for 100kV EBL system installation
- Commission new process gases on Metal etcher, PECVD and ALD systems
- Install *Badger* equipment interlocks

Submitted by: Vito Logiudice P.Eng.
Director of Operations, *Quantum NanoFab*
April 27, 2016

Memo

To: Faculty Lab Members, UWaterloo *Quantum NanoFab*

Copy: Arthur Carty, Executive Director, Waterloo Institute for Nanotechnology (WIN)
 George Dixon, V.P. University Research
 Raymond Laflamme, Executive Director, Institute for Quantum Computing (IQC)
 Terry McMahon, Dean of Science
 Pearl Sullivan, Dean of Engineering

From: Vito Logiudice on behalf of *Quantum NanoFab* Management Team:
 David Cory
 Tong Leung
 Vito Logiudice

Date: December 16, 2014

Re: Addition of 100kV Electron Beam Lithography (EBL) system to *Quantum NanoFab*

UWaterloo's jointly shared IQC, WIN *Quantum NanoFab* is currently equipped with a 30kV electron beam lithography system (*Raith 150TWO*). This system has served our community well since it was first commissioned in 2009. The addition of a high performance 100kV EBL system would enable the following capabilities beyond what we can currently achieve with the *150TWO*:

- Ultra-high resolution ultimate feature size (<10 nm)
- High resolution patterning of dense patterns (<100 nm pitch) in thick resist layers (>400 nm)
- Excellent stitching (<30 nm) and overlay performance at large writefield sizes (≥500x500µm)
- High throughput writing while maintaining high resolution and accurate stitching
- Advanced automation of tool calibration tasks to enhance efficient tool utilization (deskew, focus, aperture alignment, stigmatism, writefield alignment)

An addition of this nature was planned from the start. The fab has a dedicated class 100 clean room designed and built to accommodate the stringent environmental requirements of these types of tools.

IQC will fund the acquisition of the system for near-term installation in the fab so we do not have to wait for a future CFI before moving forward. This important addition will greatly benefit our growing community of Lab Members and their leading edge research initiatives. Access to the system will be made available to our entire community of registered *Quantum NanoFab* Lab Members.

All EBL equipment manufacturers offer these types of systems and most larger academic clean rooms are so equipped. We therefore have a wealth of experience available to build on as we move forward.

Our plan is to publish a request for proposal by end January, 2015 and to issue a formal order by mid March, 2015. Typical delivery lead times range from eight to ten months. We anticipate the system being installed and commissioned during the first half of calendar year 2016.

We welcome the community's input should important processes exist that cannot currently be completed via the *Raith 150TWO*.

APPENDIX B: YEAR-BY-YEAR FINANCIAL SUMMARY OF FAB OPERATIONS

Annual Report - Clean Room Financial Summary

FISCAL YEAR ENDING APRIL 30					
	2012	2013	2014	2015	TOTAL
INVOICING					
Invoice Total Value for Year	\$86,583	\$157,915	\$111,333	\$80,860	\$436,691
Funds Received for Year (into Fab Operating Fund 100)	\$66,638	\$120,084	\$106,072	\$59,806	\$352,600
Number of Invoices Issued to Users	86	129	90	86	391

SALARY EXPENSES

Technician Salary and Benefits paid by IQC	80,610	247,500	181,313	204,799	714,222
Technician Salary and Benefits on CFI-IOF (Fund 105) (no Metrology technicians)	142,035	26,613	106,901	158,639	434,188
CleanRoom Salary and Benefits on Fab Operating (Fund 100)			2,095	2,274	4,369
TOTAL	222,645	274,113	290,309	365,712	1,152,779

SUPPLIES, MAINTENANCE AND EQUIPMENT EXPENSES

Supplies/Equipment/Maintenance paid by IQC	34,935	28,546	0	0	63,481
Supplies/Equipment/Maintenance on CFI-IOF (Fund 105)	34,232	65,827	88,654	160,789	349,502
Supplies/Equipment/Maintenance on Fab Operating (Fund 100)			397,828	141,590	539,418
TOTAL	69,167	94,373	486,482	302,379	952,401

PRAXAIR EXPENSES

Praxair paid by IQC	16,113	14,351	10,206	0	40,670
Praxair on CFI-IOF (Fund 105)	16,113	13,547	10,287	0	39,947
Praxair on Operating (Fund 100)			0	0	0
TOTAL	32,226	27,898	20,494	0	80,618

GRAND TOTAL	324,038	396,384	797,285	668,091	2,185,798
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SPENDING BY GRANT

Paid by IQC	131,658	290,397	191,519	204,799	818,373
Spending on CFI-IOF (fund 105) no metrology nor director salary	192,380	105,987	205,842	319,428	823,637
Spending on Operating (Fund 100)	0	0	399,923	143,864	543,787
GRAND TOTAL	324,038	396,384	797,285	668,091	2,185,798

** Salaries do NOT include metrology lab technician salaries paid on CFI-IOF nor director salary and benefits

*** IQC aims to verify/confirm these figures prior to discussions with WIN

APPENDIX C: FAB FEES INVOICED PER FACULTY MEMBER IN 2014/15

Table 7: Total Fab Fees Invoiced per Faculty Member in 2014/15

Name	IQC	WIN	Other UW
Hany Aziz		\$295	
Michal Bajcsy	\$2,780		
Dayan Ban		\$1,862	
Jonathan Baugh	\$8,837		
Raffi Budakian	\$182		
David Cory	\$8,990		
Bo Cui		\$7,216	
Karim Karim			
Andy Knights			
Raymond Laflamme			
Adrian Lupascu	\$826		
Vivek Maheshwari			
Hamed Majedi			
Vadim Makarov	\$149		
Raafat Mansour		\$632	
Matteo Mariantoni	\$7,271		
Michael Mayer			\$303
Guo-Xing Miao	\$89		
Carolyn Ren			
Safieddin Safavi-Naeini		\$10,823	
German Sciaini			\$3,968
Simarjeet Saini		\$14,397	
Grum Teklemariam			
Zbig Wasilewski			
Christopher Wilson	\$7,431		
Amir Yacoby			
Mustafa Yavuz		\$2,783	
John Yeow		\$1,981	
TOTAL	\$36,555	\$29,167	\$15,095

APPENDIX D: ACCESS FEES IN EFFECT SINCE SEPT. 1, 2014



Facility Access Fees

Tool Type	Tool Name	Academic Rate	Industrial Rate
E-beam Lithography	RAITH 150TWO	\$ 60	\$ 180
Mask Aligner	SUSS-MA6 front/back	\$ 35	\$ 105
HMDS oven	YES-HMDS	\$ 25	\$ 75
semi-auto spin/bake	BREWER-UVspinbake	\$ 30	\$ 90
PR spin/bake station	BREWER-Ebeamspinbake	\$ 35	\$ 105
PR spin/bake station	REYNOLDSTECH-twincoater	\$ 25	\$ 75
atmospheric oven	FISHER-oven	\$ 15	\$ 45
E-beam evaporator	INTLVAC-Ebeam	\$ 35	\$ 105
ALD & PECVD	OXFORD-ALD/PECVD cluster	\$ 50	\$ 150
Automated sputter	PLASSYS-Nb sputter	\$ 40	\$ 120
oxidation/anneal furnace	TYSTAR1-atm	\$ 40	\$ 120
LPCVD Nitride furnace	TYSTAR2-nitride	\$ 45	\$ 135
LPCVD Poly furnace	TYSTAR3-Poly & SiC	\$ 45	\$ 135
LPCVD LTO furnace	TYSTAR4-LTO	\$ 45	\$ 135
Sputter	AJA-2-chamb, loadlocked	\$ 40	\$ 120
atmospheric RTA/RTP	ALLWIN-RTP	\$ 40	\$ 120
ICP/RIE - Cl chemistries	OXFORD-metalRIE	\$ 45	\$ 135
ICP/RIE - F chemistries	OXFORD-Si deep RIE	\$ 45	\$ 135
Ashing RIE	YES-ash	\$ 25	\$ 75
Ion mill 6" wafer	AJA-ionmill	\$ 45	\$ 135
Cont. ang. goniometer	RAMEHART-contactangle	\$ 15	\$ 45
LWD opt microscope	OLYMPUS-scope3	\$ 15	\$ 45
Dicing saw	DISCO-saw	\$ 40	\$ 120
wirebond pull tester	WESTBOND-pulltest	\$ 10	\$ 30
Semi-auto wirebond	WESTBOND-wirebond1	\$ 40	\$ 120
multimode wirebond	WESTBOND-wirebond2	\$ 40	\$ 120
Flip chip die bonder	TRESKY-diebond	\$ 45	\$ 135
diamond scribe tool	OEG-scriber	\$ 30	\$ 90
epoxy dispenser robot	NORDSON-epoxy	\$ 15	\$ 45
H plasma cleaner	LFC-plasmaclean	\$ 30	\$ 90
epoxy cure oven	Cureoven	\$ 15	\$ 45
wafer cleaner	ULTRON-cleaner	\$ 20	\$ 60
reflectometer	FILMETRICS-F40	\$ 10	\$ 30
reflectometer -auto	FILMETRICS-F50	\$ 10	\$ 30
wafer microscope	OLYMPUS-scope1	\$ 20	\$ 60
wafer microscope	OLYMPUS-scope2	\$ 20	\$ 60

QuantumNanoFabFees_rev_7.xlsx

Rates in effect as of September 1, 2014

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Facility Access Fees

Tool Type	Tool Name	Academic Rate	Industrial Rate
stylus profilometer	VEECO-profilometer	\$ 20	\$ 60
auto. 4-point probe	CDE-4pp	\$ 20	\$ 60
stress meas. tool	TOHO-stress	\$ 30	\$ 90
ellipsometer	WOOLLAM-ellip	\$ 40	\$ 120
Wetbench - Acids	ACIDBASEnonHF	\$ 25	\$ 75
Wetbench - HF	HFACID	\$ 25	\$ 75
Wetbench - solvents	SOLVENT1	\$ 25	\$ 75
Wetbench - solvents	SOLVENT2	\$ 25	\$ 75
Wetbench - RCA clean	RCACLEAN	\$ 25	\$ 75
Wetbench - KOH	REYNOLDSTECH-bulkSi	\$ 40	\$ 120
Wetbench - Piranha	PIRANHA	\$ 25	\$ 75
Wetbench - UV dev	DEVELOPUV	\$ 25	\$ 75
Wetbench - EBL dev	DEVELOPEBL	\$ 25	\$ 75

Additional Fees:

- 1) For Academic Users, cleanroom consumables costs are recovered via a charge of \$1.84 per each equipment "enable" within Badger.
For Industrial Users, the cleanroom consumables fee is \$5.52 per equipment enable.

- 2) For Academic Users, equipment training is completed by facility staff and is charged at \$25 per hour.
For Industrial Users, equipment training is charged at \$75 per hour.

- 3) For Academic Users, general support provided by facility staff is charged at \$50 per hour.
For Industrial Users, general support is charged at \$150 per hour.

Memo

To: Raymond Laflamme, Executive Director, Institute for Quantum Computing (IQC)
Terry McMahon, Dean of Science
Ian Orchard, Vice-President Academic & Provost

Copies: Arthur Carty, Executive Director, Waterloo Institute for Nanotechnology (WIN)
David Cory, Scientific Director (IQC), Quantum NanoFab
Tong Leung, Scientific Director (WIN), Quantum NanoFab

From: Vito Logiudice, Director of Operations, Quantum NanoFab

Date: April 24, 2015

Re: New position for Quantum NanoFab: Accounting & Administration Assistant

Interest in the IQC & WIN shared Quantum NanoFab facility continues to grow. After 8 months of operations the facility has grown to 86 registered users under 25 different faculty members spanning the Faculties of Science and Engineering. These figures do not include new users from Medella Health, a startup funded through the university's Velocity program, nor Ranovus Inc., a well-funded private company headquartered in Ottawa. Both companies have manifested an interest in gaining immediate facility access. In addition, a potentially significant user from McMaster University, Prof. Andy knights, has also expressed a strong interest in transferring existing nanofabrication processes to the Quantum NanoFab.

Our professional organization has attained a level of operations which justifies the addition of another member to the Quantum NanoFab Team to help with a steadily growing list of accounting, customer service and administrative tasks. As described in the facility's management & operational plan first published in 2010 (<https://fab.qnc.uwaterloo.ca/governance>), our original vision called for the eventual augmentation of our team's staffing levels to assist with this wide range of tasks. The objective was to proceed with this new position once operations were permanently transferred to the QNC building from the RAC1 temporary cleanroom, and once the facility was being used by a critical mass of users spanning multiple departments and faculties.

This application is being submitted at this time since both conditions have been met. It is our strong belief that the workload of our growing operations will keep the eventual new hire busy on a full time basis.

APPENDIX F: FAB EQUIPMENT LIST

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- [Available Process Equipment & Capabilities](#)**
- [Available Packaging Lab Equipment](#)
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CAS Log in

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Log in

Login Name

Password

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Available Process Equipment & Capabilities

Deposition

- [ALD / PECVD Cluster Deposition System](#)
- [LPCVD Low Temperature Oxidation \(LTO\) Furnace](#)
- [LPCVD Poly Silicon and Silicon Carbide Furnace](#)
- [LPCVD Silicon Nitride Furnace](#)
- [Rapid Thermal Processor \(RTP\)](#)
- [PVD E-Beam & Resistive Heating Thermal Evaporator](#)
- [PVD Nb Superconducting Films Sputter System](#)
- [PVD Twin Chamber Sputter System](#)
- [Thermal Oxidation Furnace](#)

Lithography

- [E-Beam Lithography System \(30kV\)](#)
- [E-Beam Lithography System \(100kV\)](#)
- [Front/Back Mask Aligner](#)
- [Oven: Convection](#)
- [Oven: HMDS & Image Reversal](#)
- [Spin Coater: Dual General Purpose Hood](#)
- [Spin Coater: E-Beam Resists](#)
- [Spin Coater: UV Resists](#)

Dry Etch

- [Ion Mill](#)
- [Photoresist Strip](#)
- [RIE: Deep Silicon Etch \(DRIE\)](#)
- [RIE: Metal & III-V Materials](#)

Wet Benches

1. [Bulk Silicon Etch](#)
2. [Diffusion Pre-Clean \(RCA Chemistries\)](#)
3. [E-Beam Resist Develop](#)
4. [HF Acids Only](#)
5. [Non-HF Acids & Bases](#)
6. [Piranha Organics Clean & Resist Strip](#)
7. [Solvent Processing Station #1](#)
8. [Solvent Processing Station #2](#)
9. [UV Resist Develop](#)

Characterization

1. [4-Point Probe](#)
2. [Electrical Probe Station](#)
3. [Ellipsometer](#)
4. [Microscope #1](#)
5. [Microscope #2](#)
6. [Reflectometer: Thin Film Mapping](#)
7. [Reflectometer: Thin Film Spot Measurement](#)
8. [Surface Profiler](#)
9. [Wafer Stress Measurement](#)

Packaging

1. [Contact Angle Goniometer](#)
2. [Convection Cure Oven](#)
3. [Diamond Scriber](#)
4. [Dicing Saw](#)
5. [Die Bonder](#)
6. [H2 Plasma Cleaner](#)
7. [Measurement Microscope](#)
8. [Wirebonder: Manual Wedge/Ball](#)
9. [Wirebonder: Semi-automatic Wedge](#)
10. [Wire Pull Tester](#)

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