

# Quantum-Nano Fabrication Facility

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Annual Report  
2011/12

Vito Logiudice

5/16/2012



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## SPECIAL THANKS

We are deeply indebted to:

**Mike and Ophelia Lazaridis**

**The University of Waterloo**

**Canada Foundation for Innovation**

**Ontario Ministry of Economic Development and Innovation**

**Industry Canada**

## 1. EXECUTIVE SUMMARY

This report summarizes the operational activities of the joint IQC and WIN Quantum-Nano Fabrication facility (Quantum NanoFab) for the 2011/12 fiscal year.

Existing temporary operations began in 2009 and were made possible via the substantial contributions of uW's Institute for Quantum Computing (IQC). IQC financed the construction of a \$500k cleanroom in the RAC1 building in 2008/09 which has since permitted the achievement of several key objectives well in advance of Quantum-Nano Centre building occupancy:

- Creation of governance model jointly endorsed and adopted by IQC and WIN Executive
- Hiring of key members of professional fab team
- Hiring of new faculty with interests in nanofabrication
- Formal documenting of facility access policies
- Documenting of detailed equipment operating procedures
- Creation of multiple process technology reference documents
- Implementation of a robust uW-CAS password-protected website
- Implementation of a billing system endorsed by uW Finance

A significant development in 2011 was the Waterloo Institute for Nanotechnology's (WIN) gracious agreement to fund 50% of the ongoing administrative costs associated with operating the Quantum NanoFab. Costs associated with facility administrative functions are now equally and jointly shared by IQC and WIN.

Over the course of 2011/12, facility use has grown substantially to over 3500 hours of lab equipment bookings. This represents a 300% increase over the previous full year of operation. Fifteen faculty members are now registered Lab Members as are a total of 45 Co-Op students, graduate students and post-doctoral fellows.

Key objectives for 2012/13 include securing the additional funds needed to complete the QNC cleanroom fit-out exercise, completing the fit-out, completing the final lab equipment purchases on the original CFI grant, and relocating existing RAC1 temporary operations to the soon-to-be-commissioned *Mike & Ophelia Lazaridis Quantum-Nano Centre*.

## 2. GOVERNANCE

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, in October 2010.

The organizational structure can be found in Appendix A. Additional details are available online:

<http://qncfab.uwaterloo.ca/vision-gov-pol/governance/view>

## 3. PEOPLE

### Quantum NanoFab Team:

Equipment Technologists	Brian Goddard Rodello (Rod) Salandanan
Process Engineering	Nathan Nelson-Fitzpatrick
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 ACHIEVEMENTS AND ACTIVITIES IN 2011/12

### People

- Addition of highly qualified MEMS Nanofabrication process engineer to Fab Core Team: N. Nelson-Fitzpatrick
- Addition of experienced Information Technology expert to Fab Support Team (1 day per week commitment): S.G. Weiss
- Addition of experienced Accounting expert to Fab Support Team (1 day per week commitment): M.L. Payerl

### Finances

- Key agreement between IQC & WIN: salaries of the facility's Director of Operations and the salaries of two part-time support positions shared equally between both institutes since May 2011 on an ongoing basis
- Implemented a monthly billing system with formal approval from uW Finance
- Implemented test framework needed for eventual roll-out of a powerful lab management software platform, Open CORAL, currently in use at NINT, MIT, etc.
- Implemented a monthly expense tracking & categorization methodology which will serve as the foundation for a detailed operations cost model. Cost model will enable annual adjustment of facility access fees in line with future cost recovery targets.

### QNC Cleanroom

- Cleanroom construction 90% complete; certification expected July 2012
- Successfully addressed issues with multiple cleanroom air handling units
- Finalized specifications for high purity water system; tender completed (Siemens selected)
- Secured detailed quotations for post-occupancy fit-out exercise
- Identified power and ventilation issues (to be resolved post-occupancy)

### Lab Equipment

- Commissioned state-of-the-art ALD/PECVD cluster deposition system
- Ordered Nb sputter system (WIN/IQC faculty working with superconducting films)
- Negotiated free replacement of column assembly on widely used e-beam lithography system which will enhance system stability
- Achieved IQC & WIN users consensus on major specifications for 4-tube furnace

### Cleanroom Operations

- Facility website access expanded from uW campus only to world-wide access
- Revision-tracked equipment standard operating procedures (SOP's) created for entire lab toolset; these are accessible to the lab member community via password-protected facility website
- Multiple team-driven lab process improvement initiatives
- Facility membership procedure further simplified and openly broadcast via public website portal
- Created policy for temporary & permanent suspension of Lab Member access privileges for unacceptable lab behaviour
- Several lab member delinquencies dealt with firmly but fairly thus minimizing equipment contamination/downtime and lab user frustration

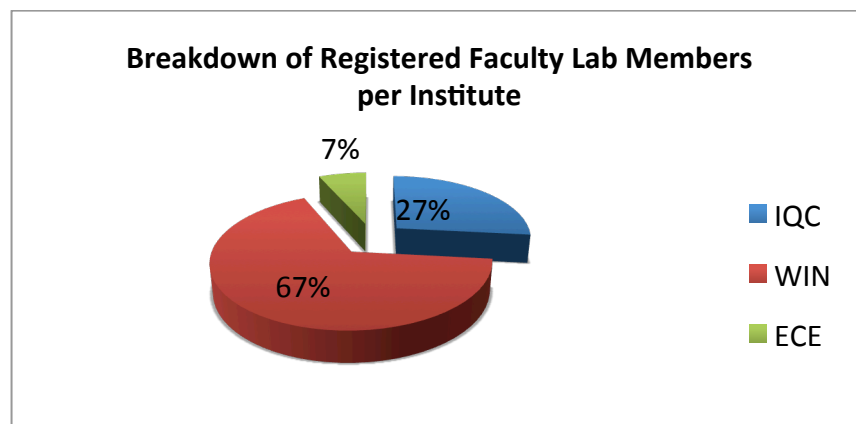
### Safety

- No injuries to report
- One (false) toxic gas alarm caused by a power failure which resulted in the evacuation of the RAC1 building in July 2011
- Three of four Core Team members completed uW sanctioned first aid training
- uW Safety Office acquired professional grade cleanroom safety and behaviour programs to the combined benefit of the multiple cleanroom operations on campus. These will be incorporated into the Quantum NanoFab training program in 2013.

## 5. LAB MEMBERSHIP

**Table 1: uW Faculty Currently Registered as Lab Members**

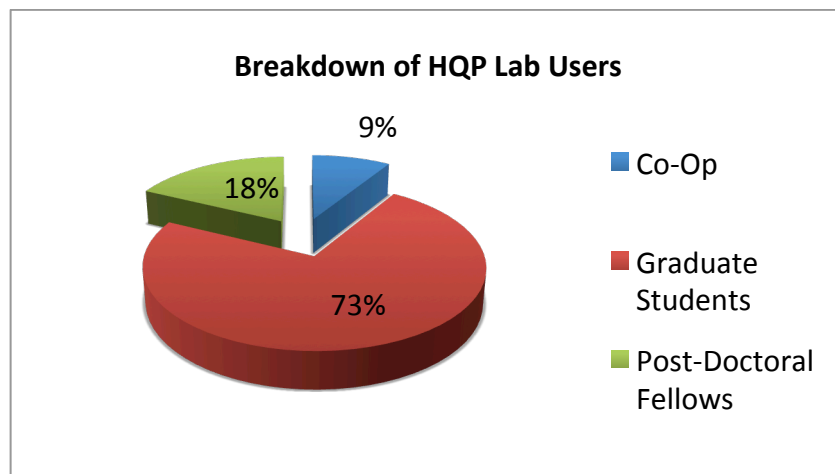
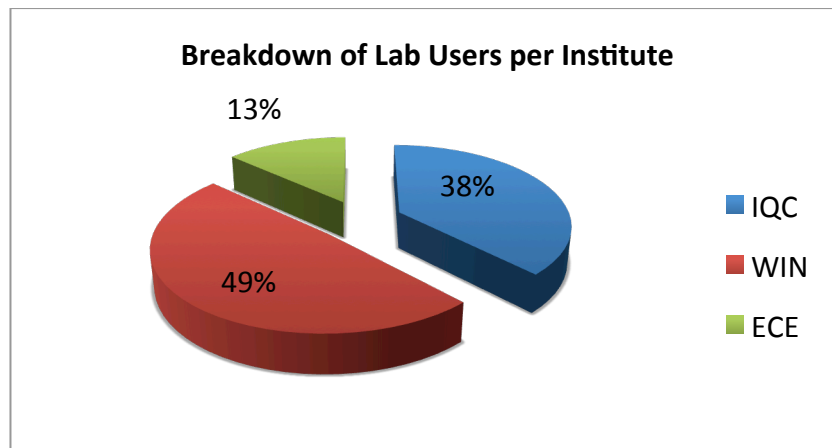
Name	IQC	WIN	UW
Hany Aziz		✓	
Chris Backhouse		✓	
Jonathan Baugh	✓		
David Cory	✓		
Bo Cui		✓	
Irene Goldthorpe		✓	
Jan Kycia	✓		
Zoya Leonenko		✓	
Adrian Lupascu	✓		
Raafat Mansour		✓	
Pavle Radovanovic		✓	
Safieddin Safavi-Naeini			ECE
Simarjeet Saini		✓	
Andrei Sazonov		✓	
Shirley Tang		✓	
<b>TOTAL:</b>	<b>4</b>	<b>10</b>	<b>1</b>





**Table 2: Breakdown of Lab Users per Institute**

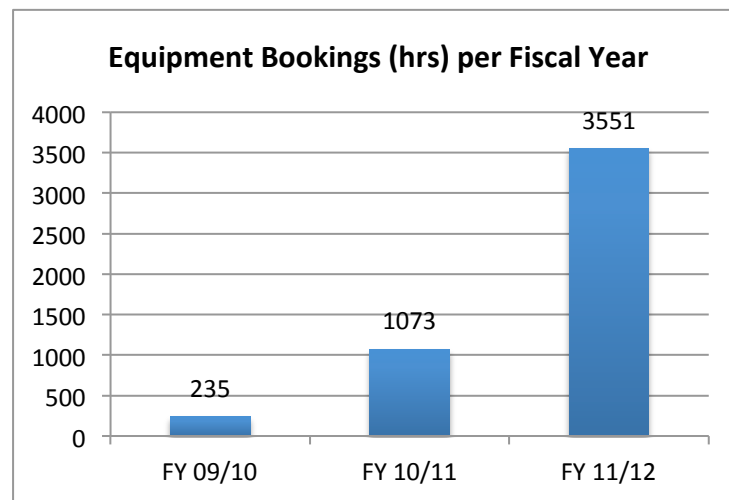
Category	IQC	WIN	other (ECE)	TOTAL
Co-op Students	1	3		4
Graduate Students	10	18	5	33
Post-Doctoral Fellows	6	1	1	8
<b>TOTAL:</b>	<b>17</b>	<b>22</b>	<b>6</b>	<b>45</b>



## 6. EQUIPMENT BOOKINGS

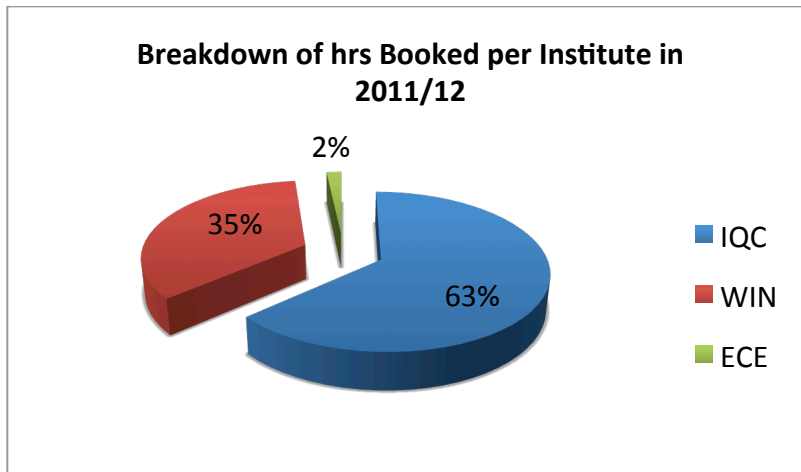
**Table 3: Equipment Bookings (hours)**

2009/10	2010/11	2011/12	TOTAL*
			*since start of operations
235	1073	3551	<b>4859</b>



**Table 4: Equipment Hours Booked per Faculty Member in 2011/12**

Name	IQC	WIN	UW (ECE)
Hany Aziz		2	
Chris Backhouse			
Jonathan Baugh	1016		
David Cory	207		
Bo Cui		181	
Irene Goldthorpe		62	
Jan Kycia			
Zoya Leonenko		3	
Adrian Lupascu	1033		
Raafat Mansour		55	
Pavle Radovanovic		12	
Safieddin Safavi-Naeini			60
Simarjeet Saini		888	
Andrei Sazonov		3	
Shirley Tang		29	
<b>TOTAL:</b>	<b>2256</b>	<b>1235</b>	<b>60</b>



## 7. EXPENSES & INCOME

Expenses are divided into direct and indirect costs. Indirect costs are paid out of IQC and WIN operating accounts; direct costs are paid out of a combination of CFI-IOF and IQC funds.

Facility access fees were collected throughout the year as a function of the fee schedule which is published on the public portal of the fab website.

### 7.1. INDIRECT COSTS

**Table 5: Indirect Costs funded via IQC & WIN operating accounts \***

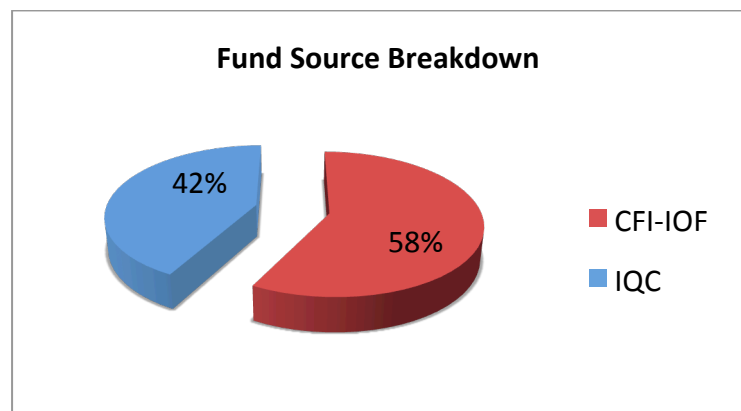
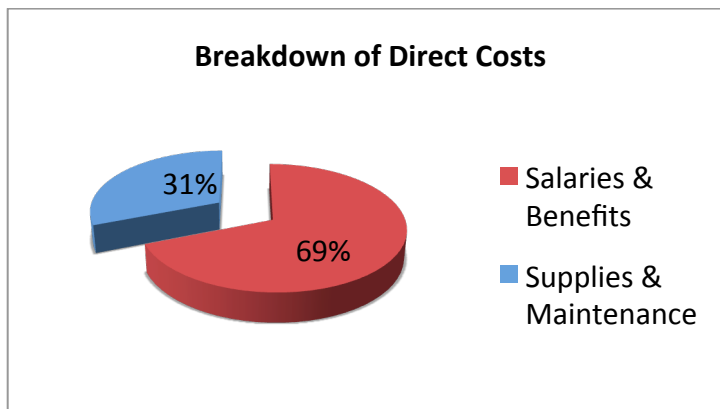
\* These costs are not CFI-IOF admissible and are therefore directly and equally borne by both institutes

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

## 7.2. DIRECT COSTS

**Table 6: Breakdown of Direct Costs & Respective Funding Sources**

Category	Cost	% of total	% paid via CFI-IOF	% paid by IQC
<b>Salaries &amp; Benefits:</b> HQP dedicated to infrastructure operations & maintenance	\$222,645	69%	61.5%	38.5%
<b>Supplies &amp; Maintenance:</b> cleanroom, chemicals, process gases, lab equipment	\$69,168	21%	49.5%	50.5%
<b>Supplies:</b> Bulk nitrogen gas	\$32,225	10%	50.0%	50.0%
<b>TOTAL (\$):</b>	<b>\$324,038</b>		<b>\$187,260</b>	<b>\$136,777</b>



### 7.3. INCOME

A total of \$86,999.97 was invoiced over the period May 1, 2011 to April 30, 2012. At the time of publication, approximately 75% of the relevant internal account transfers had been completed, with the balance expected within the month.

Access fees charged to the Lab Member community are deposited in an account dedicated to Quantum NanoFab operations. Management aims to build up funds in this account for future out-of-warranty lab equipment repairs.

Spending of the CFI-IOF funds granted against CFI project # 11544 is being restricted to the operations of the following two major and jointly shared open-user facilities:

- Quantum-Nano Centre NanoFabrication Facility
- Quantum-Nano Centre Metrology Facility

The existing and future success of both facilities is largely dependent on the excellent people whom have been and whom have yet to be hired for these ongoing operations. Thus, Management of both these facilities will retain a major portion (75% to 85%) of available CFI-IOF funds for the salaries of HQP dedicated to the operations & maintenance of the two facilities. The balance will be spent on lab supplies and equipment service contracts.

## 8. FACILITY ACCESS PHILOSOPHY & ACCESS FEES FOR 2012/13

A common failing of academic fabrication facilities is the lack of practical equipment and process training provided to its users. Circumstances are often further complicated when students with no fabrication experience are mandated by their supervisors to fabricate variations of published devices. Under such difficult circumstances, results are typically less than satisfactory and ultimately lead to frustration for the student, their supervisor, as well as for the other users of the facility and staff. As an added consequence, people whom are not given adequate training prior to beginning fab work often cause unintended costly damage to lab equipment and sometimes cause extended equipment downtime to the detriment of all.

Management believes it is in the best interest of uW's combined pool of excellent faculty and researchers to maintain the existing barriers to facility access (Appendix B). These access and eligibility requirements ensure that all users are equipped with a minimum of theoretical and practical knowledge, and they also ensure that all users successfully complete thorough equipment operator training sessions before being granted autonomous access.

The entire Membership is charged for facility access in a consistent and transparent manner, in line with rates published on the public portal of the facility website (Appendix C). In addition to generating required income and to satisfying CFI guidelines, access fees encourage all Lab Members to:

1. Respect the state of the art infrastructure to which they are given privileged access.
2. Better manage their time and to better prepare their work so as to minimize time wasted in the cleanroom. Without an adequate fee structure, experience suggests that users are likely to perform inefficient, wasteful and potentially detrimental process iterations in the lab rather than first thinking through & planning their fabrication process outside the facility.

Finally, monthly billing encourages equitable and consistent access to all and serves to formally document facility use. This data is required for ongoing reporting and audit purposes, and will prove invaluable for future grant applications.

At this time, Management intends to maintain access fees at the same levels in place at the end of the 2011/12 fiscal year. A review of the fee structure will be initiated once the Open CORAL software platform has been rolled out and once temporary RAC1 cleanroom operations have been relocated to the QNC cleanroom in 2013. Current access fees are available online and are included for reference in Appendix C.

As a final note, a single access fee structure remains in place for the entire membership, regardless of affiliation (IQC, WIN, other) or faculty status (junior, senior). Current rates are highly subsidized by IQC, WIN, the University of Waterloo and CFI. The extent of these subsidies is detailed in the individual monthly invoices sent to each Faculty Lab Member, an example of which is included in Appendix D.

## 9. 2012/13 KEY OBJECTIVES & ACTIVITIES

Timeline for QNC cleanroom occupancy & RAC1 to QNC operations transfer:

- May '12: Secure additional funding needed to complete QNC cleanroom fit-out exercise
- June '12: Initiate tender for QNC cleanroom fit-out & peripherals
- July '12: Take delivery of cleanroom & confirm environmental stability (2 months)
- Sept. '12: Complete cleanroom electrical & ventilation remedial work pre-fit-out
- Oct. '12: Initiate QNC cleanroom fit-out
- Feb. '13: Complete cleanroom fit-out
- April '13: Commence staged transfer of RAC1 operations to QNC
- June '13: Complete transfer of RAC1 operations to QNC

Additional parallel activities:

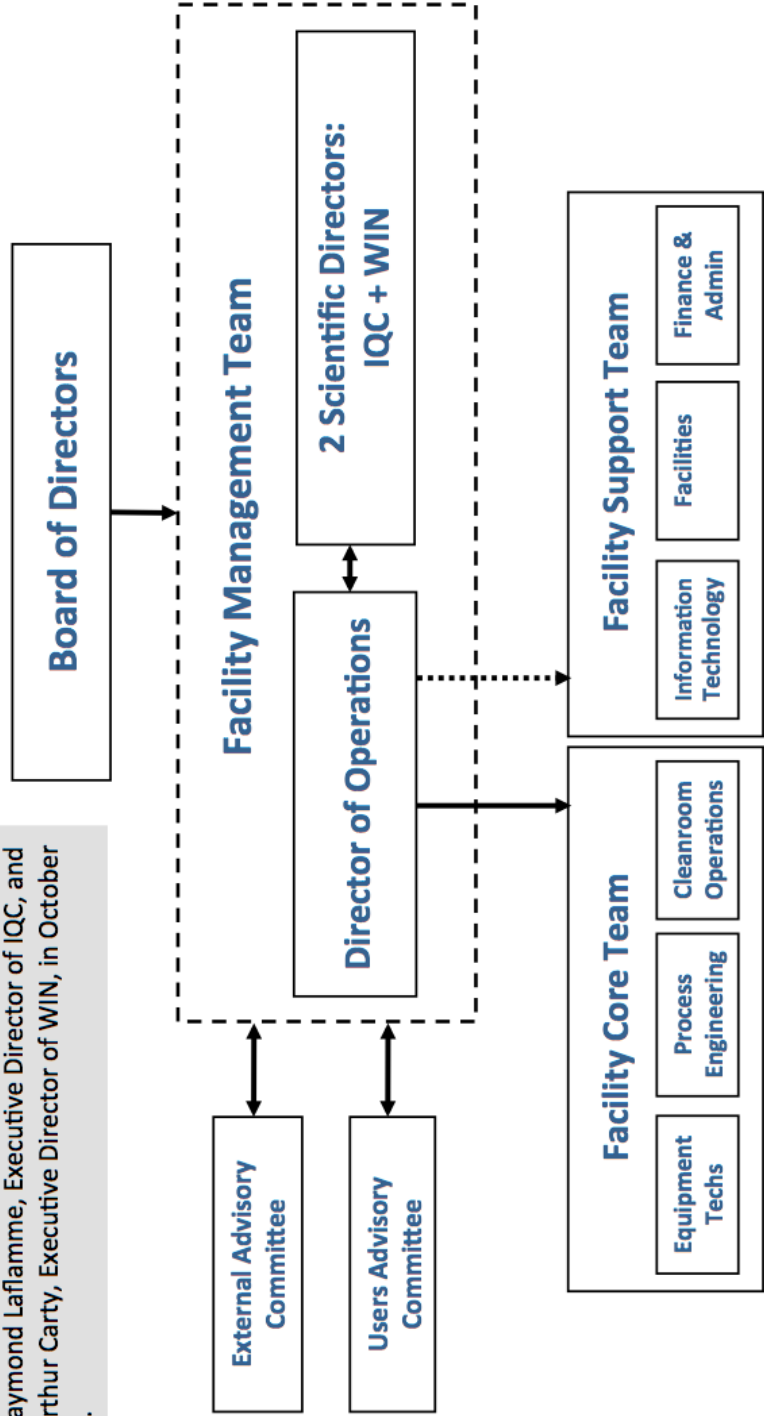
- Purchase & install hoods & cleanroom furnishings
- Test & validate stability of all mechanical, ventilation, safety & electrical systems
- Purchase & install 4-tube furnace (will serve to confirm stability of QNC environment)
- Purchase & install ion mill
- Purchase & install balance of cleanroom and packaging lab equipment
- Roll out Open CORAL lab management S/W platform
- Complete first draft of facility Cost Model by fiscal year-end
- Broaden cleanroom, safety and process technology training activities
- Participate in QNC building operations plan roll-out to ensure cleanroom needs are met

**Ongoing team focus and drive towards our vision of enabling world-class research via state-of-the-art facilities and operations, to the combined benefit of our stakeholders, researchers and collaborators.**

Submitted by: Vito Logiudice  
Director of Operations, Quantum NanoFab  
<https://qncfab.uwaterloo.ca/>  
May 16, 2012

# Organizational Structure


The Quantum NanoFabrication facility's management structure received the approvals of Dr. Raymond Laflamme, Executive Director of IQC, and Dr. Arthur Carty, Executive Director of WIN, in October 2010.





https://qncfab.uwaterloo.ca/access/becoming-a-lab-member

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« May 2012 »

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### How to become a Lab Member

Steps 1 through 9 are mandatory for all new members. Existing members must complete steps 7 to 9 for each machine on which they would like to be qualified.

**NOTE: Activities in the facility are video recorded on a continuous basis.** Proceeding with steps 1 to 9 below signifies understanding and acceptance of this and all other [safety policies](#).

uWaterloo's Central Authentication Service (CAS) is used for lab member identification purposes. Please be sure to include your WatIAM userid and uWaterloo email address on the form referenced in step 2 below.

1. Verify & confirm eligibility requirements before proceeding.
2. Ask your supervisor to complete and submit an [Account Authorization Form](#) on your behalf. **An online account will be created for you once the Account Authorization Form has been received.** NOTE: A signed original must be received. Electronic copies are not acceptable.
3. Complete the mandatory [Safety Training](#).
4. Upload a screenshot of your UW training record to your personal member page (example [here](#)).
5. All fabrication processes are subject to review and approval by management. Submit your fabrication process for review via the following form: [Process Review Request](#)
6. Review the facility's safety features and protocols and then, before your very first equipment training session, ask your trainer via email to complete a lab safety walk-through.
7. Submit an [Equipment Training Request](#) for the machine on which you wish to be trained (one request must be submitted per machine).
8. Contact the appropriate staff member to complete your hands-on equipment training session
  - **IMPORTANT: You must review the online equipment standard operating procedure (SOP) before your session.**
9. Successfully pass the equipment qualification test.

**PLEASE NOTE:** Steps 7 to 9 must be repeated for *each* machine on which you would like to be trained.

**Mailing List:** As a new member of the Quantum Nanofab community, you are encouraged to subscribe to the moderated QNC Fab Members mailing list by sending a blank email to [qncfabmembers-subscribe@lists.uwaterloo.ca](mailto:qncfabmembers-subscribe@lists.uwaterloo.ca)

The objective of this list is to encourage dialogue between members of the community. It can be used to discuss any facility-related topics such as process or equipment related questions, etc.

Note as well that facility staff will use this list to advise the lab member community of any special news items such as unexpected facility closures, etc. If you wish to eventually unsubscribe, send a blank email to [qncfabmembers-unsubscribe@lists.uwaterloo.ca](mailto:qncfabmembers-unsubscribe@lists.uwaterloo.ca)

**CAS Log in**

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**Log in**

[Forgot your password?](#)

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  - Publications: Acknowledgements
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## Membership Eligibility Requirements

### Level A Member: Graduate Students & Post-Docs

Access to this facility is currently limited to University of Waterloo graduate students and Post-Doctoral Researchers, with two exceptions as listed below.

### Level B Member: UW Undergrads with 8-month URA's

In the case of undergraduate students who have been granted an Undergraduate Research Assistantship (URA) or similar, the Management Team appreciates the mutual benefit to both supervisor and student in gaining access to this facility for durations of 8 months (minimum) or more.

Consequently, the Management Team accepts the inclusion of URA students (or similar) amongst our member base provided the following conditions are respected:

1. Graduate students and Post-Docs will have priority over URA students for system training requests and for system access.
2. URA students must meet all regular Lab Membership requirements and system training requirements (example here).
3. Prior to taking equipment-specific qualification tests and gaining independent access to said systems, URA students must first shadow (partner with) a qualified peer for a few sessions. Please note that the system cannot be directly operated by the trainee during these sessions.

### Level C Member: Co-op students

UW Undergraduate students who have been hired on a Co-op basis may be granted limited facility access. In all cases, the following conditions apply:

1. Management reserves the right to revoke access at any time should the student's proficiency level be deemed inadequate during or post training.
2. The Co-op student must be under the supervision of a UW faculty member whom is an existing member of the RAC1/QNC Nanofab community.
3. The conditions listed above for Level B Members must be respected.
4. The Co-op student must be accompanied by a Level A Member at all times when working in the facility.
5. Limited equipment use. Training on and access to will be limited to the following equipment:

#### 1. Characterization:

- thin film measurement (Filmetrics systems only)
- microscopes

#### 2. Wet Benches:

- Develop/Solvent Wetbench ONLY

#### 3. Lithography:

- YES HMDS Oven
- Spin coaters (pieces & wafers)

#### 4. Dry Etch:

- YES PR Stripper
- Oxford Si Etch
- Oxford III-V & metals Etch

#### 5. Deposition:

- Oxford ALD/PECVD Cluster

CAS Log in

CAS Log in

Log in

Login Name

Password

Log in

Forgot your password?

**Facility Access Fees**

<p><b>Please Note:</b>                      Access rates are heavily subsidized by the following organizations:                      - Innovation Canada (CFI)                      - The Institute for Quantum Computing (IQC)                      - The Waterloo Institute for Nanotechnology (WIN)                      - The University of Waterloo</p> <p>Rates will be adjusted in the future to ensure long-term sustainability of operations.                      A minimum 3-month notice will be given prior to new rates coming into effect.</p>		<p><b>Equipment Groups &amp; Hourly Fees per Equipment Group **</b></p> <p>** Changes to access rates will be announced 3 months in advance of their coming into effect</p>								<p>NOTES:                      1) Fees shown are per person granted access, not per faculty member.                      2) Access rates are low as we are not equipped to implement monthly or quarterly caps at this time. This will be revisited in the future.                      3) There is no cap on special material costs (ex: Au, Pt, Ge or specialty chemicals) which are charged separately.                      The cost of routine process gases and chemicals (ex: routine resists and acids) is included in the rates shown.                      4) The lab access fee covers the cost of cleanroom gloves, wipes, apparel, etc.</p>
		E-Beam Lithography	Optical Lithography	Dry Etch	Deposition	Wet Processes	Ox-Diff, Anneal & Doping	Characterization & Testing	Assembly & Packaging	
	Raith 150TWO e-beam writer	Suss MA6 front/back aligner	Oxford ICP380 RIE - Chlorine	Oxford PECVD / ALD cluster	Solvent Fumehood		Dektak 150 profiler & film stress measurement			
		YES-310TA HMDS vapour prime oven	Oxford ICP380 DRIE (dedicated to Si etch)	IntiVac Nanochrome II evaporator	Non-HF Acid Fumehood		Olympus MX61 microscope			
		YES-CV200RFS plasma asher			HF Acid Fumehood		Filmetrics F50-UV film mapper			
		Spin-coat fumehood								
Equipment Use Fee (charged separately):	\$40.00	\$25.00	\$30.00	\$30.00	\$5.00	not available	NO CHARGE	not available		
Lab Access Fee (charged separately):					\$1.00					
Hands-on Training Fee (charged separately):					\$25					
General Support Fee (charged separately):					\$50					

APPENDIX D: SAMPLE INVOICE

Customer

**Dr. First Name Last name**  
 University of Waterloo  
 Institute for Quantum Computing  
 RAC1  
 200 University Avenue West,  
 Waterloo, Ontario Canada N2L 3G1  
 first.last@uwaterloo.ca

Quantum NanoFab  
 University of Waterloo  
 Building RAC 1  
 200 University Avenue West,  
 Waterloo, Ontario  
 CANADA N2L 3G1

519-888-4567 x38392  
 mlpayer1@uwaterloo.ca

University of Waterloo :: IQC :: Chemistry

Account Number	Terms	Period Begins	Period Ends	Invoice Date	Invoice #
XXXX XXX XXX XXXX XXXXXX XXXX XXXX XXX	Due upon receipt	01 Apr, 2012	30 Apr, 2012	Thu, 10 May, 2012	XXXX

Quantity	Description	Unit Price	Unit Subsidy	Extended Price	Extended Subsidy	Invoice Amount
12.2500	E-Beam Evap1	\$39.00	\$9.00	\$477.75	\$110.25	\$367.50
3.0000	Filmetrics F50-UV	\$10.00	\$10.00	\$30.00	\$30.00	\$0.00
12.2667	MA6 Aligner	\$39.00	\$14.00	\$478.40	\$171.73	\$306.67
2.2500	MX61 Microscope	\$15.00	\$15.00	\$33.75	\$33.75	\$0.00
5.0000	Oxford Cluster	\$39.00	\$9.00	\$195.00	\$45.00	\$150.00
7.2500	Oxford III-V & Metals Etch	\$39.00	\$9.00	\$282.75	\$65.25	\$217.50
13.5333	Pieces Coater	\$25.00	\$5.00	\$338.33	\$67.67	\$270.67
34.0500	Raith 150TWO	\$85.20	\$45.20	\$2,901.06	\$1,539.06	\$1,362.00
7.2667	Veeco Dektak	\$20.00	\$20.00	\$145.33	\$145.33	\$0.00
15.2500	Wetbench: Non-HF Acids & Bases	\$20.10	\$15.10	\$306.53	\$230.28	\$76.25
11.3167	Wetbench: Develop / Solvent	\$20.10	\$15.10	\$227.47	\$170.88	\$56.58
3.5000	Wetbench: HF Acid	\$20.10	\$15.10	\$70.35	\$52.85	\$17.50
1.2500	YES PR Stripper	\$25.00	\$5.00	\$31.25	\$6.25	\$25.00
3.0516	Gold Deposition (Lot Number 100)	\$60.47	\$0.00	\$184.51	\$0.00	\$184.51
3.0000	Training	\$50.00	\$25.00	\$150.00	\$75.00	\$75.00
0.5000	Staff Support	\$50.00	\$0.00	\$25.00	\$0.00	\$25.00
120.0000	Cleanroom Consumables Fee	\$1.00	\$0.00	\$120.00	\$0.00	\$120.00
				\$5,997.48	\$2,743.30	\$3,254.18

Total Invoice Amount  
 (Canadian Funds)



Please approve this invoice by signing and returning to the attention of Mary Lyn Payerl.

(authorized signature)

(print name)

(date)