Memo

To: uWaterloo *Quantum NanoFab* users community

From: Vito Logiudice on behalf of *Quantum NanoFab* Leadership Team:
Arthur Carty
David Cory
Raymond Laflamme
Tong Leung
Vito Logiudice

Date: December 12, 2011

Re: Quantum NanoFabrication Facility: Guiding principles for equipment selection

Project: CFI # 11544 *"From Nano Structures to Quantum Information Processing: A Technology Incubator for the 21st Century"*

PI: Raymond Laflamme

The QNC cleanroom fit-out exercise is scheduled to commence in Q2/2012. This requires that the specifications for the following fab equipment be identified by mid-January 2012:

1. 4-tube furnace stack
2. Sputter deposition system (for insulating films)
3. Ion mill
4. Fumehoods
5. Semi-automatic photoresist spin-coater

These and future *Quantum NanoFab* equipment acquisitions will be made under the same guiding principles used to purchase the equipment currently installed in the RAC1 temporary facility (existing equipment is listed in Appendix A):

1. **Select equipment which will be routinely used by a large majority of researchers**
    - Consistently idle equipment will not perform well. Daily use ensures that systems remain in an optimal state of repair and performance.
    - This is a shared facility with a diverse membership. Equipment dedicated to limited or excessively contaminating applications will not be installed in this facility and will not be purchased under this CFI project.

2. **Select proven platforms from well-established and reputable equipment vendors**
    - Funds will be spent on excellent systems with a significant, existing presence in North America.

3. **Place all equipment under the operational control of the facility's Director of Operations**
    - Ensures the facility and its equipment are professionally and rigorously operated and maintained.
    - Ensures fair and consistent access to anyone qualified to become a lab member and prepared to abide by facility governance and access policies:

      http://qncfab.uwaterloo.ca/

The Quantum NanoFab Leadership Team is providing the community with an opportunity to comment on the specifications for this ensemble of equipment.

Interested parties are asked to submit their input via email to Vito Logiudice or to any member of the leadership team **by January 14, 2012**.

Base specifications are summarized as follows. Specific requests for community input are highlighted in bold text.

1. 4-tube furnace stack

a) Purpose: High purity deposition or thermal growth of various materials.

b) Mask material: N/A

c) Materials:
- TUBE 1: LPCVD deposition of low-stress silicon nitride
- TUBE 2: LPCVD deposition of polysilicon and amorphous silicon
- TUBE 3: undoped low temperature oxide (LTO) and phosphorous-doped low temperature oxide (PSG)
- **TUBE 4: ?**
  Possibilities:
  a) atmospheric forming gas contact anneal
  b) atmospheric dry/wet thermal oxidation
  c) LPCVD deposition of silicon carbide
  d) other?
  NOTE: We will proceed with option "a" if no input is received

d) Substrate size:
- 10mm x 10mm pieces to 150mm diameter wafers

e) Features of interest:
- each furnace tube independently controlled & capable of simultaneous operation
- entire stack fully computer controlled and automated
- multiple recipe storage and password-driven system access
- precise computer control of all recipe parameters (temperature profile, gas flow, pressure)
- data logging of all recipe parameters
- gas flow control via precision mass flow controllers (MFC's)
- 3-zone, precision furnace elements
- automated, speed-controlled load/unload including load station with laminar flow module
- flat zone large enough to accommodate one 25-wafer cassette
- independent gas manifold for each tube
- vented gas manifold cabinet
- dry pumps with pressure control, gate valve, mesh traps, etc.
- exhaust abatement system
- automatic gas cylinder cabinets for toxic/flammable process gases

f) Uniformity:
- better than 5% over a 150mm wafer

2. <u>Sputter deposition system (insulating films)</u>

a) Purpose: System dedicated to depositing good quality insulating films (no metals)

b) Mask material: N/A

c) Materials:
- SiO_x
- SiC
- Al_2O_3
- MgO_2
- **OTHER?**

d) Substrate size:
- 10mm x 10mm pieces to 150mm diameter wafers

e) Features of interest:
- load-locked
- turbo-pumped process chamber
- dry roughing pump
- 3 confocally mounted, **600W (?), 3” diameter (?)** planar RF magnetron sources with independent automatic match networks & power supplies

<u>NOTE:</u> We will proceed with 600W, 3” diameter if no input is received

- Ability to ignite at least 2 targets at once for co-sputtering
- clamped targets for easy changeout
- **Sputter down configuration?**

<u>NOTE:</u> We will proceed with “sputter down” if no input is received

- independently RF biased (300W, for cleaning), rotating substrate holder (20 rpm) with dedicated automatic match network
- **substrate heating to 700°C?**

<u>NOTE:</u> We will proceed with 700°C maximum if no input is received

- water-cooled, tilting substrate holder
- 3 gases: Ar, O_2, N_2
- precision gas mass flow controllers
- precision, automatic pressure control
- fully computer controlled and automated
- multiple recipe storage and password-driven system access
- data logging of all recipe parameters

f) Uniformity:
- better than 5% over a 150mm wafer

3. <u>Ion Mill</u>

a) Purpose: Controlled etching of thin-film materials which are not easily etched by routine wet etch or dry (RIE) etch methods. This is accomplished by exposing the material to a large-area, collimated beam of Ar ions.

b) Mask material: Photoresist

c) Materials:
- Bismuth
- Selenium
- Tellurium
- BST (Barrium Strontium Titanate)
- YCBO
- Strontium
- Ruthenium
- Gold
- Platinum
- Copper
- Iron
- Al_2O_3
- Nb, NbN, NbTi, NbTiN
- **OTHER?**

d) Substrate size: - 10mm x 10mm pieces to 150mm diameter wafers

e) Features of interest:
- load-locked
- turbo-pumped process chamber
- dry roughing pump
- 15cm (minimum) RF Inductively Coupled Plasma source
- water-cooled, tilting, rotating substrate holder (20 rpm)
- SIMS end-point detection
- Ar gas only (but pre-configured to accept 2 more future gases)
- precision gas mass flow controllers
- automatic pressure control
- fully computer controlled and automated
- multiple recipe storage and password-driven system access
- data logging of all recipe parameters
- single, 2” RF sputter source with automatic match network & power supply
- exhaust abatement system

f) Uniformity: - better than 5% over a 150mm wafer

4. Fumehoods

a) Purpose: Routine processes including:
- Furnace pre-clean (RCA cleans)
- Photoresist strip via piranha solutions
- Metals etch (ex: PAN etchants for Al etch)
- Silicon nitride etch (phosphoric acid solutions)
- Bulk silicon etch (TMAH or KOH based etchants)
- **OTHER?**

b) Mask material: N/A

c) Materials: See “a” above

d) Substrate size: - 10mm x 10mm pieces to 150mm diameter wafers

e) Features of interest:
- dedicated baths where reasonable (ex: heated quartz bath for piranha with H_2O_2 spiking mechanism)
- automatic spin rinser/dryers where desirable
- Nitrogen blow guns
- hotplates
- automated acid waste neutralization facility for ensemble of acid benches
- temperature-controlled baths where desirable
- **OTHER?**

5. Semi-automatic photoresist spin-coater

a) Purpose: Reliable, consistent and uniform coating of various photoresist types with minimal resist consumption.

b) Mask material: N/A

c) Materials: e-beam & UV resists, SOG

d) Substrate size: - 10mm x 10mm pieces to 150mm diameter wafers

e) Features of interest:
- good low-speed operation for improved coverage over severe topographies
- manual substrate load
- covered bowl
- motorized syringe dispense system mounted on programmable dispense arm
- resist nozzle auto clean
- edge-bead remover
- nitrogen purge for removing particles on substrate prior to dispense
- solvent dispense nozzle for substrate solvent cleaning

f) Uniformity: - better than 5% over a 150mm wafer

Appendix A

Equipment currently available in the RAC1 temporary facility:

1. **Deposition**
    a. PVD: IntlVac Nanochrome II e-beam and thermal evaporator
    b. PECVD & ALD: Oxford Instruments System 100 PECVD clustered with a FlexAL thermal & plasma ALD
2. **Dry Etch**
    a. Photoresist strip & descum: YES-CV200RFS O_2 & N_2 plasma etch
    b. Silicon etch: Oxford Instruments ICP380 Deep RIE (Bosch & mixed-gas processes)
    c. III-V & Metals etch: Oxford Instruments ICP380 inductively coupled plasma RIE
3. **Lithography**
    a. E-beam exposure: Raith 150^{TWO} direct write 30keV EBL system
    b. UV exposure: Suss-Microtec MA6 front/back aligner & broadband exposure system
    c. Manual photoresist spin-coaters (2)
    d. Hotplates (2)
    e. Oven: YES-310-TA HMDS vapour prime & ammonia-based image-reversal oven
4. **Fumehoods** (3 + 1 spin-coating hood)
    a. Acids (non-HF)
    b. Acids (HF)
    c. Develop + Solvents
5. **Characterization**
    a. Reflectometers (2)
        i. Filmetrics F50-UV thin film mapper
        ii. Filmetrics F40 spot measurement system
    b. Profilometer: Veeco Dektak 150
    c. Microscope: Olympus MX61 semiconductor inspection microscope

General specifications for each system can be found on the facility's public site:

https://qncfab.uwaterloo.ca/equipment/summary

Additional, more detailed information is password-protected and is available to registered members of the *Quantum NanoFab* community:

https://qncfab.uwaterloo.ca