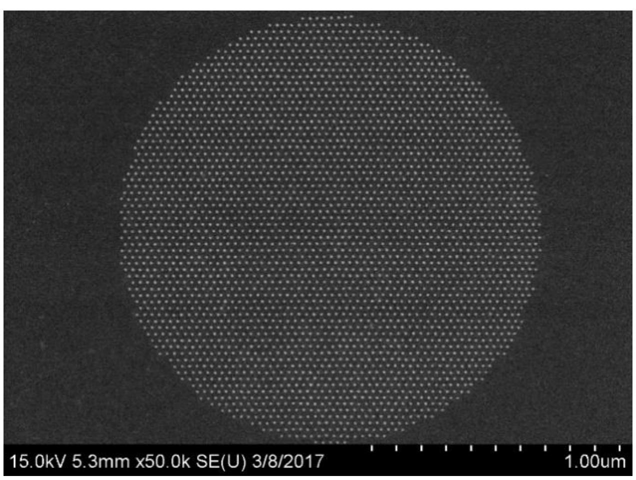
Applied Quantum Materials Inc.

AQM HSQ / H-SiO_x

H-SiO_x is a high purity, silsesquioxane-based solid with a long shelf life (>1 year when stored correctly). It is soluble in most organic solvents (e.g., anisole, *n*-butyl acetate, hexanes, methyl isobutyl ketone [MIBK], 2-propanol, toluene, xylenes). H-SiO_x is commonly dissolved in MIBK, but carrier solvent investigations by AQM support an increased shelf-life in *n*-butyl acetate (HDPE container). The solutions are dispensed onto substrates/wafers and dispersed via spinning. After spinning, a film of H-SiO_x remains that can be used as a resist or spin-on dielectric. H-SiO_x can be used in electron beam (EB), extreme ultraviolet (EUV), and nanoimprint lithography systems.

Sufficiently dosed H-SiO_x forms a low dielectric constant (low-κ) silicon-rich oxide that is resistant to removal by hydroxide-based developers, such as tetramethylammonium hydroxide (TMAH) (e.g., MF-319, MF-CD-26) and Salty Developer (NaOH/NaCl).

AQM is constantly synthesizing, testing, and improving its H-SiO_x to meet and exceed customers' expectations. AQM has sold H-SiO_x since 2017 and has distributors located in the United States (DisChem Inc.), Europe (EM Resist Ltd), China (GT Nano), Japan (OptoSirius), Korea (HunetPlus).



Lithography features:

- Thin uniform films (5 nm – 2 μm thickness)
- High resolution (capable of ≤10 nm patterning)
- Excellent line edge roughness
- Good dry-etch resistance

Other Applications:
- Photoresist for mask making.
- Mask for etching, e.g. Si, SiO_2, Si_3N_4 or metals.
- Silicon-based photonics – waveguide components, grating couplers, and photonic crystals.
- Generation of stamps with nanopatterns.

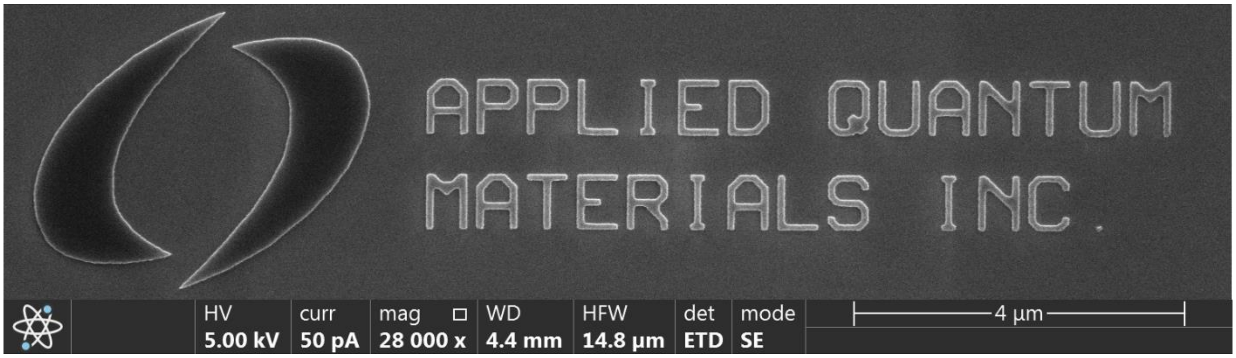


Figure 1. SEM image of an AQM logo (~13.5 µm wide, ~80 nm thick layer) exposed at 400 µC/cm^2 (RAITH150 Two at 30 kV, 15 µm aperture), developed in MF-319 for 90 seconds, and then rinsed with deionized H_2O for 60 seconds. Taken at the UofA nanoFAB.

Purchasing:

AQM H-SiO_x solid can be purchased separately or in a resist kit containing solid, HPLC grade *n*-butyl acetate (≥99.7) or MIBK (≥99.5%), syringes with PTFE filters.

H-SiO_x solutions can be made to standard 1, 2, 4, 6 or custom weight percentage. For the best results, it is recommended that freshly opened *n*-butyl acetate or MIBK is used. AQM is currently developing our own line of developer solutions: Salty Developer (NaOH/NaCl); TMAH (various concentrations). Contact us for details and pricing.

Examples H-SiO_x solutions available:

Solution w/w	*n*-Butyl Acetate	H-SiO_x
1 %	25.0 mL	0.223 g
6 %	17.8 mL	1.00 g
6 %	25.0 mL	1.41 g
20 %	4.5 mL	1.00 g
20 %	5.0 mL	1.10 g

Solution w/w	MIBK	H-SiO_x
1 %	25.0 mL	0.202 g
6 %	19.6 mL	1.00 g
6 %	25.0 mL	1.28 g
20 %	5.0 mL	1.00 g

Solutions should be made with high accuracy measuring instruments (do not use glass) for the most consistent coating thicknesses.

HDPE containers are filled to 80% capacity due to shipping regulations. Common sizes available include 8, 30, 60, 125, 250, 500, and 1000 mL (Max volumes: 6, 24, 48, 100, 200, 400, and 800 mL, respectively)

Shelf-Life and Storage:

- Solid: at least 1 year when stored in a vacuum (≤30 mmHg) at ambient temperature in HDPE.
- Dissolved in *n*-butyl acetate: greater than 3 months (estimate: at least 9 months) when contained in a sealed HDPE bottle, kept in a low-moisture environment.
- Dissolved in MIBK: at least 3 months when contained in a sealed HDPE bottle, kept in a low-moisture environment.
- Solutions: Shelf-life may be extended by storing at significantly lower temperatures. Storing in a fridge is not significantly colder than room temperature. Containers should never be opened below room temperature.

Applied Quantum Materials Inc.
B211, 2011 – 94 St.
Edmonton, AB, Canada, T6N 1H1
Solutions in Silicon
contact@aqmaterials.com
Tel: 1(587) 635-2060
www.aqmaterials.com

Spin Curves:

H-SiO$_x$-15 in n-butyl acetate:
Spin curves were constructed using 10 x 10 mm P-Type Silicon wafers. The wafers were centered on a Laurell Model WS-400B-6NPP Spin Coater. Using a sterile syringe, 1-2 drops of H-SiO$_x$ in *n*-butyl acetate was added; the spinner lid was closed, and the wafer spun at the desired speed for a total of 60 seconds (1 second ramp to speed). Thicknesses were measured on a Filmetrics F50-UV.

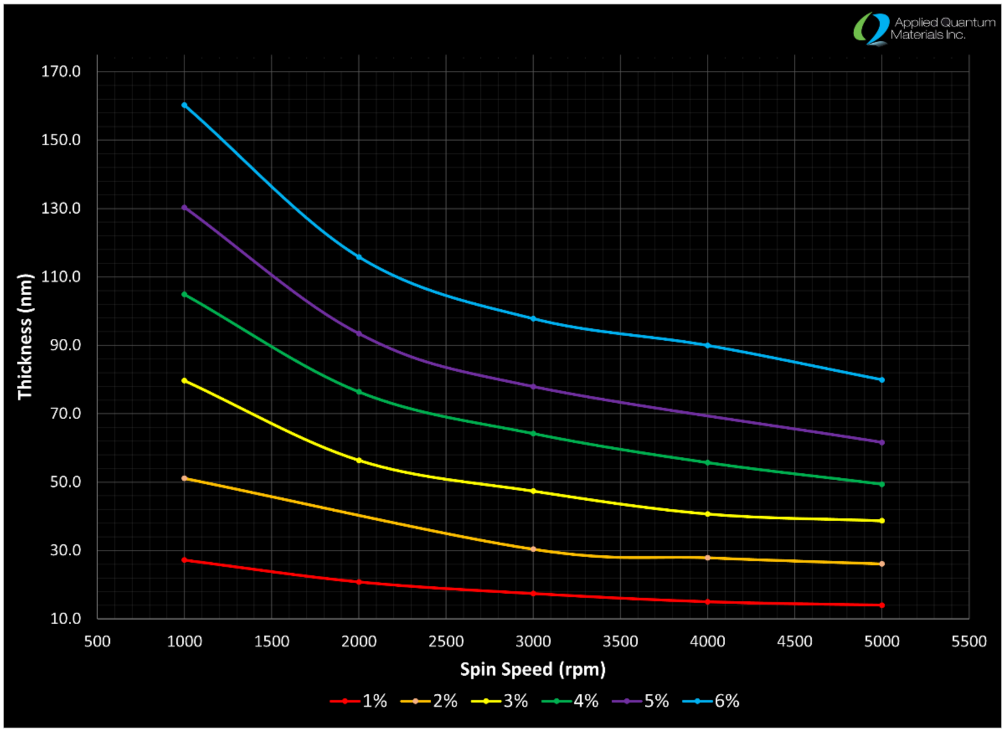


Figure 2. Spin Curves for H-SiO$_x$ at 1, 2, 3, 4, 5 and 6% (w/w) in *n*-Butyl acetate.

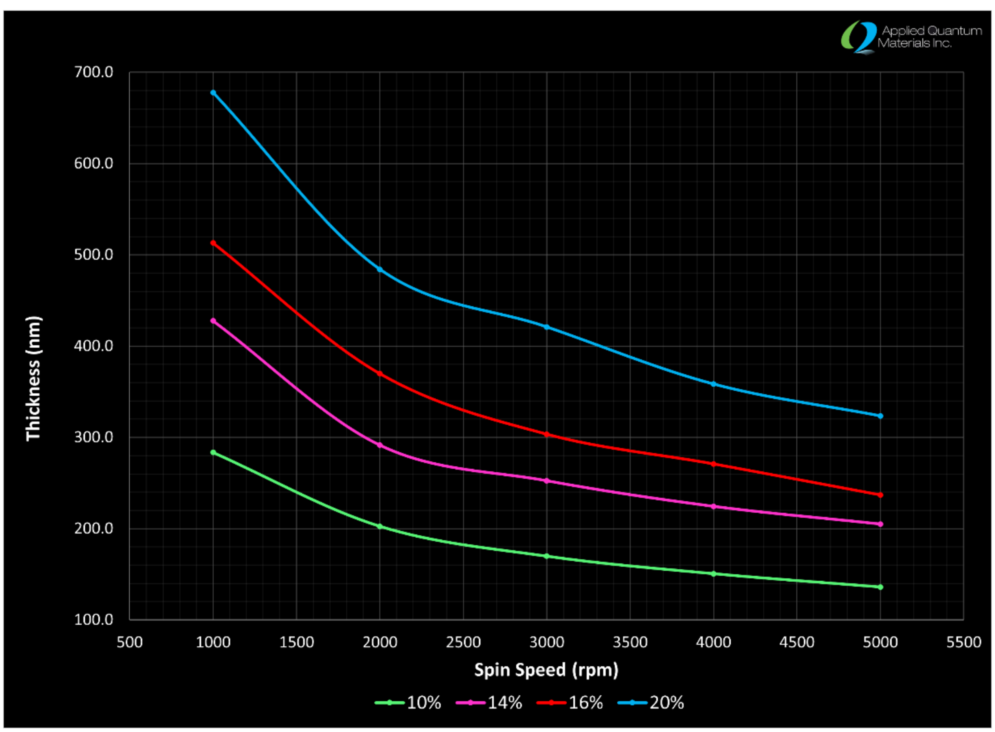


Figure 3. Spin Curves for H-SiO$_x$ at 10, 14, 16, and 20% (w/w) in *n*-Butyl acetate.

H-SiOx-15 in MIBK:

Spin curves were constructed using freshly piranha cleaned 10 x 10 mm P-Type Silicon wafers. The wafers were prebaked at 180 °C for >3 minutes, transferred to a Brewer 200X Spin Coater, and centered. Using a sterile syringe, 1-2 drops of H-SiO_x in MIBK (passed through a 0.1 µm PTFE filter if specified) was added; the spinner lid closed, and the wafer spun at the desired speed for a total of 60 seconds (1 second ramp to speed). A post-apply bake at 80 °C for 3 minutes was performed before measuring the thicknesses on a Filmetrics F50-UV.

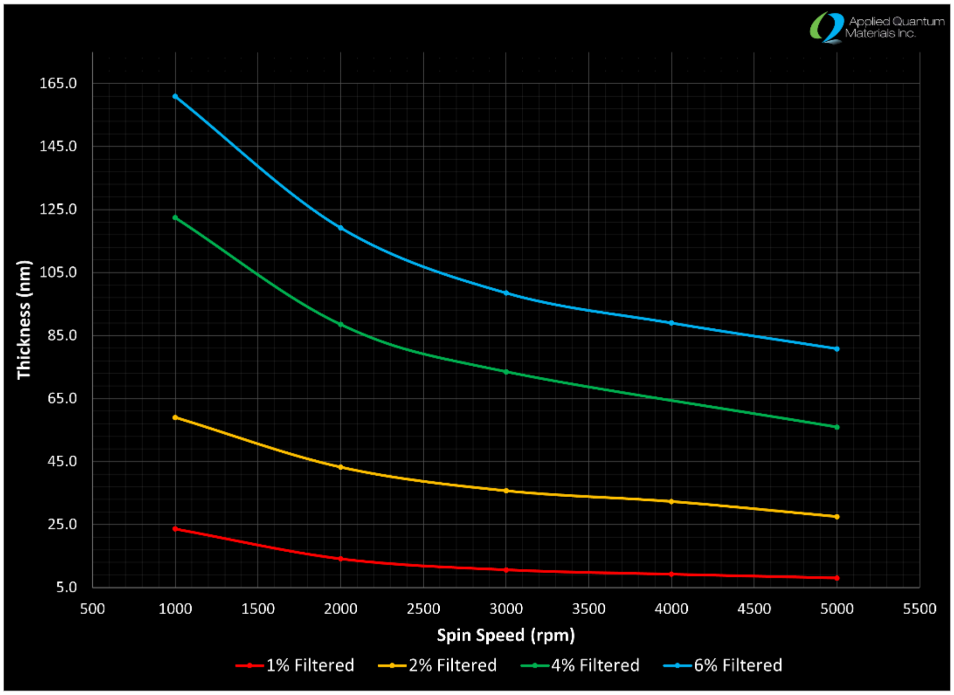


Figure 4. Spin Curves for H-SiO_x at 1, 2, 4 and 6% (w/w) in MIBK.

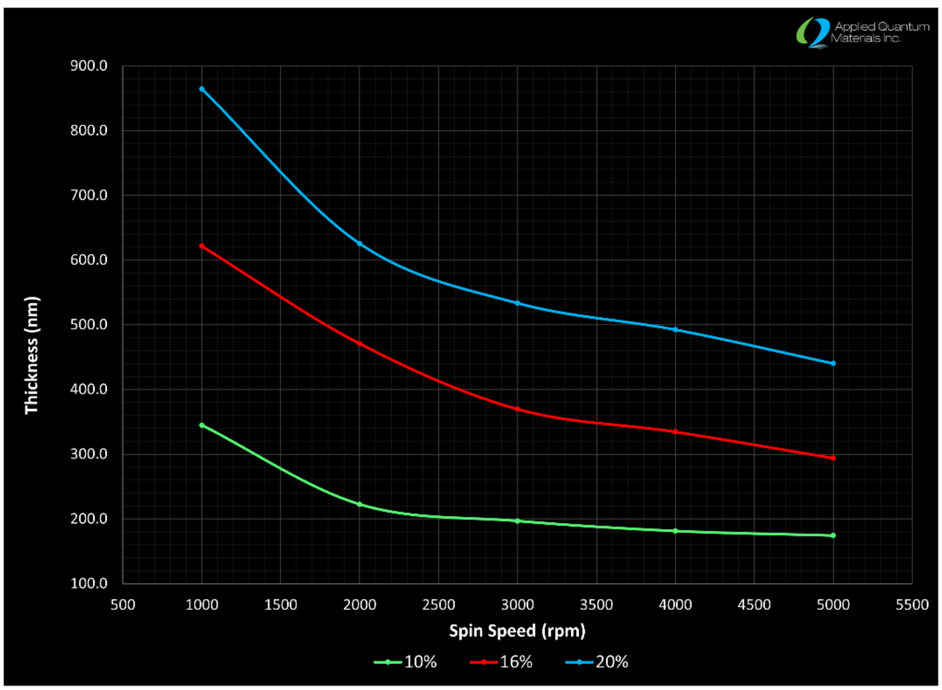


Figure 5. Spin Curves for H-SiO_x at 10, 16, and 20% (w/w) in MIBK.

Contrast Curves:

H-SiO_x-15 deposited in n-butyl acetate

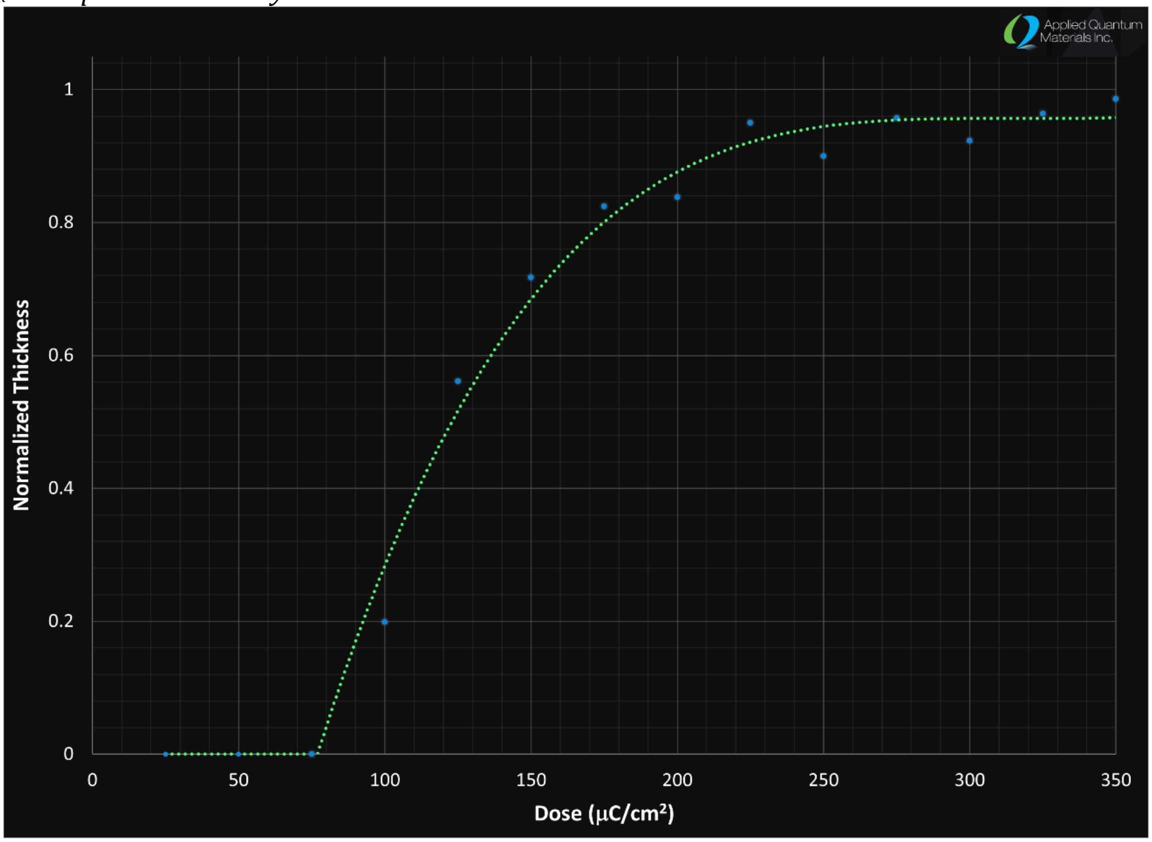


Figure 6. Contrast Curve of ~100 nm H-SiO_x. Developed in MF-319 for 90 sec.

Note: Contrast curve was constructed using the thicknesses of rectangles (supposed to be 20 x 50 μm) formed on an ~100 nm thick layer of H-SiO_x (spin process above). The H-SiO_x was exposed using a RAITH150 Two at 30 kV, developed in MF-319 for 90 seconds, and rinsed with deionized water for 60 seconds. The dose rectangles thicknesses were determined using an Alpha-Step IQ.

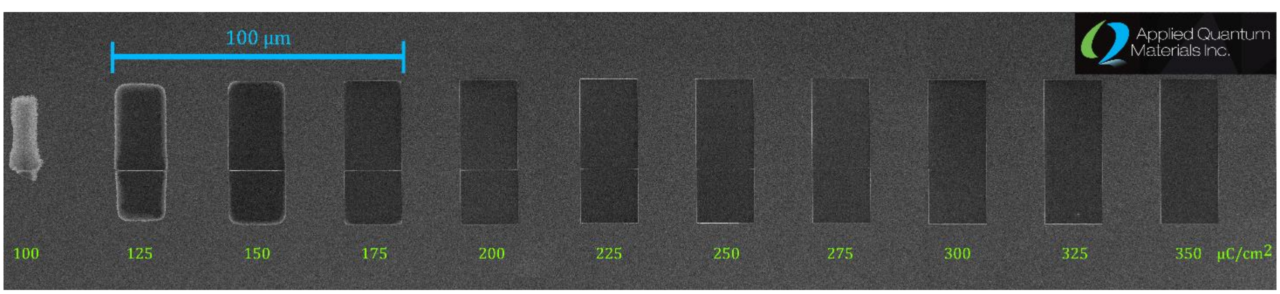


Figure 7. SEM image of dose rectangles formed on an exposed (RAITH150 Two at 30 kV, 15 μm aperture) and developed (MF-319, 90 seconds, deionized H_2O 60 seconds) ~100 nm thick layer of H-SiO_x. The dose rectangles are supposed to be 20 x 50 μm.

Note: For smaller features (e.g., lines smaller than 100 nm) higher doses (>500 μC/cm^2) are required for an ~100 nm thick layer developed in MF-319 for 90 sec.

H-SiO_x-15 deposited in MIBK

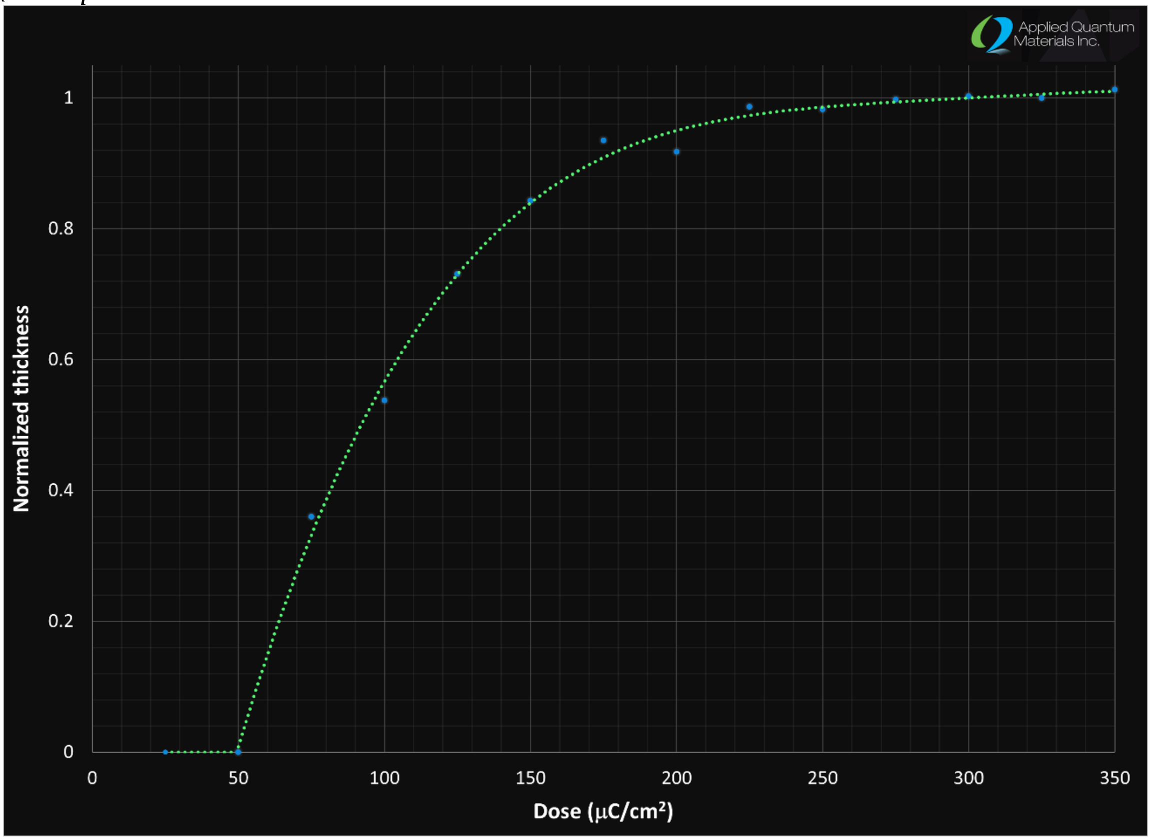


Figure 8. Contrast Curve of ~80 nm H-SiO_x. Developed in MF-319 for 90 sec.

Note: Contrast curve was constructed using the thicknesses of rectangles (supposed to be 20 x 50 μm) formed on an ~80 nm thick layer of H-SiO_x (spin process above). The H-SiO_x was exposed using a RAITH150 Two at 30 kV, developed in MF-319 for 90 seconds, and rinsed with deionized water for 60 seconds. The dose rectangles thicknesses were determined using an Alpha-Step IQ.

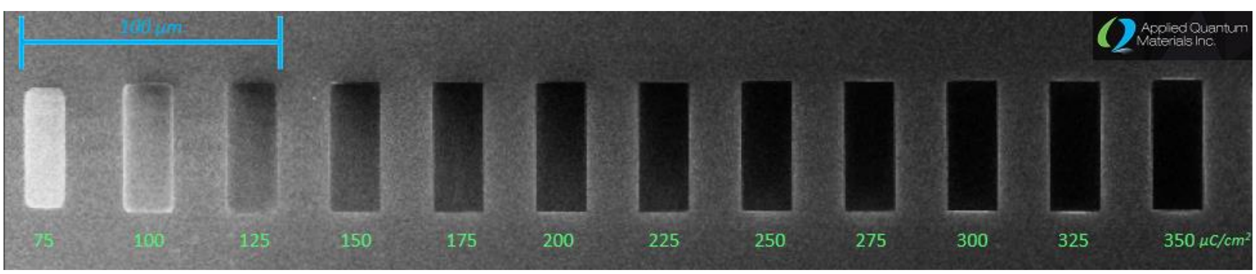


Figure 9. SEM image of dose rectangles formed on an exposed (RAITH150 Two at 30 kV, 15 μm aperture) and developed (MF-319, 90 seconds, deionized H_2O 60 seconds) 80 nm thick layer of H-SiO_x. The dose rectangles are supposed to be 20 x 50 μm.

Note: For smaller features (e.g., lines smaller than 100 nm) higher doses (>400 μC/cm²) are required for an ~80 nm thick layer developed in MF-319 for 90 sec.