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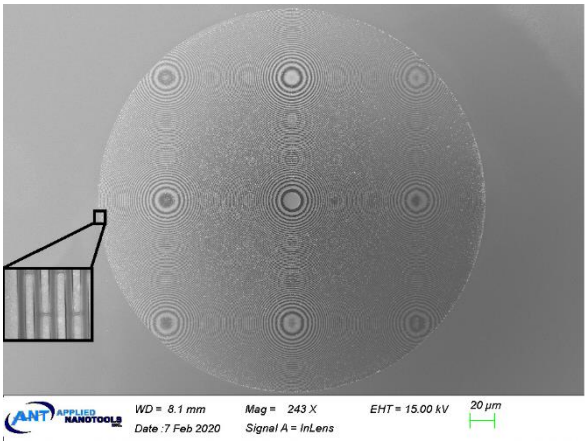
Quantum Materials for Next-Generation Photonic and Optoelectronic Devices

Photopolymerization of resins is a versatile and rapidly advancing approach for fabricating complex 3D microstructures such as metasurfaces, optical waveguides, and stereolithography-based devices. Incorporation of AQM's photoluminescent silicon quantum dots (SiQD) into these printed architectures enables active optical functionality, including photonic microdevices, luminescent metasurfaces, fluorescent cell-scaffolding systems, spatially encoded biosensors, lab-on-a-chip platforms, and volumetric or microscale emissive display elements.



AQM's silicon-based inorganic polymers like HSQ are a foundation for electron-beam (EBL), EUV, ion-beam, direct write, and nanoimprint lithography. These materials can be modified by appropriate thermal or plasma treatments to modulate etching selectivity and surface topography. Next generation applications include:

- **Quantum Photonic Integrated Circuits (QPICs):** silicon waveguides, micro-optics, couplers, photodetectors and modulators, while integrating III-V materials for light generation. Photonic crystals are used to manipulate and control the flow of light.
- **Single-Photon Sources and Detectors:** Advanced light sources including SiQDs can be paired with waveguide-integrated superconducting nanowire single-photon detectors (SNSPDs). These Zero-dimensional semiconductor nanocrystals offer size-tunable light emission. They are ideal for high-efficiency LEDs, displays with superior colour purity, and single-photon sources for quantum communication.
- **Diffractive X-Ray Lenses & Fresnel Zone Plates:** Ultra-fine 3D staircases and ring patterns designed to focus X-rays for high-precision microscopy.
- **Micro-Supercapacitors & NEMS:** 3D printed networks that act as scaffolds for hierarchical energy storage or tiny mechanical components.
- **3-Dimensional Metastructures:** Polymeric resins create nanoscale structures by stereolithography, 2 photon polymerization and volumetric additive manufacturing producing micro-optics, and micro-electromechanical systems (MEMS). Because these structures are solid inorganic glass, they are chemically resistant, can withstand temperatures of 600 C, and can achieve nanoscale feature sizes as low as 20 nm.
- **Ultra-High-Resolution Lithography:** HSQ preserves sharp, low line edge roughness, compact molecular profiles when exposed to high-energy beams like electrons, photons, and x-rays. This allows resolutions down to <5 nm half-pitch, vital for manufacturing advanced transistors and nanophotonic devices.
- **Superior Interlayer Dielectric (ILD):** HSQ provides excellent planarization and gap-filling properties. Our "spin-on-glass" has a low dielectric constant, (κ~3) and reduces resistance-capacitance delays, allowing for faster signal propagation in microchips.
- **Thin-Film Protection:** Due to its low-temperature curing capabilities, our resins act as a protective coating that shields components against corrosion and degradation.