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Investigation of the Mechanical Frequency Response of Silicon Photonic Crystal Membranes

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Silicon-on-insulator (SOI) has become a popular substrate for microelectromechanical systems and photonic integrated circuits by leveraging established complementary-metal-oxide semiconductor technologies. The mechanical characterization of microstructures developed on SOI is both a challenging and necessary step required to validate and optimize designs.

By incorporating metal across a photonic crystal (PC) membrane and passing an AC current through it, a time-harmonic Lorentz-force with components in two directions can be established under an external magnetic field. Deflections of the membrane were monitored using perturbations in the optical signal through near-field coupled silicon PC edge waveguides. The near-field coupling of the silicon photonic edges is significantly enhanced by the dispersive properties of PC waveguides that effectively slow light. [1].

Here at the Western Nanofabrication Facility, a lift-off electron-beam evaporation process was used to pattern Silver and Chromium across a PC membrane. Subsequent buffered hydrofluoric acid (BHF) etching selectively removes the buried oxide, forming a PC membrane. The frequency of harmonic oscillations in the optical transmission was found to match the frequency of the current injected into the metal. The mechanical frequency response of the membrane was characterized by recording the perturbation amplitude of the optical transmission as a function of the frequency of AC current.

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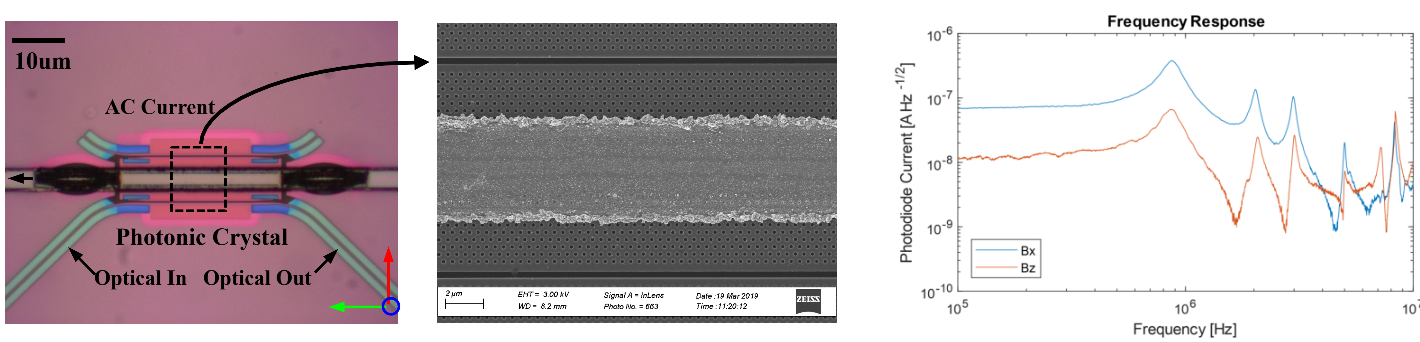

Fig. 1 (a) Optical image of device after BHF etching showing the optical I/O, deposited metal, and photonic crystal region (b) LEO 1530 SEM image of region indicated with 5 μm wide patterned Silver/Chromium microwire (c) Dynamic response of the photonic crystal membrane under two different external magnetic field orientations.

[1] M. Zylstra, A. Bakhtazad, J. Sabarinathan, “Photonic crystal split defect directional couplers for sensor applications” ICOOPMA, Montreal, Canada, Jun. 2016.

Combining the Power of Light, Lithography & Ligands in a Quest for Patterned Ceramics

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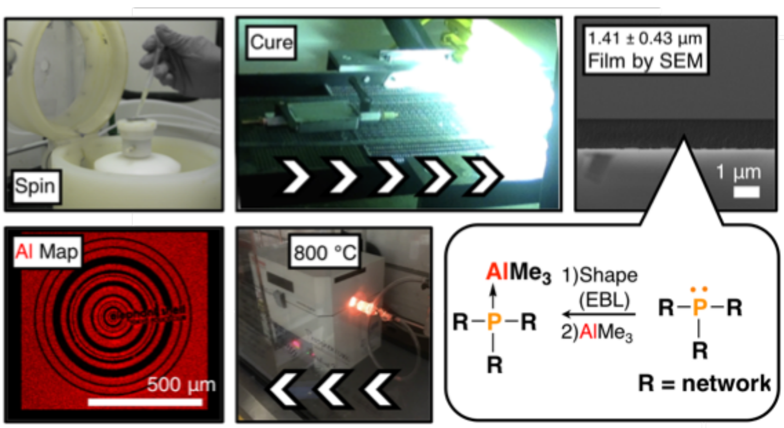
In 1965, the cofounder of Intel, Gordon E. Moore predicted that the number of components in an integrated circuit would have to double every year in order to keep up with increasing data storage demands for digital electronic devices. The prediction has been an accurate model for the industry in the past five decades and has provided the challenge for information technology (IT) engineers to incorporate more silicon-based components into smaller spaces. However, this method of shrinking silicon-based materials has reached its performance limit. In order to move away from these small-scale demands, IT engineers are now forced to seek new materials that function in a completely different way from classic electronic materials. While an optimal material has yet to be developed, promising candidates are ceramics composed of elements spanning the periodic table.[1]



Inspired by the self-assembly and pyrolysis of metal-containing block-copolymers,[2–4] the Ragogna Research Group at Western is in the process of developing a new general method to simultaneously synthesize and pattern ceramics with varied elemental composition.[5] We have developed a phosphorus-based material that can be cast into thin films and cured with ultraviolet light into a solid material. This solid material can be selectively degraded using electron beam lithography (EBL), which allows us to apply patterns to the material. The advantage of using phosphorus in this context is that it has an ability to act as a ligand to a wide array of elements. Patterns can be applied to the solid thin films and the material can subsequently be functionalized with metals. We have found that on pyrolysis, the material degrades leaving behind a ceramic that exhibits shape retention of the original pattern.

Taking advantage of the ability of phosphorus to bind to a wide array of metals, this method could be easily extended to other elements. We have already explored how it behaves in the presence of Co, Mo, Al, Ge and Sb and continue to explore its affinity for the diverse elements of the periodic table.[6] Further, the fact that the material is cured using UV-light will allow us to entertain the alternative possibility of patterning these materials by scalable photomasking techniques.

References

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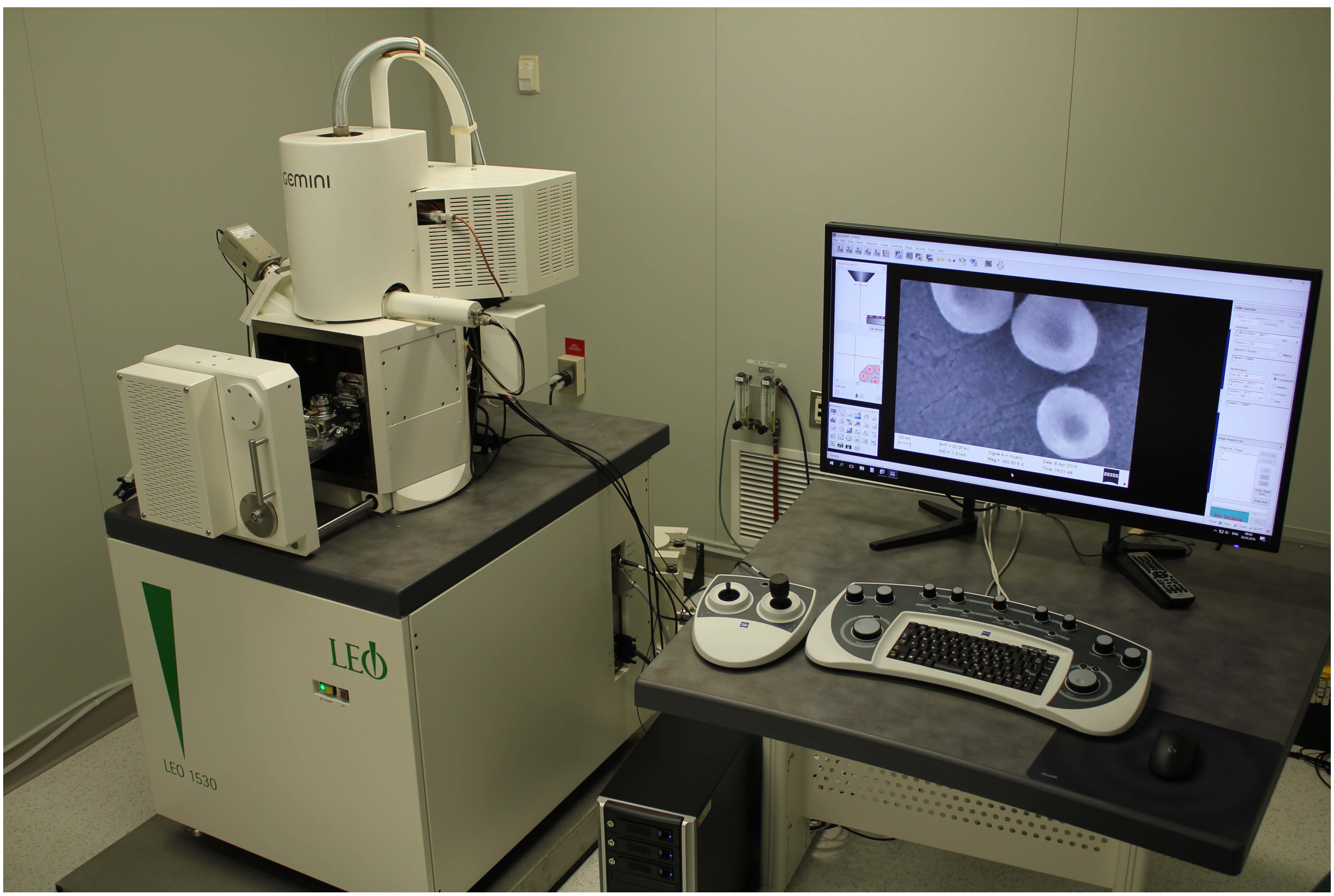
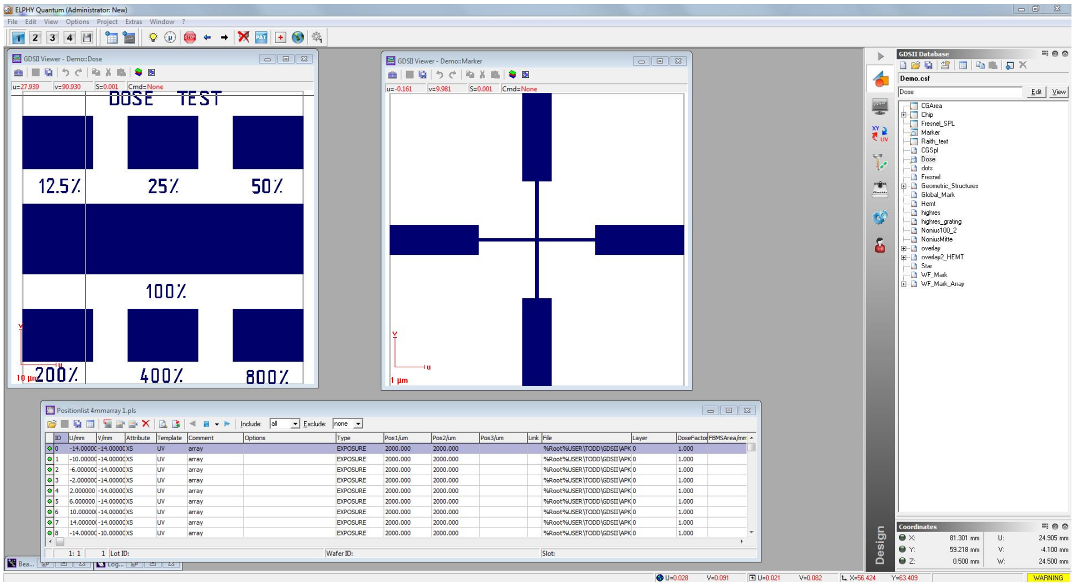
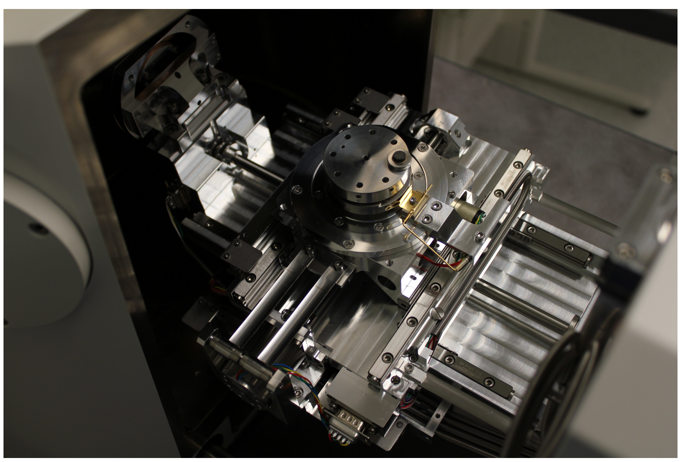
New Instrumentation at The Western Nanofabrication Facility

The upgrade to the 1530 Field Emission SEM is complete. The microscope stage has been replaced with a new 5-axis manipulator, allowing a full range of imaging geometries. The control system has been fully updated with a Windows 10 PC, the latest Zeiss SmartSEM 6.0 software, and a full hardware control panel and joystick. The Zeiss software is renowned for its intuitive interface and is exceptionally user friendly. High quality images are easily acquired even by occasional users. Training is now available now.

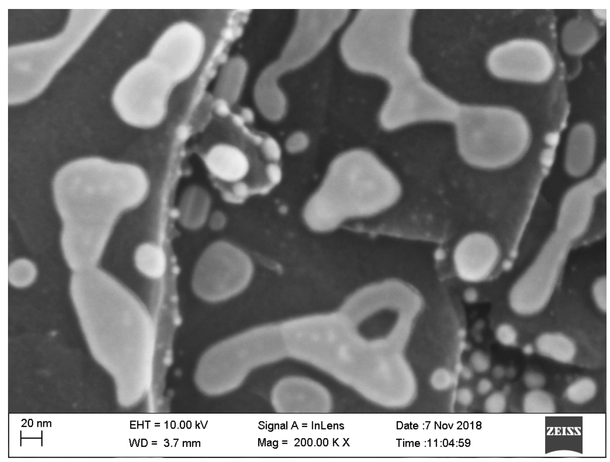




The e-beam lithography system has also been upgraded with the installation of the Raith Elphy Quantum system. The new software provides user friendly writing of patterns from CAD drawings in electron beam sensitive resist. The patterns can then be transferred to the substrate with subsequent etching or deposition processes.



The new 5-Axis stage. The stage accepts sample holders for mounting stubs, wafer pieces and full 4-inch wafers.



Gold on Carbon 200K Magnification

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