Nanoscale Science and Technology Division
Room 304 - Session NS2+AP+BI-MoA

Fabrication and Operation of Nano-Systems
Moderator: David Czaplewski, Argonne National Laboratory

4:00pm **NS2+AP+BI-MoA-8 Control of Color Centers in Diamond using Photonic and Phononic Crystals*, Kazuhiro Kuruma,*** Harvard University **INVITED**

Color centers in diamond are one of the promising solid-state quantum emitters for the realization of on-chip quantum network. In particular, SiV centers have been investigated owing to their optically accessible spins as well as large and stable zero phonon line emission in photonic nanostructures. The integration of the SiV centers into the nanostructures such as photonic crystal nanocavities has been demonstrated as an efficient spin-photon interface for various quantum applications [1]. However, SiV centers need operations at mK temperatures [2] or under static strain [3] to achieve a long spin coherence time. I will show another potential approach using phononic crystals as a way to enable the realization of a long spin coherence time at higher temperatures[4]. Our efforts aimed at efficient control of the SiV spins using diamond optomechanical cavities will also be discussed [5]. Finally, I will present our works on the integration of tin-vacancy (SnV) centers, alternatives to SiV centers for operations at higher temperatures, into free-standing photonic crystal nanocavities [6].

1. M. K. Bhaskar, R. Riedinger, B. Machielse, D. S. Levonian, C. T. Nguyen, E. N. Knall, H. Park, D. Englund, M. Lončar, D. D. Sukachev, and M. D. Lukin, "Experimental demonstration of memory-enhanced quantum communication," Nature 580, 60–64 (2020).
2. D. D. Sukachev, A. Sipahigil, C. T. Nguyen, M. K. Bhaskar, R. E. Evans, F. Jelezko, and M. D. Lukin, "Silicon-Vacancy Spin Qubit in Diamond: A Quantum Memory Exceeding 10 ms with Single-Shot State Readout," Phys. Rev. Lett. 119, 223602 (2017).
3. Y.-I. Sohn, S. Meesala, B. Pingault, H. A. Atikian, J. Holzgrafe, M. Gündoğan, C. Stavrakas, M. J. Stanley, A. Sipahigil, J. Choi, M. Zhang, J. L. Pacheco, J. Abraham, E. Bielejec, M. D. Lukin, M. Atatüre, and M. Lončar, "Controlling the coherence of a diamond spin qubit through its strain environment," Nat. Commun. 9, 2012 (2018).
4. C. Chia, K. Kuruma, B. Pingault, M.. Lončar. "Controlling Coherence Time of Silicon Vacancy Centers in Diamond Using Phononic Crystals." CLEO 2021, FTh4M.2, San Jose, California, May 2021.
5. M. Haas, K. Kuruma, G. Joe, B. Machielse, D. Assumpcao, C. Chia, N. Sinclair, and M. Lončar, "Visible-Wavelength Optomechanical Crystal for Coupling Phonons to a Silicon Vacancy Center in Diamond", CLEO 2022, FW4I.2, San Jose, USA, May 2022
6. K. Kuruma, B. Pingault, C. Chia, D. Renaud, P. Hoffmann, S. Iwamoto, C. Ronning, and M. Lončar, "Coupling of a single tin-vacancy center to a photonic crystal cavity in diamond," Appl. Phys. Lett. 118, 230601 (2021).

4:40pm **NS2+AP+BI-MoA-10 Scalable Preparation of Intrinsically Chiral Metal Surfaces for Enantioselective Processes*, Nisha Shukla,*** *A. Gellman,* Carnegie Mellon University, USA

Chiral surfaces are critical components of enantioselective heterogeneous processes such as those used to prepare enantiomerically pure pharmaceuticals. While the majority of chiral surfaces in practical use are based on achiral materials whose surfaces have been modified with enantiomerically pure chiral adsorbates, there are many inorganic materials with valuable surface properties that could be rendered enantiospecific, if their surfaces were intrinsically chiral.

This work discusses recent developments in the fabrication of intrinsically chiral surfaces exhibiting enantiospecific adsorption, surface chemistry and electron emission. We propose possible paths to the scalable fabrication of high-surface-area, enantiomerically pure surfaces and discuss opportunities for future progress.

5:00pm **NS2+AP+BI-MoA-11 Wrinkle-Induced, Scale-Dependent Mechanical Properties in Nanometer Thick Films*, Jian Zhou,*** *N. Moldovan, L. Stan, J. Wen, D. Jin,* Argonne National Lab*; D. Lopez,* Pennsylvania State University*; D. Czaplewski,* Argonne National Lab

Micro- and nano-electromechanical (MEMS/NEMS) devices have relied heavily on materials typically used in electronic devices. The majority of MEMS/NEMS devices are fabricated with a top-down approach to take advantage of the corresponding highly reproducible fabrication processes associated with silicon related materials. As a natural extension, as devices move into the nanoscale regime, new materials are introduced using the same fabrication paradigms used for electronics: ultra-flat surfaces, controlled stresses, simply defined materials properties, with precision 2-dimensional or 2+ dimensional definition using lithographic techniques. New materials, such as 2D materials, began to be incorporated with great promise. However, creating 2D material films that behave like traditional silicon-related films has become challenging due to their unconventional growth/deposition techniques. A typical method for depositing a 2D film is through a transfer process, which struggles to create flat, low stress, thin films. This has led to films that have variations in properties, as observed in large deviations in values reported for parameters such as Young's modulus.

In this work, we explore the variation in properties of films as they become more 2+dimensional textured versus being ultra-flat. We measure the response of resonators fabricated from both ultra-flat and wrinkled films. The ultra-flat films follow expected behaviors with small deviations in resonant frequency and bending rigidity. However, the wrinkled films have a frequency response that is highly variable, up to 45 times that found in flat films. Additionally, we find that the increased rigidity and distribution of values is scale-dependent. As we vary the in-plane dimensions of the resonant structures, we find that the characteristic values scale with the structure dimension. This matches very well with a theoretical model proposed to describe thermal fluctuations in thin films. This opens a new paradigm for device design that allows a single film to have multiple elastic properties based solely on the patterning size. Going forward, we see this being an interesting tool in the design of devices made from single nanometer-thick films.

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