ITST

INSTITUTE FOR TERAHERTZ SCIENCE AND TECHNOLOGY

Thursday Seminar Series

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Nano- and opto-mechanics of fully self-assembled nanowires

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Advances in the growth and fabrication of semiconductor nanostructures have led to both the production of exquisitely sensitive force transducers and the development of solid-state quantum devices. Force transducers, typically monolithic Si cantilevers, form the basis of techniques such as atomic force miscroscopy, magnetic force microscopy, and sensitive mass detection. On the other hand, quantum devices including quantum wells, quantum dots (QDs), and single electron transistors play essential roles in technologies like lasers, optical detectors, and in experiments on quantum information. These two types of devices have – until now – occupied distinct material systems and have, for the most part, not been combined.

New developments in the growth of inorganic nanowires (NWs), however, are set to change the status quo. Researchers can now grow nanometer-scale structures from the bottom-up with unprecedented mechanical properties. Unlike traditional top-down cantilevers, which are etched or milled out of a larger block of material, bottom-up structures are assembled unit-by-unit to be almost defect-free on the atomic-scale. This near perfection gives NWs a much smaller mechanical dissipation than their top-down counterparts, while their higher resonance frequencies allow them to couple less strongly to common sources of noise. Meanwhile, layer-by-layer growth of NWs is rapidly developing such that both axial and radial heterostructures have now been realized. Such fine control allows for band-structure engineering and the production of devices including field effect transistors, single photon sources, and QDs.

As a result, we are investigating the potential of bottom-up NW structures in a variety of sensing applications. I will first discuss recent measurements of the mechanical properties of GaAs NW cantilevers. I will show that the nonlinear dynamics of the nanowire can be used to obtain mechanical frequency mixing and amplification. Then, I will present an “as-grown” hybrid system made from a QD-in-NW structure. Not only is the structure’s hybrid interaction unusually strong, but its “built-in” nature produces a system whose inherent coherence is unspoiled by external functionalization and whose fabrication is simpler than top-down techniques.

Refreshments Served