Nanoscale Science and Technology Division
Room Ballroom A - Session NS-TuP
Nanoscale Science and Technology Poster Session

NS-TuP-1 Collection of Raman Signal in a Liquid Using Plasmonic Vortex Fiber*, Rohil Kayastha,* *B. Birmingham, Z. Zhang,* Baylor University

Tip-enhanced Raman spectroscopy (TERS) has been demonstrated to achieve nanoscale resolution by focusing the light beam at the tip directly from the free space using the surface plasmon polariton (SPP). Conventional TERS applications possess problems such as low excitation and collection efficiency, optical alignments, and so on. Application of TERS in a liquid environment exposes additional challenges because of difficulty in focusing the excitation beam as the beam diffracts at the air-liquid interface between different refractive indexes. Here, a plasmonic fiber-based TERS, using SPP in a conical Kretschmann configuration, nano-focuses the radially polarized beam at the tip apex to excite and uses the back-collection method to collect the Raman signals to overcome the aforementioned challenges.

A tapered fiber was gold (Au) coated to be used as the plasmonic tip for TERS. Both linear and radial polarized beams can plasmonically excite into SPP mode at the tapered region, however, only a radial polarized mode can be localized without destructively interfering which achieves nano-focused light at the tip apex. Therefore, vortex fiber, a polarization-maintaining optical fiber, was used to guide the radially polarized mode. The plasmonic excitation of vortex fiber with internal illumination of the radially polarized beam was studied to demonstrate nano-focusing of the light beam near the tip apex using a liquid sample. The concentration dependence of the plasmonic coupling in the liquid sample was demonstrated. The Raman signal displayed dependence on the refractive index of the liquid as the concentration of the solution changed. Stronger Raman signals at the air-liquid interface were observed in comparison to when the fiber tip was fully submerged into the liquid which is due to the combination of the coupling of the waveguided mode from the fiber to the SPP mode and to a waveguided mode in the tapered liquid layer that forms over the tip. The air-liquid interface experiment also demonstrates that most of the signal is obtained near the tip apex than from the shaft of the probe. The plasmonic tip has been incorporated into a near field scanning optical microscope (NSOM) to obtain the topographical and spectroscopic information on a substrate with nanoscale resolution. The polarization dependence of the light beam (radial and azimuthal polarization) will also be tested to compare and understand the plasmonic coupling to enhance the coupling efficiency thus, enhancing the Raman signal.

NS-TuP-2 Chemical Mechanical Planarization Slurry Stability Study*, Yibin Zhang,* FUJIFILM Electronic Materials USA., Inc.

The stability of slurry for Chemical Mechanical Planarization (CMP) is one of the big concerns in semiconductor fabs. It might potentially be a deal-killer for its application due to its short period of stability even though it has a good performance in other aspects, like removal rate, erosion, and dishing. one of the main reasons for defectivity, an important factor of slurry performance in the CMP process, is the presence of large agglomerates in the slurry. As a result, lots of efforts have been done to stabilize of slurry and formulate highly stable slurries, which minimize the formation of oversize agglomerates. A highly stable CMP slurry is critical to reduce process-dependent defectivity such as scratches and particle residues.

In this work, we present a novel optical technique, MultiScan Emulsion and Dispersion Stability Analyzer, which can efficiently and accurately check the stability of certain formulations of the slurries or screen raw materials and their combination’s stability. A few samples will be analyzed to demonstrate the capability of stability investigation by using this technique. In the meantime, the traditional stability test method will be used as well for comparison. We propose some mechanisms respectively for stability for each sample. This technique will save >50% time for routine shelf-life stability study compared to the traditional test method.

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NS-TuP-3 A New Tool for Quantum and Nanoscale Materials Engineering*, Gianfranco Aresta,* Ionoptika Ltd, UK

Quantum computing is the next great frontier of science. It has the potential to revolutionise many aspects of modern technology, including digital communications, “quantum-safe” cryptography, as well as incredibly accurate time measurements.

Single impurity atoms in semiconductors are receiving attention as potential quantum technologies, and proof-of-concept devices have shown promise. However, such devices are incredibly challenging to manufacture, as single atoms must be placed within ~ 20 nm of each other within a pure ^{28}Si matrix.

All working devices thus far have been fabricated using hydrogen lithography with an STM followed by atomic layer deposition. It is labour-intensive and requires several days of meticulous preparation to create just a single quantum bit (qubit). Real-world devices will require arrays of hundreds or thousands of impurity atoms, highlighting the requirement for a scalable method of positioning single atoms with nanometre precision.

We report on a new commercial instrument for the fabrication of quantum materials and devices via ion implantation. A well-established technique in the semiconductor industry, ion implantation is both flexible and highly scalable. The instrument features a high-resolution mass-filtered focused ion beam (FIB), a high-sensitivity deterministic implantation system, 6-inch wafer handling, and a high-precision stage.

The ion dose delivered to the sample can be adjusted across a wide range, providing several materials engineering capabilities in a single tool. The deterministic implantation system allows single ion implantation with confidence levels as high as 98%. Operating in a high beam current mode provides direct-write capabilities such as isotopic enrichment and targeted ion-implantation of nanomaterials such as nanowires and graphene.

The liquid metal ion source and mass filtered column can implant many different elements with isotopic resolution. Available sources include silicon, erbium, gold, and bismuth, while many others of technological interest are in development.

NS-TuP-4 Atomic Silicon Wires: Dopant Mediated Charging Characterization*, Max Yuan,* University of Alberta, Canada*; R. Wolkow,* University of Alberta, Quantum silicon, Canada*; R. Achal, J. Croshaw,* Quantum Silicon, Canada*; T. Chutora, F. Altincicek, C. Leon,* University of Alberta, Canada*; L. Livadaru,* Quantum silicon, Romania*; J. Pitters,* Quantum silicon, Canada

CMOS technologies are approaching their performance limits. Atomic silicon electronics are poised to provide the next-generation of devices. This beyond CMOS platform consists of exactingly patterned dangling bond (DB) circuitry on hydrogen passivated silicon (H-Si).[1] Many passive and active components can be made of DBs, here we investigate atomic silicon wires. We employ a recent dopant based charge sensing procedure in conjunction with non-contact atomic force microscopy to study the charging behavior of atomically fabricated DB wires on H-Si (100) 2x1. On its own, this method can be used to rapidly detect local net charge with single electron sensitivity; coupled with AFM, it can drastically improve confidence in data interpretation.[2] In this scheme, a single DB sensor is employed to detect a sharp step in its I(V) spectroscopy due to the ionization of a nearby arsenic dopant. As charged DBs are fabricated nearby, local band bending shifts the dopant ionization voltage which can act as a charge sensor. Wires, both parallel and perpendicular to the dimer direction were systematically lengthened and studied using this method. The charging behavior for various lengths of wire, and novel observations, such as a length dependent flip flop in electron occupation for perpendicular wires are demonstrated. This method and these results will be used to improve the characterization of DB structures and will eventually be directly compared to theory to improve the modeling of DB circuitry.

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