Advanced Surface Engineering
Room: Central Hall - Session SE-TuP

Advanced Surface Engineering Poster Session

SE-TuP1 Analysis of the Physical Damage during HBr/O_2/Ar Gate Etching using Various Pulsed Plasmas, ***K.Y. Jeon***, *J.Y. Lee, G.J. Min*, Samsung Electronics Co. Ltd., Republic of Korea

Recent device has been rapidly scaled. The plasma oxidation and lattice damage by energetic ions cause the silicon oxidation in the channel and source/drain regions of the transistors. In addition, they generate the defects such as the Si/SiO_2 interface trap sites, contaminations, Si bond breaking and interstitial atoms. Those damaged regions by energetic ions can no longer be neglected. The continuous wave plasma is widely used in the conventional etch process, but it has some limitations to control the ion energy. It is difficult to reduce the damage layer in the atomic scaled device.This various plasma conditions in Gate etch process affect the physical damage on the substrate Si lattice and the gate oxide. In this work, the Si damage has been compared after etching by various plasma generation methods. Si etches has been performed in ICP chamber by using continuous wave HBr/O_2/Ar plasmas, bias pulsed HBr/O_2/Ar plasmas, synchronous pulsed HBr/O_2/Ar plasmas, and especially DC pulsed plasma. Ellipsometry and TEM were used to analyze the Si lattice damage. Plus some electrical tests such as time zero dielectric breakdown (TZDB), charge pumping current, C-V measurement respectively. As a result, the pulsed plasma etching method is promising alternatives in respect of the physical Si damage, including the charge build-up and etch uniformity, and the mask selectivity

SE-TuP2 Deposition of Hard SiOC(− H) Films by Atmospheric Pressure Plasma Enhanced CVD Method, ***M. Noborisaka***, *R. Horikoshi, A. Shirakura, T. Suzuki*, Keio University, Japan

Atmospheric pressure-plasma enhanced CVD method is a cost-effective process which has been widely developed because we do not have to vacuum during the deposition of thin films. In this study, SiOC(−H) films were synthesized by atmospheric pressure-plasma enhanced CVD method from tetramethoxysilane (TMOS) and O_2 diluted with N_2. The deposited films were characterized by Fourier-transform infrared spectroscopy, nano-indentation technique, transmission electron microscopy and ellipsometry. The partially crystalline phase of silica was found in the deposited films. The nano-hardness of the films increased from 4.0 GPa to 6.9 GPa as the substrate temperature increased from 80°C to 300°C. The hardness slightly increased up to 4.5 GPa from 4.0 GPa by decreasing the TMOS flow rate at the substrate temperature of 80°C. The results suggested that increase in the relative ratio of Si−O−Si bonding in the network structure to Si−O−Si bonding in the cage structure led to increase in hardness.

SE-TuP3 Thermal Transport at Metal-Carbon Interfaces, *J.J. Gengler*, Spectral Enegies LLC/Air Force Research Laboratory, *S.V. Shenogin,* UES Inc./Air Force Research Laboratory, ***A.A. Voevodin***, *A.K. Roy, C. Muratore*, Air Force Research Laboratory

Carbon nanotubes are appealing for diverse thermal management applications due to their high thermal conductivity (as high as 3,000 W m^{-1} K^{-1}) coupled with interesting mechanical properties (stiff and strong, but also exhibiting foam-like deformation in arrays). Unfortunately, CNT surfaces are generally non-reactive and demonstrate weak bonding to other materials, limiting thermal interfacial conductance. Functionalization with "linker molecules" has been shown to enhance interfacial conductance, but reduces thermal conductivity of the nanotubes themselves by altering carbon bond hybridization within the nanotube. Metal coatings provide a way to increase thermal interface conductance associated with carbon nanostructures, while maintaining their high thermal conductivity. We used Molecular Dynamics and vibrational modes analysis to study heat transfer through carbon nanotube - metal interfaces in highly nonequilibrium conditions (NEMD). The simulation results were compared to experimental measurements of conductance for metallized highly oriented pyrolitic graphite (HOPG) substrates. HOPG was selected as a practical 2-dimensioinal analog for nanotube sidewalls to facilitate experimentation by analysis of the two-color time domain thermoreflectance (TDTR) data from the samples. The TDTR analysis of the different metals on HOPG was made possible by employing an optical parametric oscillator on the probe beam which allows for tuning the probe beam wavelength to match absorption bands for each metal studied. Metal films were selected to identify effects of atomic mass (inversely proportional to Debye temperature), chemical interactions (i.e., interfacial carbide formation) and electron configuration. Measurements of chemically inert metals at the carbon interface, including Al, Cu and Au demonstrated a strong dependence on Debye temperature, with conductance values differing by a factor of 3. The effects of interfacial carbide layers with varied areal densities on HOPG surfaces on thermal conductance were also examined, in addition to the presence of molecular interlayers. These results were applied to 3D assemblages of carbon nanotubes, such as dry spun CNT yarn, where metallization yielded significant enhancements of thermal conductivity in addition to increased tensile strength.

SE-TuP4 Multilayer on a Staircase Substrate for Hard X-ray Gratings, ***C. Liu***, Argonne National Laboratory, *S. Lynch, E. Bennett, A. Gomella,* National Institutes of Health, *L. Assoufid,* Argonne National Laboratory, *H. Wen*, National Institutes of Health

Traditional hard x-ray transmission gratings are fabricated using lithography processes. They are constrained by the maximal attainable aspect ratio of the vertical walls, which limits the smallest attainable grating periods. Advanced X-ray phase contrast imaging techniques require large-area, high-density transmission gratings with smaller periods and higher aspect ratio to cover larger energy range for thicker samples. A new type of grating using multilayers grown on staircase substrates may meet this requirement. A thin Si substrate can be anisotropically etched to a staircase. With each stair surface supporting a multilayer as a micro grating and an X-ray beam shining through the layers at an oblique angle to the substrate and parallel to the layer surfaces, one has a large-area transmission grating with small grating periods. This method represents a new way to make gratings for hard x-rays. A [93 nm W / 93 nm Si] x 81 multilayer was grown on a 20 mm x 20 mm, 26°-blaze-angle Si staircase substrate using dc magnetron sputtering deposition. The multilayer thickness matches the stair height. A nitride layer was coated before multilayer deposition so that the Si substrate can be etched away to reduce x-ray absorption. Efforts have been made to grow the multilayer so that a major portion of layers is parallel to the stair surface with minimal amount on the sidewall. The sample was tilted during multilayer deposition to face the target. Deposition collimators were used to direct the coating flux. Uniform coatings were achieved using the profile-coating technique with specific masks made for each sputter gun. SEM images of sample cross sections and preliminary results of synchrotron x-ray diffraction and contact radiography at 25 keV are presented.

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