Film properties and in-situ optical analysis of TiO2 layers synthesized by remote plasma ALD

relationship between ALD process parameters and the conformality of the ALD films in the nanopores as a function of nanopore dimensions and aspect ratios. SEM was used to measure pore diameters (40-80nm) before and after the ALD deposition. The HfO_2 nanotubes were then released by dissolution of the AAO template and examined via TEM imaging of the nanotubes on standard grids. TEM profiles showed HfO_2 nanotubes with lengths 1-2 microns (determined by the AAO template) and having wall thicknesses in the range 3-10 nm which vary with position along the depth of the original AAO nanopores. The AAO templates are attractive both for the applications above and for the ease with which they generate very high aspect ratio nanopores to study ALD conformality, while the nanotube release through AAO template dissolution provides a very simple means to achieve TEM analysis of ALD conformality. These advantages are particularly striking in comparison to requirements for more conventional high aspect ratio devices such as DRAM trench structures, where challenging lithography, dry etching, etc. must be combined with difficult cross-sectional TEM sample preparation to understand and optimize ultrathin conformal device layers.

4:20pm **TF-MoA8 Molecular Layer Deposition of Alucone Polymer Films Using Trimethylaluminum and Various Glycols**, ***A.A. Dameron***, *S.D. Davidson, B.B. Burton, J.A. McCormick, A.S. Cavanagh, S.M. George*, University of Colorado at Boulder

Conformal polymeric films can be grown by a sequential, self-limiting surface chemistry process known as molecular layer deposition (MLD) that is very similar to atomic layer deposition (ALD). The MLD reactants are typically monomers for step-wise condensation polymerization and can yield completely organic or organic-inorganic alloys. Our earlier work has demonstrated polyamide growth using diamines and diacid chlorides. Alucone MLD is performed using trimethylaluminum (TMA) and various glycols as the reactants. When the glycol is ethylene glycol (EG), the alucone is poly(aluminum ethylene glycol), $[Al\text{-}(OCH_2CH_2O)_x]_n$. Alucone films have been fabricated on silicon substrates at temperatures ranging from 85 °C to 175 °C. In situ quartz crystal microbalance and ex situ x-ray reflectivity experiments have confirmed linear growth of the alucone film versus number of TMA/EG reaction cycles at all temperatures. The MLD growth rates decreased at higher temperatures. Growth rates were 4 Å per cycle at 85 °C and 1.7 Å per cycle at 135 °C. In situ and ex situ Fourier transform infrared spectroscopy (FTIR) have also been used to monitor the surface reactions during alucone growth. Experiments with other glycols, such as benzene-1,4-diol (hydroquinone), demonstrate the general applicability of the alucone MLD surface chemistry to fabricate organic-inorganic films with tunable functionality.

4:40pm **TF-MoA9 Film Properties and In-Situ Optical Analysis of TiO_2 Layers Synthesized by Remote Plasma ALD**, ***W. Keuning***, *J.L. Van Hemmen, O. Muraza, E. Rebrov, M.C.M. van de Sanden, W.M.M. Kessels*, Eindhoven University of Technology, The Netherlands

TiO_2 is a widely studied material due to its optical and photocatalytic properties and its hydrophilic nature after prolonged UV exposure. When synthesized by atomic layer deposition (ALD) the TiO_2 can be deposited with ultimate growth control with a high conformality on demanding topologies and even at room temperature when e.g. using a plasma based process. We report on the deposition of TiO_2 films using remote plasma ALD with titanium (IV) isopropoxide as precursor and O_2 plasma as oxidant. Stochiometric TiO_2 films with carbon and hydrogen levels below the detection limit of Rutherford backscattering/elastic recoil detection (< 2 at.%) have been deposited within the temperature range of 25°C to 300°C. Depending on the ALD conditions and film thickness amorphous films turn anatase for temperatures higher than 200°C as revealed by X-ray diffraction. It is demonstrated that this change in crystal phase can also be observed by spectroscopic ellipsometry revealing an increase in growth rate per cycle (from typically 0.45 Å/cycle to 0.7 Å/cycle) and change in bandgap (from 3.4 eV to 3.7 eV) when the TiO_2 becomes anatase. An accompanying change in surface topology is clearly observed by atomic force microscopy. The hydrophilicity of low temperature TiO_2 films is studied by contact angle measurements for adhesion purposes revealing that the amorphous films are super-hydrophilic after UV exposure.