Tuesday Evening, May 21, 2019

Special Interest Talks

Room Town & Country - Session SIT1-TuSIT

Special Interest Session I

Moderators: Christopher Muratore, University of Dayton, **Michael Stüber**, Karlsruhe Institute of Technology, Germany

7:00pm **SIT1-TuSIT-1 Advanced Monitoring of Thin Film Growth from Real-time Diagnostics*, Grégory Abadias,*** Institut Pprime - CNRS - ENSMA - Université de Poitiers, France **INVITED**

Thin metallic films deposited on Si are largely used in many technological areas, such as microelectronics, catalysis, architectural glazing or plasmonics. In the case of high-mobility metals on weakly interacting substrates (e.g. Ag on SiO_2), the growth proceeds in a 3D fashion, known as Volmer-Weber. The control of islands size and shape at the beginning of growth is vital for many applications as the characteristic length scales and physical attributes of ultrathin films are mostly set-in during the coalescence stage.

By employing a panel of *in situ* and real-time diagnostics, we could obtain valuable insights on the thin film growth dynamics as well as stress evolution in a variety of sputter-deposited metallic systems (Ag, Cu, Au, Ta and Mo). More particularly, the characteristic thickness of film percolation and film continuity can be determined from a combination of real-time electrical resistivity and wafer curvature measurements. This will be highlighted for the case of Ag and Cu deposited on amorphous carbon as a function of deposition flux F and substrate temperatures T_s.

We will also provide examples on how chemical alloying or interface reactivity can affect the growth morphology and stress evolution of Ag and Cu films. Growth monitoring was performed *in situ* by employing either surface differential reflectance spectroscopy or spectroscopic ellipsometry. We will show that strategies based on interfacial or alloying design can be efficiently employed to manipulate growth and obtain ultra-thin, ultra-smooth, continuous layers.

Finally, we will discuss the issue of phase transformation during growth of ultrathin layers, with special focus on silicide formation. By coupling simultaneously X-ray diffraction, X-ray reflectivity and wafer curvature during sputter-deposition of metal layers on amorphous Si, information about thickness-dependent crystalline phases, texture, grain growth and microstrain can be gained. This will be demonstrated for Mo/Si and Pd/Si systems. A complex nanostructure formation is uncovered from these synchrotron studies, pointing out to different silicide formation mechanisms and subsequent structural development.

Special Interest Talks
Room Town & Country - Session SIT2-WeSIT

Special Interest Talk II

Moderators: Christopher Muratore, University of Dayton, **Michael Stüber**, Karlsruhe Institute of Technology, Germany

1:00pm **SIT2-WeSIT-1 Linking Intrinsic Plasma Characteristics to the Microstructure and Properties of Thin Films*, Ivan Petrov,*** University of Illinois, USA, Linköping University, Sweden, USA*; G Greczynski, L Hultman,* Linköping Univ., IFM, Thin Film Physics Div., Sweden*; J Greene,* University of Illinois, USA, Linköping University, Sweden, National Taiwan Univ. Science & Technology, Taiwan **INVITED**

From its inception, the benefits of sputter deposition have stemmed from the presence of plasma in the vicinity of the growing film. Bombardment with charged particles and energetic photons affect the substrate initial condition and all stages of film growth: nucleation, coalescence, texture evolution, and recrystallization. Measuring and controlling the fluxes and energies of the charged particles incident at the substrate is essential to achieving low-temperature growth of high-quality thin films. Under typical direct current magnetron sputtering (DCMS) conditions, the dominant ion species incident at the growth surface while sputtering with N_2/Ar gas mixtures optimized to obtain stoichiometric nitride films is Ar^+, while the ratio of the gas-ion flux to deposited metal flux J_i/J_{Me} is ≤ 1. Densification is achieved by increasing the ion energy E_i commonly above 100 eV. However, at higher ion energies, a steep price is extracted in the form of residual ion-induced compressive stress resulting from both recoil implantation of surface atoms and trapping of rare-gas ions in the lattice. An alternative approach is offered by strongly magnetically-unbalanced magnetron sputter deposition systems, which allow ion-to-neutral flux ratios J_i/J_{Me} incident at the growing film to be varied over extremely wide ranges (up to > 20) at very low ion energies (E_i ~ 10-20 eV) (below the lattice displacement threshold). Using high-flux, low-energy ion irradiation during deposition opens new kinetic pathways to independently control the texture (from completely 111 to completely 200) and microstructure (from underdense to fully dense) in transition metal (TM) nitride films grown on amorphous substrates as well as to achieve low-temperature epitaxy of refractory materials and metastable alloys.

The invention of high power impulse magnetron sputtering (HiPIMS) opened the way to exploit metal-ion irradiation, which is particularly attractive for low-temperature growth of refractory ceramic thin films. HiPIMS discharges can ionize up to 90% of the sputtered metal flux; equally important is the time separation between metal- and gas-ion fluxes incident at the substrate . In recent years, it has been demonstrated that the use of synchronized bias to select the metal-rich portion of the ion flux provides a new dimension for ion-assisted growth in which momentum can be tuned by selection of the metal ion in the hybrid/cosputtering configuration and stresses can be eliminated/reduced since the metal ion is a component of the film. Thus, the control of intrinsic plasma conditions continues to drive research and caters to tooling-component, and microelectronics industry, as will be exemplified in the presentation.

Author Index

Bold page numbers indicate presenter