Plasma Science and Technology
Room 201 ABCD W - Session PS2-FrM

Plasma in EUV Scanner Technology

Moderators: François Reniers, Université Libre de Bruxelles, **Scott Walton**, Naval Research Laboratory

9:15am **PS2-FrM-5 Measurement of Cold Spit Tin Particle Trajectories in a Hydrogen Plasma**, ***Jaime Robertson***, University of Illinois Urbana-Champaign; *Raoul de Rooij, Andrei Yakunin, Victoria Voronina,* ASML, Netherlands; *David Ruzic,* University of Illinois at Urbana-Champaign

The extended exposure of tin (Sn) particles to hydrogen radicals has demonstrated the ejection of sub-micron sized particles from a surface covered in micron sized Sn droplets. This work experimentally investigates the three mechanisms, spitting, etching, and particle lift off, behind the mass transport of Sn, focusing on measuring the size, velocity, and directionality of the particles and the frequency of particle migration. Using a quartz crystal microbalance (QCM), measurements of the mass flux from a surface covered in micron sized droplets of Sn were performed with plasma radical densities similar to and greater than in the scanner. While etching rates of Sn by hydrogen were measured similar to other reports, significant, acute decreases in the mass were also observed throughout the duration of testing associated with either spitting or particle lift off. Further imagery, on a SEM, of the surface before and after exposure to hydrogen plasma confirmed a change in surface morphology. Larger Sn droplets appeared to have cratering along the surface, believed to be the result of cold spitting Sn. This is due to buildup of hydrogen beneath the surface forming a pressure gradient within the Sn particles leading to surface fracturing and particle ejection. An additional test was designed with a silicon wafer placed above the surface of the Sn droplets that captured cold spit particles. An SEM was then used to measure the size and position, allowing for the interpretation of mass and directionality of Sn leaving the surface. Velocity of spit particles is being determined by measuring the deflection of the cold spit particles through an electric field, having a known charge buildup on the surface. Based on the distance traveled before reaching the chamber walls, the incident velocity of particles is calculated. Measurement of liquid spit particles is underway using aerogel, with diagnostic techniques like ballistics work. The liquid particles are captured in the aerogel before using a uCT to generate a 3D rendering of the surface. Based on the cratering characteristics such as depth and width found at the surface of the aerogel, velocity of each particle is calculated. Additionally, this work is being performed on various surface materials to determine how the preferential recombination of hydrogen radicals with various surface materials impacts the rate of degradation of the Sn. Initial tests revealed a reduction in mass loss rates for gold when compared to aluminum. This is likely due to the greater recombination coefficient of gold when compared to aluminum.

9:30am **PS2-FrM-6 Invited Paper**, ***Seth Brussaard***, ASML **INVITED**

10:00am **PS2-FrM-8 Stannane Decomposition and Sticking Coefficient in Extreme Ultraviolet Lithography Environments**, ***Emily Greene***, *Nathan Barlett, Jameson Crouse, Eric Mushrush, Alex Shapiro,* University of Illinois; *Niels Braaksma,* ASML; *David Ruzic,* University of Illinois

In extreme ultraviolet (EUV) lithography environments, large quantities of tin are evaporated, leading to the deposition of tin on various chamber surfaces, including collector mirrors. Hydrogen plasma etching is used to remove these deposits, but this process also produces stannane (SnH_4). Since stannane exists in a gaseous state under operational conditions, it can be evacuated from the chamber via a vacuum pump. However, stannane is unstable and often decomposes, causing the redeposition of tin on chamber surfaces. This work aims to experimentally study the decomposition of stannane on EUV-relevant surfaces as a function of temperature. Stannane is synthesized in liquid form through the reaction of lithium aluminum hydride with tin tetrachloride. The liquid stannane is then released into a vacuum chamber containing a temperature-controlled stage equipped with a quartz crystal microbalance (QCM). This setup enables the quantitative determination of the stannane sticking coefficient as a function of surface material and temperature. To analyze surface morphology after stannane exposure, scanning electron microscopy (SEM) is used to image the exposed samples. Additionally, this study seeks to determine the vapor pressure of stannane gas by measuring the pressure of a sealed liquid stannane vessel as it is submerged in chemical slurries of varying temperatures. By improving the understanding of stannane decomposition, this investigation aims to enhance the maintenance and efficiency of EUV lithographic systems.

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