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Interaction Between Ionized Air and Silver Film

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Low pressure plasmas have found wide application in materials processing, such as etching, deposition, and sintering [1, 2]. However, to date no study has been reported on the in-situ micro- and nano- structural evolution during the interaction between ionized gas and materials. This report utilized a lab-made wet cell designed for TEM to create a localized observation window for the interaction between ionized gas and materials, and in-situ observed the microstructural evolution of silver film during the radiation of ionized gas for the first time.

The environmental wet cell used in this study (see Fig. 1) utilizes two silicon nitride (SiNx) grids. The top SiNx grid was partially coated with 60 nm thick silver film via an E-beam evaporation system (Temescal six pocket E-Beam Evaporation System) and a shadow mask. A small volume of air was confined between the two grids during assembly. The cell seals via three O-rings [3] that couple the windows to the enclosure and the top piece of the enclosure to the bottom.

The samples were observed under a JEOL 2010 LaB_6 TEM. The air between the two grids was (partially) ionized by the collision of high-energy electrons. The ions then interacted with silver film. Interaction with the ionized gas significantly enhances the kinetic response of the material relative to observations in vacuum. These rates have been characterized as a function of electron beam current to provide insight into the phenomena. Current was varied through the use of condenser apertures, condenser lens 1 and condenser lens 2. At least three regimes of morphologically distinct phenomena of interest are observed. The different response appears to result from a complex interaction between, ion enhanced diffusion, ion enhanced oxidation, and electron beam reduction. Observations of such interactions are infrequent in the literature. However, interest in in-situ environmental TEM studies is rapidly expanding [4, 5] An improved understanding of these interactions will enable improved in-situ characterization of materials and will also provide new insights into interactions between materials and ionized gases/plasmas [6].

References

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FIG. 1. Image of the environmental wet cell used for this study, which is assembled simply with O-rings and screws, and utilized commercial silicon nitride grids as the substrates.

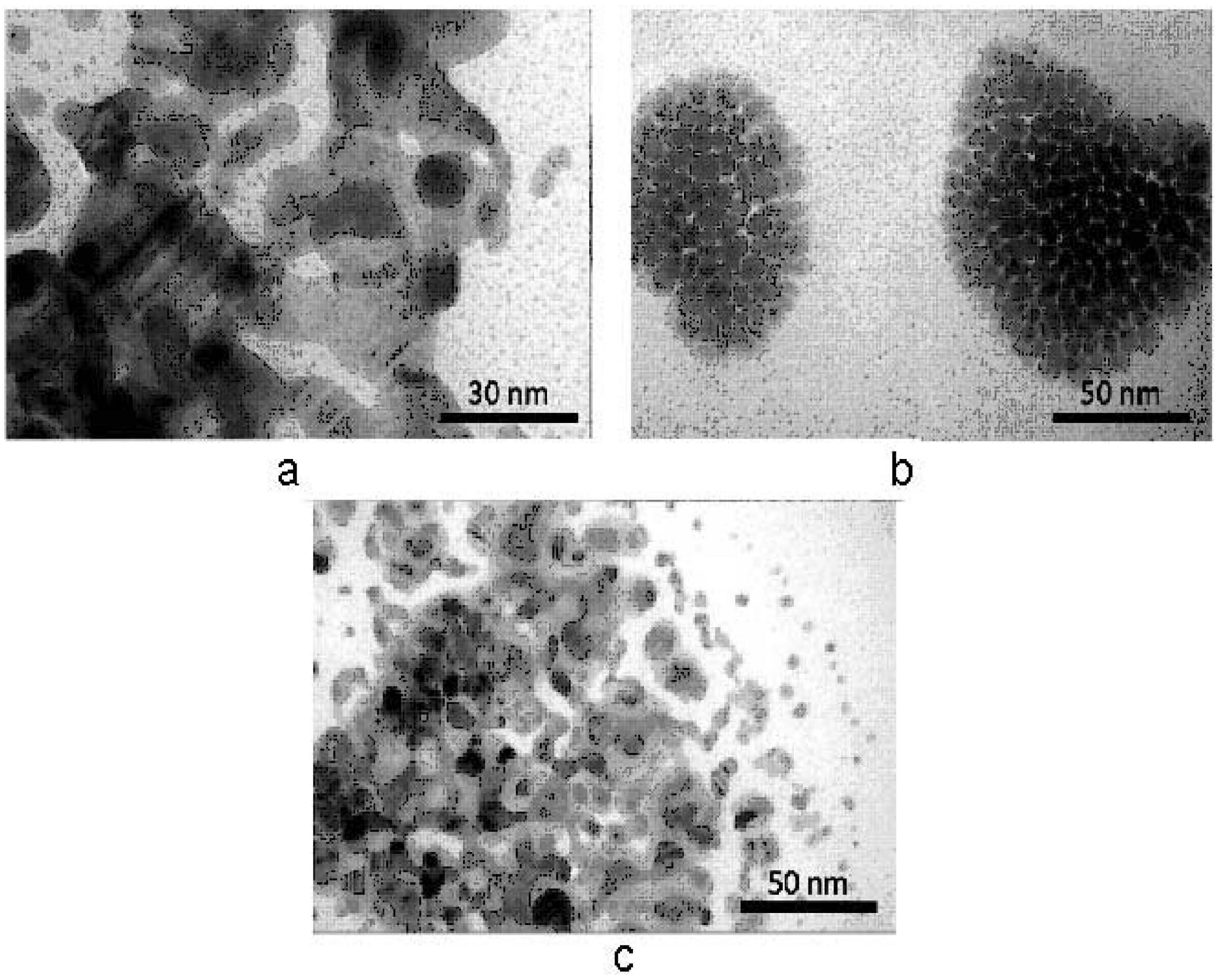

FIG. 2. Various microstructures during the interaction between the silver film and the ionized air/electron beam; a) 'low current', b) 'intermediate current', and c) 'high current'.