Reactions between plasma discharges and polymer films containing metal precursors

S. Ghosh[1], R. Yang[2], P. X. L. Feng[2], C. A. Zorman[2], and R. M. Sankaran[1]
[1]Department of Chemical Engineering
[2]Department of Electrical Engineering and Computer Science
Case Western Reserve University
e-mail: mohan@case.edu

***Abstract*— Low-pressure, low-temperature plasmas are widely used for materials applications such as thin film etching and deposition. Plasmas are capable of non-thermally dissociating gaseous precursors to enable reactions to occur at surfaces near room temperature. Recently, we have shown that plasmas can be used to reduce metal ions dispersed in a polymer film to form metallic structures [1, 2]. The process is a potential low-cost alternative to metal deposition methods such as vacuum evaporation. However, the mechanism for the reactions at the interface of the plasma and the polymer films remains unknown. Here, we compare reactions carried out by a plasma to an electron beam (e-beam) to explain the possible role of electrons in the reduction of metal ions to metal nanostructures.**

Polymer films containing ionic metal precursors are prepared by first dispersing metal salts such as AgNO3 with polymers such as polyvinylalcohol (PVA) in water. The solutions are coated onto substrates to form thin films (~1 micron thick). The films are then exposed to either a plasma or an e-beam. In the case of plasma exposure, we have developed our own atmospheric-pressure dc plasma system that allows the films to be processed at ambient conditions. Alternatively, the films are exposed to an e-beam using a TeScan Vega electron beam system.

Following exposure, the films are characterized by electron microscopy, energy-dispersive spectroscopy, and conductivity tests to assess the reduction of the metal ions to solid, crystalline metal. We find that exposure to the plasma and the e-beam both result in the reduction of metal ions. However, in the case of the plasma, the polymer is removed, probably due to oxidation, whereas the e-beam causes conformational changes to the polymer. The effect of temperature on particle formation in the films will also be discussed.

REFERENCES

[1] S. W. Lee, D. Liang, X. P. A. Gao, and R. M. Sankaran, Adv. Funct. Mater., Vol. 21, 2155-2161 (2011).
[2] S. W. Lee, H. Zamani, P. X. L. Feng, and R. M. Sankaran, J. Vac. Sci. Technol. B, Vol. 30, 010603-1 (2012).