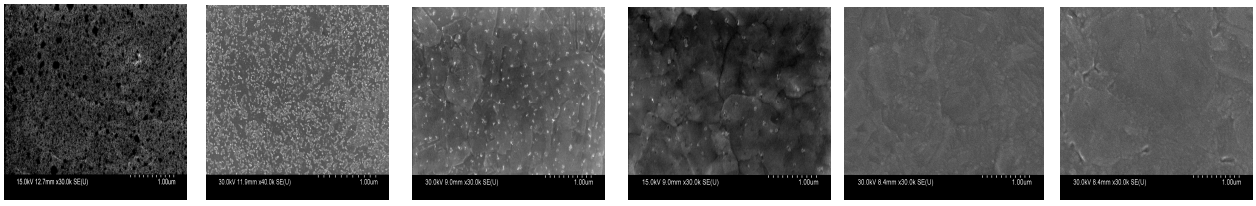
Deliverable Name: Report on the development and optimization of formulations based on a suitable ionic liquid for selective removal of post etch residue over copper and low-k dielectric
Task ID: 425.034
Task Title: Improvement of ESH impact of Back End of Line (BEOL) cleaning formulations using ionic liquids to replace traditional solvents
Task Leader: Srini Raghavan – The University of Arizona

II. Technical Results:

Post plasma etch residue films were prepared by spin coating DUV based photoresist films on copper followed by etching in a reactive ion etcher using CF_4/O_2 plasma. Deep Eutectic Solvent (DES) containing eutectic mixture (2:1 urea: choline chloride) at room temperature, 40°C and 70°C was used to clean the residue films. Following cleaning, the samples were rinsed with DI water. The removal of residue film was characterized using a Hitachi S-4800 Field Emission Scanning Electron Microscope (FE-SEM). Additionally, the etch rate of low-k material (Black Diamond®) in DES formulation was measured using ellipsometry.

A high magnification SEM image of the residue film on copper clearly shows the presence of a rough film with a number of pores as shown in Figure 1 A. Cleaning in 2:1 DES at room temperature results in incomplete film removal, even after 60 minutes (Figure 1 B) whereas 2:1 DES at 40°C and 70°C removed most of the residue film in ~10 minutes as shown in Figure 1 C and 1 D. Complete removal of the residue film was achieved in these compositions in ~20-30 minutes (Figure 1 E and 1 F). Also it has been found that DES provides a lower dielectric etch rate compared to the conventional cleaning solutions as shown in Figure 2.



A B C D E F

Figure 1: High magnification SEM image of A) residue film prepared using CF_4/O_2 plasma on copper and residue film cleaned in 2:1 urea: choline chloride B) at room temperature for 60 minutes, C) at 40°C for 10minutes, D) at 70°C for 10minutes E) at 40°C for 30minutes and F) at 70°C for 20minutes

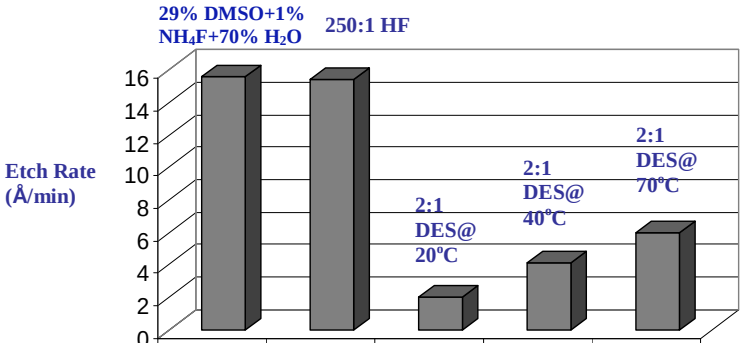


Figure 2: Etch rate of blanket low-k in different cleaning formulations

Summary:

Deep eutectic solvent mixtures containing urea and choline chloride at a molar ratio of 2:1 at 40°C and 70°C can be used to effectively remove fluorinated etch residues on copper. Additionally, the residue removal can be obtained with a high degree of selectivity with respect to low-k materials (Black Diamond®).