

Epitaxial growth of nanocrystalline Ag films on native-oxide-covered Si substrates

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Epitaxial growth of metal films on silicon substrates has been the subject of extensive study over the past decades, since the material system potentially offers unique electronic, magnetic, or plasmonic properties. Ag on Si, a prototypical example of non-reactive metal/semiconductor system, can form a well-defined interface, offering a potential for ideal metal contact and Schottky barrier formation. While bulk of literature is available on the growth of Ag on Si surfaces cleaned in ultrahigh vacuum (UHV), relatively little has been reported on the growth in the presence of an adlayer. Presence of foreign atoms on Si surface is expected to alter the growth dynamics and resulting film properties.

By employing radio-frequency magnetron sputtering, cube-on-cube domain epitaxy of silver films was accomplished on the Si(001) substrates that were initially covered with native silicon oxide. Energetic bombardment by sputtered Ag particles was found to play a critical role in the epitaxial growth, enabling desorption of native oxide at temperatures significantly lower than that reported in conventional thermal annealing in UHV. Native oxide was found to desorb at temperatures as low as 200 °C as a result of kinetic interaction with the deposition flux. At deposition temperatures of 550 °C or above, native-oxide was completely removed from the Si surface, and the grown films showed strong epitaxial relationship, Ag(001)[110]//Si(001)[110]. X-ray photoemission spectroscopy analysis confirmed that the desorbed silicon oxide migrated to the top surface of Ag layer during sputter deposition. SEM and XRD analyses revealed that the Ag films initially formed a 2D-like layer and evolved into a granular structure with the grain size ranging from 5 to 100 nm.

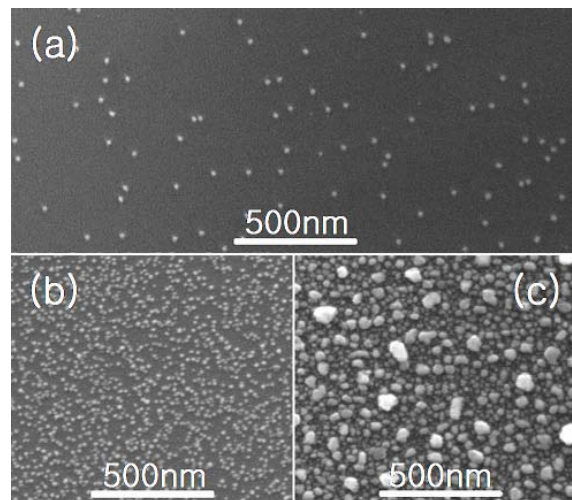


Figure 1. SEM images of nanocrystalline epitaxial Ag films grown on initially native-oxide-covered Si substrates.