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Nanoscale studies of ultrathin gold films with various adhesion materials: Ti, Cr, APTMS, MPTMS and APS

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Noble metals, especially Au, as the most common material for plasmonic and micro-electronic devices, do not adhere well on dielectric substrates, such as glass. This is due to their inability to form stable metal-oxide bonds. Subsequently, Au thin films require the use of an intermediate adhesion promoter to guarantee the integrity and performance of the application. The first choice in nano-fabrication are commonly Ti and Cr, which build nanometre thick alloys with Au to form a stable thin film system [1, 2]. Another approach to achieve an ultrathin Au film on SiO₂ substrate is the use of an interfacial self-assemble monolayer (SAM) of organosilanes, here (3-aminopropyl)-trimethoxysilane (APTMS), (3-mercaptopropyl)-trimethoxysilane (MPTMS) and 3-aminopropylsilatran (APS) to avoid diffusion mechanisms at the interface, which decrease the Au thin film properties [3, 4]. However, the influence of the underlying adhesion layer on the noble metal thin film performance is not sufficiently understood.

Here, we investigate the nanoscale structure and chemistry of ultrathin gold films with various adhesion materials. In particular, surface roughness, grain size, grain orientation and interdiffusion of the adhesion material into the gold film are analysed, as well as the adhesion strength of the thin films. Atomic force microscopy (AFM), transmission Kikuchi diffraction (TKD), transmission electron microscopy (TEM), scanning TEM (STEM), electron energy-loss spectroscopy (EELS) and mechanical pull tests are used to understand and compare the morphology, microstructure and chemistry of the different thin film interfaces and their effects on thin film properties to optimise future fabrication processes.

References:

Keywords: adhesion layer, Au thin film, organosilane, microstructure