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Nanoscale Characterisation of Thin Film Adhesion Layers

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Motivation and background
In the field of plasmonic and microelectronic devices, the fabrication of noble metal films on dielectric or semiconductor substrates requires an adhesive intermediate layer that guarantees the stability of the structure. The most common materials for this purpose are the metallic adhesion layers Cr or Ti. However, they deteriorate the optical characteristics of ultra-thin and ultra-smooth layers for plasmonic waveguides and hyperbolic metamaterials. Here, we investigate the adhesion mechanism between gold and silicon oxide substrates, comparing the classical Cr and Ti adhesion layers with the organosilane APTMS (3-aminopropyl)trimethoxysilane, to establish an improved understanding of the structural effects and material properties.

Samples
Au films were deposited on silicon oxide TEM grids and wafers, using two different deposition techniques, e-beam evaporation Wordentec GCL800 and Sputtering system LEIKER. The single layers on TEM grids were examined in plan-view geometry and the double layers on wafers were examined in cross-sectional geometry.

Chemistry and optical properties
Electron energy-loss spectroscopy (EELS) scans of TEM window grids with dampening effects of the metallic adhesion layers, while the organosilane contains the plasmonic signal.

Morphology
- Atomic force microscopy (AFM):
- ADF STEM:

Conclusion and Outlook
We conducted comprehensive studies on effects of adhesion layers on Au thin films and propagating plasmonic modes. The results present promising tendencies of the ultrathin film coverage, grain size distribution, film quality and plasmonic interactions. Further High-resolution TEM (HRTEM), transmission Kikuchi diffraction (TKD) and electron energy-loss spectroscopy (EELS) will be used to understand and compare the morphology, microstructure and chemistry of the thin films. After elaboration the most promising fabrication method, further organosilanes will be investigated with respect to optical and mechanical properties in order to avoid the dampening influences of metallic adhesion layers for more advanced plasmonic applications in the future.

References