Nanoscale Characterisation of ultrathin gold films deposited on silica with organosilane adhesion layers

Heinig, Mario; Todeschini, Matteo; Malureanu, Radu; Bastos da Silva Fanta, Alice; Wagner, Jakob Birkedal; Kadkhodazadeh, Shima

Publication date: 2019

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.
Nanoscale Characterisation of Ultrathin Gold Films Deposited on Silica with Organosilane Adhesion Layers

M. F. Heinig¹, J. Sukham², R. Malureanu², M. Todeschini¹, A. Bastos da Silva Fanta¹, J. Birkedal Wagner¹ and S. Kadkhodazadeh¹

¹DTU Nanolab, National Centre for Nano Fabrication and Characterization
²Department of Photonics Engineering, Technical University of Denmark
marhein@dtu.dk

Fabrication of thin metallic films on dielectric or semiconductor substrates is central to the plasmonics research field. Here, gold is the most used material, but due to its chemical inertness typically require an adhesion promoter to bind to the substrate. Metals such as Ti and Cr are often used for this purpose. However, they are known to degrade the plasmonic response of the metallic layer [1]. In this study, we investigate the adhesion mechanism between gold and SiO₂ substrates, using Ti, Cr and organosilanes as adhesion layers [2, 3]. In particular, surface roughness, grain size, grain orientation and interdiffusion of the adhesion material into the gold film are analysed. Transmission and scanning electron microscopy, transmission Kikuchi diffraction and electron energy-loss spectroscopy (EELS) are used to understand and compare the morphology, microstructure and chemistry of the different thin film interfaces.


Keywords: adhesion layer, metal thin film, microstructure
Nanoscale Characterisation of ultrathin gold films deposited on silica with organosilanes adhesion layers

Mario Frederik Heining1, Matteo Todeschini1, Radu Malureanu2, Alice Bastos da Silva Fanta1, Jakob Birkedal Wagner1, Shima Kadkhodazeheh1

1 DTU Nanolab, National Centre for Nano Fabrication and Characterization, Kgs. Lyngby, Denmark
2 DTU Fotonik, Technical University of Denmark, Kgs. Lyngby, Denmark
* E-mail: marhein@dtu.dk

Motivation and background
In the field of plasmonic and microelectronic devices, the fabrication of noble metal thin 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 metallic adhesion layers Cr or Ti. However, they deteriorate the optical characteristics of ultra-thin and ultra-smooth films 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 silane coupling agents, APTMS (3-aminopropyl)triethoxysilane, MPTMS (3-mercaptopropyl)trimethoxysilane, and APS 3-aminopropylsilatrane, to establish an improved understanding of the structural effects and material properties.

Surface Chemistry
Surface modified silicon oxide substrate with an increased OH-group density for more efficient organosilane coverage, enables an enhanced adhesion for metal thin film structures.

Metals sputtering of Cr and Ti
Organosilane self-assembled monolayers (SAMs) in aq. sol.

Interface Mechanisms
Electron energy-loss spectroscopy (EELS) scans for chemical characterisation of multi-stacked thin films with various adhesion materials in cross-section. Cr and Ti build thin oxide transition layers and diffusion occurs at the Au thin film edge, while the organic layers provide a continuous, undiminished thin film system.

Surface pre-treatment
SEM imaging Au ultrathin film on APS after Plasma cleaning and Piranha treatment.
> thin film quality
> (dis-)continuity

Alumina
Intermediate layer of 2nm Al2O3 to increase the OH-group density on the sample surface

> SiO2 8 [OH/nm²]
> Al2O3 18 [OH/nm²]

Conclusion and Outlook
We conduct comprehensive studies on effects of adhesion layers on Au thin films and investigate the potential of organic adhesion promoters as an alternative for thin film systems. The results present promising tendencies for the ultrathin film fabrication in terms of coverage, grain size distribution and film quality.
Further High-resolution TEM (HRTEM), transmission Kikuchi diffraction (TKD) and EELS will be used to understand and compare the morphology, microstructure and chemistry of the thin films. After elaboration the most promising fabrication method, additional 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.

References