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Determining surface coverage of ultra-thin gold films from X-ray reflectivity measurements

A. Kossoy[1*], D. Simakov, S. Olafsson[1], K. Leosson[1]

[1] Science Institute – University of Iceland, Reykjavik, Iceland

[*] Corresponding author: annaeden@hi.is, anna.kossoy@gmail.com

Phone: +354 694 8163

Fax: +354 552-8911

Abstract

The paper describes usage of X-ray reflectivity for characterization of surface coverage (i.e. film continuity) of ultra-thin gold films which are widely studied for optical, plasmonic and electronic applications. The demonstrated method is very sensitive and can be applied for layers below 1 nm. It has several advantages over other techniques which are often employed in characterization of ultra-thin metal films, such as optical absorption, Atomic Force Microscopy, Transmission Electron Microscopy or Scanning Electron Microscopy. In contrast to those techniques our method does not require specialized sample preparation and measurement process is insensitive to electrostatic charge and/or presence of surface absorbed water. We validate our results with image processing of Scanning Electron Microscopy images. To ensure precise quantitative analysis of the images we developed a generic local thresholding algorithm which allowed us to treat series of images with various values of surface coverage with similar image processing parameters.

Keywords: Ultra-Thin Films; Gold; X-Ray Reflectivity; Surface Coverage, Non-Wetting Substrate

1. Introduction

Gold is an important metal in various branches of research and technology, including electronics, photonics and biotechnology, due to its high conductivity, chemical stability, large atomic mass and surface chemistry. In particular, it remains the most important metal for plasmonic devices [1]. Preparation of structurally continuous Au films below a thickness of about 15 nm, however, is in many cases prohibited by the high surface mobility of gold and a strong tendency for the formation of isolated nanoscale islands. Challenges and opportunities related to this behavior attract a lot of research. The degree of continuity of the layer deposited on particular substrate can be determined, e.g., optically by measuring localized surface plasmon resonances, by atomic force microscopy (AFM), transmission electron microscopy (TEM), scanning electron microscopy (SEM), or by high-angle annular dark-field