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Template-Induced Growth of Sputter-Deposited Gold Nanoparticles on Ordered Porous TiO2 Thin Films for Surface-Enhanced Raman Scattering Sensors

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Ordered porous gold/titanium dioxide (Au/TiO2) hybrid nanostructured films are specifically interesting in large-scale applications using localized surface plasmon resonances (LSPRs) and surface-enhanced Raman scattering (SERS). In this work, we investigate the optical response of sputter-deposited Au/TiO2 nanohybrid thin films with a focus on the plasmonic response and application as molecular sensors. To elucidate the origin of this behavior, we apply in situ grazing-incidence small-angle X-ray scattering (GISAXS) to investigate the growth kinetics of Au on a TiO2 template during sputter deposition. Based on time-resolved GISAXS, the growth characteristics of sputter-deposited Au on TiO2 template with a final effective Au layer thickness around the percolation threshold is described with the well-known four-stage model of nucleation and cluster formation, diffusion-mediated growth, adsorption-mediated growth and grain growth. The Raman intensity of deposited molecules, probed with rhodamine 6G (R6G), depends on the deposited gold thickness. It shows its maximum at the effective Au thickness (δAu) of 3.4 nm. The maximum in SERS intensity is corroborated by the existence and optimal size of hot spots in the narrow space occurring between the sputter-deposited Au clusters, when staying below the percolation threshold.

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