Advanced fabrication of hyperbolic metamaterials

Hyperbolic metamaterials can provide unprecedented properties in accommodation of high-k (high wave vector) waves and enhancement of the optical density of states. To reach such performance the metamaterials have to be fabricated with as small imperfections as possible. Here we report on our advances in two approaches in fabrication of optical metamaterials. We deposit ultrathin ultrasmooth gold layers with the assistance of organic material (APTMS) adhesion layer. The technology supports the stacking of such layers in a multiperiod construction with alumina spacers between gold films, which is expected to exhibit hyperbolic properties in the visible range. As the second approach we apply the atomic layer deposition technique to arrange vertical alignment of layers or pillars of heavily doped ZnO or TiN, which enables us to produce hyperbolic metamaterials for the near- and mid-infrared ranges.

High-Quality Ultrathin Gold Layers with an APTMS Adhesion for Optimal Performance of Surface Plasmon Polariton-Based Devices

A low-absorption adhesion layer plays a crucial role for both localized and propagating surface plasmons when ultrathin gold is used. To date, the most popular adhesion layers are metallic, namely, Cr and Ti. However, to the best of our knowledge, the influence of these adhesion layers on the behavior of propagating plasmon modes has not been thoroughly investigated nor reported in the literature. It is therefore important to study the effect of these few- to several-nanometers-thick adhesion layers on the propagating plasmons because it may affect the performance of plasmonic devices, in particular, when the Au layer is not much thicker than the adhesion layers. We experimentally compared the performances of the ultrathin gold films to show the pivotal influence of adhesion layers on highly confined propagating plasmonic modes, using Cr and 3-aminopropyl trimethoxysilane (APTMS) adhesion layers and without any adhesion layer.
We show that the gold films with the APTMS adhesion layer have the lowest surface roughness and the short-range surface plasmon polaritons supported on the Au surface exhibit properties close to the theoretical calculations, considering an ideal gold film.
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