Optical Losses in Gold-Based Plasmonic Biosensors: Influence of Crystalline Structure

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Thin gold films are a key component of most commercial and laboratory-built plasmonic biosensors, which have found their applications in various fields, ranging from biochemical and pharmaceutical research to medical diagnostics. The biosensing principle of such devices is based on the excitation of surface plasmon resonance (SPR) in gold films and monitoring of excitation conditions during biosensing assay. The performance of plasmonic biosensors depends on optical properties of metal films and, in particular, on optical losses in metal, which in turn are partially determined by electron scattering on crystallite boundaries\(^1\). Here, we investigate how crystalline structure of gold films influences sensitivity and resolution of plasmonic biosensing. The SPR excitation was considered according to the Kretschmann’s configuration, which composes 1) the glass prism with refractive index (RI) 1.523; 2) 47-nm-thick gold films; and 3) the top aqueous layer with RI of 1.33\(^2\). Figure 1(a) shows the SPR angular reflectivity curves for structures comprising polycrystalline gold films with different crystallinity. The full-width at half-maximum (FWHM) of SPR angular curve is a characteristic of optical losses and, therefore, depends on the crystallite size \(D\) (Figure 1(b)). The resolution of SPR biosensing can be described by the figure of merit (FOM), defined as a ratio of biosensing sensitivity to FWHM. The dependence of FOM on the crystallite size is also shown in Figure 1(b), which demonstrates the increase of FOM up to 60% for different crystallites sizes. So, the performance of gold-based plasmonic biosensors strongly depends on the crystalline structure of metal films used for the excitation of SPR. Due to this, the development of efficient plasmonic biosensors should carefully address various aspects of gold film deposition, including substrate preparation as well as the choice of a fabrication method and corresponding deposition regimes.

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References

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