Surface plasmon resonance-induced Goos-Hänchen shift due to gold film

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Goos-Hänchen (GH) shift is the lateral displacement of an optical beam upon interaction with a planar surface [1]. Using the stationary-phase argument, Artmann formulated that GH shift is proportional to the derivative of the phase of the complex reflectivity which occurs only under total internal reflection [2]. This formulation has been widely used across different types of materials. There is, however, is a lesser known related effect called the angular deviation (Θ_{GH}) of the beam which occurs under partial reflection. This angular shift is proportional to the derivative of the amplitude of complex reflectivity [3].

In this work, we measured GH shift induced by reflectivity changes at surface plasmon resonance of gold (Au) film. We expect pronounced Θ_{GH} values due to the sharp dip in reflectivity at the SPR angle. The propagation dependence of Θ_{GH} would allow control over the magnitude of Θ_{GH} by simply changing beam parameters and without the need for complicated structure modification [4]. In our work, we configured our experimental setup to provide Θ_{GH}-dominated measurements.

Thin Au films were deposited by RF Magnetron sputtering in an argon (Ar) gas environment on glass slides heated at 250°C during deposition. Titanium (Ti) was deposited prior to Au deposition to serve as an adhesion layer. The standard Kretschmann configuration was used to excite surface plasmon waves. A linearly polarized HeNe laser beam (λ= 632.8 nm) impinges onto the Au film mounted on the flat side of a hemispherical prism (ϕ = 20 mm). The polarization state of the incident beam is switched between s and p states using an EO modulator. The shift is detected using a position sensitive detector positioned ~4.5 cm from the beam waist and connected to a lock-in amplifier. Since surface plasmon excitation occurs under p-polarized incidence, GH shift under s-polarized source serves as the reference.

Figure 1a shows the reflectivity measurement for a 50-nm Au film within the vicinity of the SPR angle. Our measurements showed an SPR angle at 44.4° which agree well with the reflectivity calculations for a Gaussian beam incidence [5] with measured beam waist of 10.5 μm. Focusing of the beam is induced from the curvature of the hemispherical prism. The small minimum beam waist would translate to a larger magnitude of Θ_{GH}.

Our results for the GH shift measurement showed negligible spatial contribution as shown in Figure 1b. We show an inflection point at the SPR angle and a maximal shift of around 300 μm from the center within the vicinity of the SPR angle. Deviations from the calculations could be attributed to the contribution of the Ti layer and the roughness of the sample. Our shifts are larger compared to Yallapragada, et al. in [6] even with a simple Au film.

In summary, we measured large GH shift from reflectivity changes induced by SPR on a simple Au film structure. The detection of GH shift can afford us control over SPR detection by changing beam parameters even in simple material design.

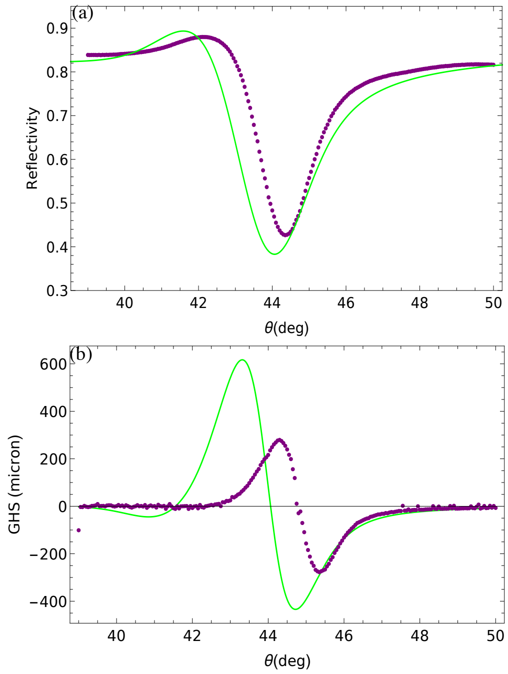

Figure 1. (a) Reflectivity and (b) GH shift measurements for Au film at SPR. The solid dots represent experimental data, while the solid lines represent theoretical calculations.

References

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