Surface plasmon resonance in thin films and gratings

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1 Introduction

Surface plasmon resonances arise when a electromagnetic wave (light) couples to the electron charge oscillations excited at the metal-dielectric interface (surface plasmon-polaritons, or simply surface plasmons). The dielectric function of a noble metal is dispersive and has a large negative real part which is frequency dependent, and a relatively small imaginary part. At the metal-dielectric interface an electromagnetic wave can be excited and propagate along the interface. The excitation requires that the k-vector of surface wave equals the component of the external light beam parallel to the surface. This is called phase or momentum matching.

The dielectric function of a metal can be described by the Drude-Lorentz free electron model. Using the boundary conditions for the fields at the metal-dielectric interface for the Maxwell's equations and the Drude-Lorentz model of the dielectric function solutions can be found leading to a strong light absorption in plane thin films and dielectric gratings coated by thin films. Using a laser beam it is possible to find experimentally at which angle of incidence the surface plasmon resonance (SPR) occurs. Using white light and illuminating a sample at various angles one can determine experimentally the dispersion relation of metal film - dielectric.

2 Objectives

- Measure the SPR angles for thin films of Au, Ag on glass substrate

- Find the dispersion relation ($d\omega/dk$) for a thin film, using a white light source for illumination and a spectrometer to measure the reflected light as function of the angle of incidence
- Find the dispersion relation for a dielectric grating coated by a thin film

3 Experimental setup

The experimental setup is based on an SPR apparatus. The angle resolved spectroscopy is achieved using 3 stepper motor rotating stages (MICOS DT-80) controlled by a LabVIEW program running on a PC. The light detection is based on Ocean Optics spectrometer. Samples with thin film coatings will be provided. The experimental results can be compared with the theoretical SPR curves and dispersion relations. These can be easily calculated using a Matlab/Octave program and the experimental data for the n and k values of the complex refractive index of the noble metals (see book of H. Raether and paper of Johnson and Christy), [2, 4, 1, 3, 5]

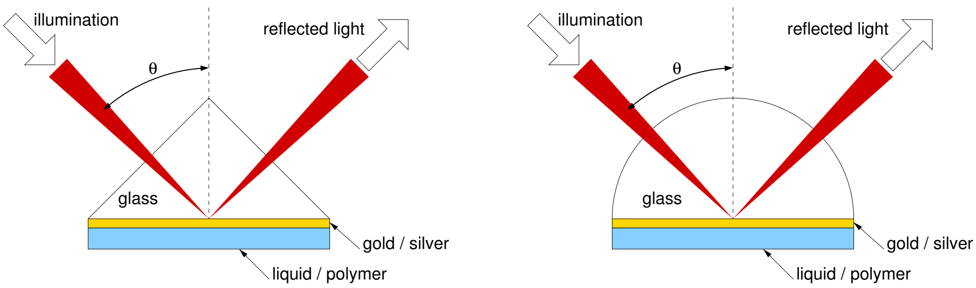

Figure 1: (left) SPR setup using a 90° prism. (right) SPR setup using a cylindrical prism.

References

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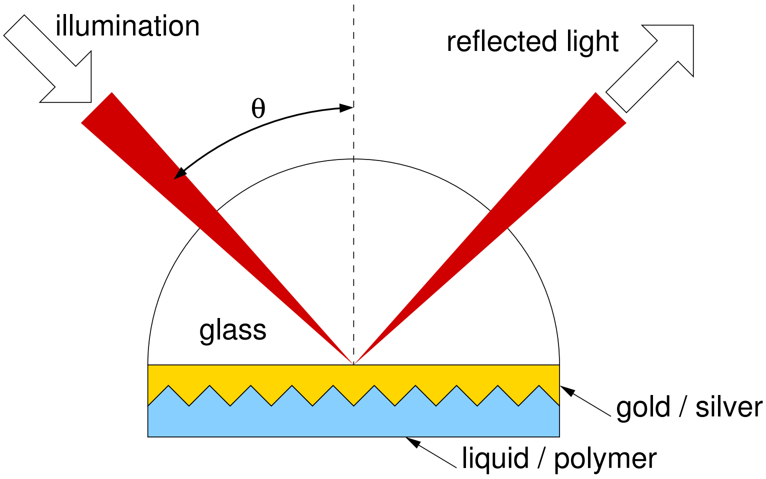

Figure 2: SPR setup for a grating

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