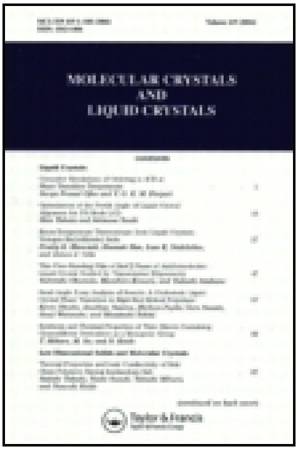

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A Measurement of Evanescent Fields Generating on Metal Thin Films and Langmuir-Blodgett Ultrathin Films

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A Measurement of Evanescent Fields Generating on Metal Thin Films and Langmuir-Blodgett Ultrathin Films

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Surface plasmons (SPs) were resonantly excited for aluminum (Al) thin films and arachidate acid (C20) LB ultrathin films on the substrates in a Kretschmann configuration of the attenuated total reflection (ATR) method. Evanescent fields generating on the Al thin films and the LB films due to excitations of the SPs were detected as luminescent light from a metallic needle probe covered with CdS in the localized evanescent fields. The luminescent light, that is, the evanescent fields were measured as a function of the incident angle of the laser beam exciting the SPs and as a function of the distance from the surface. The luminescent light intensity was biggest at a lower angle than the resonant angle. These properties were calculated and discussed. Evanescent fields were also measured for C20 LB films on Al thin films.

Keywords: evanescent field; surface plasmon; ATR; Al thin films; C20 LB film

INTRODUCTION

Surface plasmons (SPs) are known as non-radiative optical modes due to plasma oscillations of free electrons resonantly excited at a metal surface and propagate along the surface with evanescent electromagnetic fields. Since the SPs localized at the metal surface are strongly influenced by conditions of the surface, the ATR method resonantly exciting the SPs is used to evaluate structure and optical properties of ultrathin films on metal thin films [1,2].

Evanescent fields decay rapidly in the distance of sub-micrometers from some localized surface and cannot be usually observed, but they are enhanced by excitation of SPs and strongly depend upon nanometric structure of ultrathin films.

In this study, evanescent fields were investigated for Al thin films and C20 LB films on the substrates using a Kretschmann configuration of the ATR method.

EXPERIMENTAL DETAILS

Figure 2 shows the sample configuration in order to detect the evanescent fields. A 45°-right angle prism of BK-7 glass was used in this experiment. Al thin films of about 20 nm thick were vacuum-evaporated on substrates of microscopic cover glasses, and C20 LB films of 7 layers were deposited on this configuration. Since the evanescent fields localize near the sample surfaces and do not propagate in the air, the fields can not be detected directly. In this study, a platinum (Pt) needle probe covered with cadmium sulfide (CdS) was used to detect the evanescent fields. And luminescent light at 652 nm was observed from CdS excited by the evanescent fields due to SPs in the ATR configuration using the p-polarized Ar^+ laser beam at 488 nm.

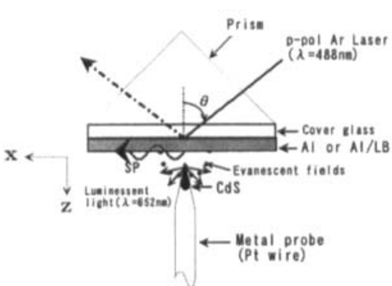

FIGURE 1 The sample configuration to detect the evanescent fields.

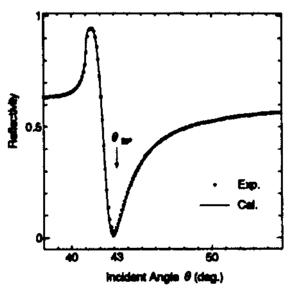

FIGURE 2 An ATR property of Al thin film.

RESULTS AND DISCUSSION

The ATR Curve

The ATR curve for the Al thin film is shown in Fig. 2. The minimum in the reflectivity was observed at a resonant incident angle of about 43.0°, θ_{SP}, where the SPs were resonantly excited at the surface of the Al thin film by the laser beam at 488 nm. The solid curve in Fig. 2 shows the theoretical curve calculated using the transfer-matrix method [3]. The theoretical curve fitted the experimental one well.

Detecting the Evanescent Fields on the Al Thin Film

Figure 3 shows the luminescent intensity at 652 nm as a function of the distance, z, from the sample surface at the resonant incident angle, θ_{SP} = 43.0°, for the same sample as used in Fig. 2. The luminescent intensity decayed exponentially near the sample surface, and the exponential decay length was about 180 nm. This length was approximately equal to the calculated penetration depth of the evanescent fields, i.e. 140 nm.

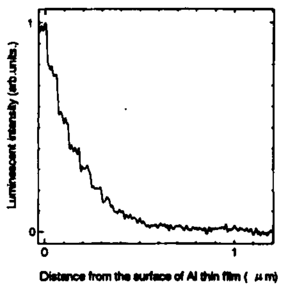

FIGURE 3 The luminescent intensity as a function of the distance from the sample surface at the resonant incident angle, θ = 43.0°.

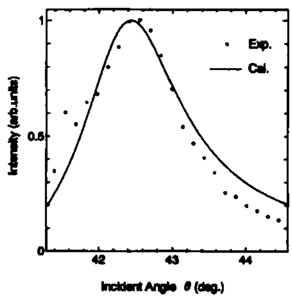

FIGURE 4 The luminescent intensity and the calculated property of the evanescent fields as a function of the incident angle of the laser beam.

Figure 4 shows the luminescent intensities as a function of the incident angle of the laser beam exciting SPs. The closed circles are the experimental results and the solid curve is the normalized calculation of the square evanescent fields at the sample surface. The maximum intensity was obtained at an angle, about 42.5°, lower than the resonant incident angle, $\theta_{SP} = 43.0°$. It is tentatively estimated that an absorption property of the Al film may cause the difference in the angles [4].

Detecting the Evanescent Fields on the Al/C20 LB Thin Film.

The luminescent intensity was also measured as a function of the distance from the sample surface for Al/C20 LB (7 layers). The incident angle of the laser beam was fixed at the resonant angle of ATR. The luminescent intensity for Al/C20 films exponentially decayed near the sample surface and was weaker than that of the Al film.

CONCLUSION

Evanescent fields due to SPs resonantly excited in the ATR method were detected as luminescent light from a Pt needle probe covered with CdS. The decay length of the evanescent fields was about 180 nm and the maximum intensity was obtained at the lower angle, about 42.5°, than the resonant incident angle, $\theta_{SP} = 43.0°$ in the ATR measurement.

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