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Emission Light and Multiple Surface Plasmon Excitations at Prism/Ag/Merocyanine LB Films

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1. Introduction

The attenuated total reflection (ATR) method using surface plasmon (SP) excitations, that is, the surface plasmon resonance (SPR) method is quite useful for measurements and sensing, since excitation condition of SP is strongly influenced by conditions of the surfaces [1]. There are many reports using ATR measurements that evaluate structure and optical properties of organic ultrathin films on metal ultrathin films, and estimate orientations of liquid crystal molecules [2, 3] and as one of sensing methods [4]. The ATR methods have been also investigated for device applications, because of strong optical absorption and strong electric fields due to SP excitations [5].

Recently, emission light at a resonant angle region of SP excitations was observed through the prism in the ATR Kretschmann configuration, when metal ultrathin films on the prism or organic ultrathin films on metal ultrathin films were directly irradiated from air by a laser beam [6, 7]. The emission light depended upon resonant conditions of SPs in the Kretschmann configuration, and it is considered that multiple SPs were excited by means of the direct excitation of organic dye films by a laser beam, that is, reverse irradiation [7, 8].

In this study, ATR properties and emission light properties have been investigated in details for hetero layer structures of merocyanine (MC) and arachidic acid (C20) Langmuir-Blodgett (LB) films on silver (Ag) films using the conventional Kretschmann configuration for ATR method and the reverse irradiation.

2. Experimental Details

MC is one of photosensitizing organic dyes and shows photoelectric properties and p-type conduction. C20 has no optical absorption and is one of dielectric materials. Ultrathin films of MC and C20 were fabricated using LB method. MC LB films were deposited mixed with C20 for good depositions and the molar ratio of the mixture was [MC]: [C20] =1:2. Ag thin film of which thickness was about 50 nm was used as the SP active layer. The Ag thin film was deposited on a microscopic cover glass by vacuum evaporation methods. Hetero structure LB films of C20 and MC LB films were deposited on the Ag thin films. Emission light properties have been investigated depending upon separation between the Ag thin film and the MC LB films.

Figure 1 shows the Kretschmann configuration and a system for detecting emission light through the prism when the sample was excited by reverse irradiation in the configuration. The sample was put on the back surface of a half-cylindrical prism (BK-7, n=1.512 at λ= 488 nm). The sample was irradiated at the vertical incident angle by a p-polarized Ar^+ laser beam at 488nm. The emission light was observed through the prism in the configuration [7, 8]. The spectra of the emission light were measured at various emission angles, θe, where the light was observed.

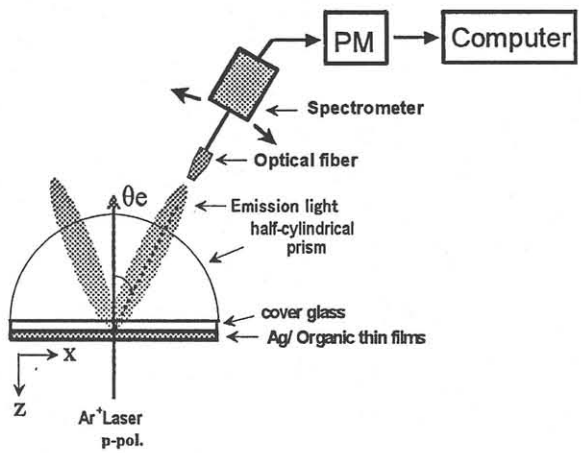

Fig.1 Kretschmann configuration and a system for detecting emission light.

3. Results and discussion

Figure 2 shows spectra of emission light through the prism from prism/Ag/C20 LB film (2 layers) /MC LB film (16 layers) at various emission angles in the reverse irradiation. The spectra strongly depended on the emission angles, and the peak wavelengths of the emission light

became shorter as the emission angles increased. Each spectrum almost corresponded to a part of broad photoluminescence (PL) spectrum of the MC LB films showing a peak at 600nm [8]. ATR properties were also measured at various laser wavelengths for the same sample.

The dispersion property of SP from the emitted light was compared with the calculated one from the ATR properties. The dispersion property of the emission light agreed well to one of the ATR measurements [7, 8]. It was thought that multiple SPs were simultaneously excited in the reverse irradiation and the emission light was generated due to the dispersion property of SP in the ATR configuration. It is tentatively estimated that polarizations of MC on the Ag film excited by the reverse irradiation induce vibrations of free electrons at the metal surface producing multiple SPs.

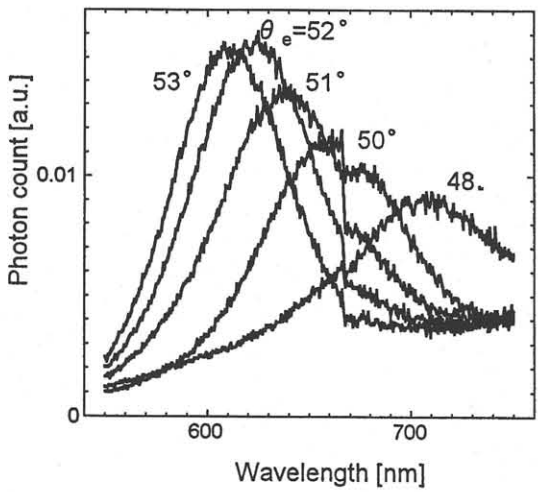

Fig.2 Emission light spectra from prism/Ag/C20 LB film (2 layers) /MC LB film (16 layers) at various emission angles in the reverse irradiation of Ar^+ laser at 488 nm.

Emission light properties were also investigated depending upon separation between the Ag thin film and the MC LB films. Total number of monolayers containing MC LB films with 4 monolayers was 20 in the hetero LB films and the space between the Ag film and the MC LB films were fabricated using C20 LB layers. Figure 3 shows emission light from prism/Ag/C20/MC/C20 LB films. The emission properties depended upon the position of the MC LB films in the hetero films, and the intensities increased with the separation between MC and Ag films and showed a maximum at the separation of C20 with 10 monolayers. The detailed reason is not clarified yet, but it is considered to be due to escape of excitons in MC to the Ag film. It is thought that the phenomenon is very useful for device applications.

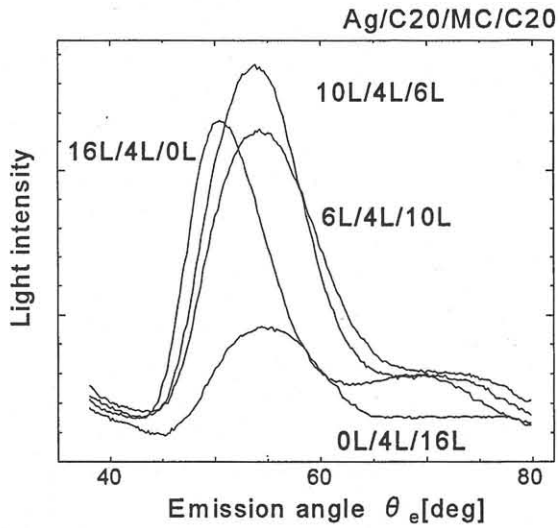

Fig.3 Emission light properties as a function of emission angle from prism/Ag/C20/MC/C20 LB films.

4. Conclusions

The emission light properties from Ag/MC LB films were investigated using the reverse irradiation. The emission light was caused by simultaneous excitations of multiple SPs. The emission properties depended upon the separation between Ag and MC LB films.

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