C-19

Wavelength dependence on magnetic response of surface plasmons for non-solid solution $Ag_{75}Co_{25}$ films

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Magnetic activity of the surface plasmons (SPs) are expected to apply supersensitive magnetic sensor. The excitation and magnetic activity of the SPs on $Ag_{75}Co_{25}$ single layer films, which is non-solid solution material, were investigated to vary film thickness, annealing temperature and wavelength of the incident light. The excitation and detection of the SPs were evaluated by attenuated total reflection (ATR) method. Excitation of the SPs were confirmed on the $Ag_{75}Co_{25}$ single layer films which are as-deposited 35 - 50 nm-thick and annealed at 300 and 500 °C with wavelengths of 600 - 780 nm. The largest magnetic activity of the SPs was confirmed on the 35 nm-thick films with wavelength of 700 nm.

1. Introduction

The magnetic activities of surface plasmons, which are supersensitive to dielectric constant change were reported at a multilayer structure with a noble metal layer and a magnetic layer, which played roles of excitation and magnetic activity, respectively [1-3].

Non-solid solution materials of a noble metal and a magnetic metal have possibility of both excitation and magnetic activity in the SPs simultaneously even on a single layer. A Ag-Co system, which is a non-solid solution material, is one of candidates for magnetic activity of the SPs. In order to induce magnetic activity in the single layer film of the SPs, the magnetic activities of the SPs excited by incident light with various wavelengths in Ag-Co films were investigated.

2. Experimental method

$Ag_{75}Co_{25}$ thin films were deposited on glass substrates by RF magnetron sputtering method. The film thicknesses were varied from 35 to 50 nm. The samples were annealed at 300 and 500 °C for 10 minutes in vacuum.

The excitation and detection of SPs were evaluated by ATR method in Kretschmann-Raether configuration as shown is Fig. 1. The light with transverse magnetic wave was irradiated on the sample through a prism and the substrate at incident angle θ in the prism varied from 38° to 58°. Incident angles as well as the incident light intensity were corrected by using a refraction angle at the interface between air and the prism. Wavelengths λ of the light were changed from 600 to 780 nm. External magnetic field of 400 mT was applied to normal direction to the film plane. Magnetic activity of the SPs was evaluated by a figure of merits using following formula;

$$\Delta R = \{ R(H) - R(0) \} / R(0)$$

where, $R(H)$ corresponds to reflectivity with magnetic field H.

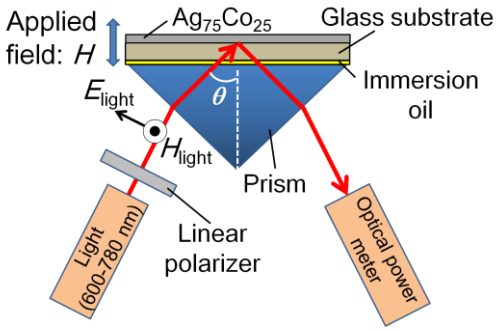

Figure 1. Attenuated total reflection method in Kretschmann-Raether configuration with applied field.

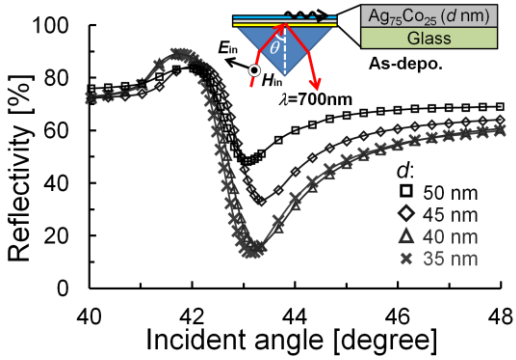

Figure 2. Reflectivity curves of the Ag-Co films which are the $Ag_{75}Co_{25}$ thickness of 35, 40, 45, and 50 nm as a function of incident angle.

3. Magnetic activity of SPs in $Ag_{75}Co_{25}$ thin films

The SP excitations in as-deposited samples with 35 to 50 nm-thick were evaluated by ATR method with the light of λ = 700 nm. The reflectivities of the samples as a function of incident angle are shown in Fig. 2. All reflectivity curves show local maximum R_{max} at ~42.0° and local minimum R_{min} at ~43.3°. These trends mean that the SPs are

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generated in the films at incident angle from 42° to 44°. The 35 nm-thick film shows a largest reflectivity difference R_{max}-R_{min} about 80%, and largest $|dR/d\theta|_{max}$ about 104 %/°. Large R_{max}-R_{min} and $|dR/d\theta|_{max}$ are effective to obtain large ΔR.

The 35 nm-thick $Ag_{75}Co_{25}$ film was annealed at 300 and 500 °C. The Co grains in Ag-Co films were expected to grow by annealing process. The reflectivities of the as-deposited and annealed samples without magnetic field are shown in Fig. 4. The SPs are excited in all annealed samples by the light of λ = 700 nm. The ΔR of as-deposited and annealed films are calculated. Largest $|\Delta R|$ of ~0.29 was obtained in the as-deposited sample, which also showed large R_{max}-R_{min} and $|dR/d\theta|_{max}$. Further investigation will be clear the relation between film structure and ΔR.

λ dependence of the incident light on the excitation and magnetic activities of the SPs was investigated of the 35 nm-thick $Ag_{75}Co_{25}$ film, which showed large R_{max}-R_{min} and $|dR/d\theta|_{max}$. The angle at local minimum is shifted to lower angle with increasing λ as shown Fig. 4. This means that the wavenumber of the incident light is matched to the wavenumber of the SPs at the each local minimum angle. R_{max}-R_{min} decreased from 77 to 72 % with increasing λ. $|\Delta R|_{max}$ and $|dR/d\theta|_{max}$ of the 35 nm-thick film with λ varied from 600 to 780 nm are shown in Fig. 5. The $|dR/d\theta|_{max}$ elevated from 70 to 120 %/° with increasing λ, because of the imaginary part of the dielectric constants in Ag and Co becomes small. The $|\Delta R|_{max}$ ~0.29 is obtained with λ of 700 nm. Both $|dR/d\theta|_{max}$ and R_{max}-R_{min} are key parameters to obtain large magnetic activity of the SPs.

4. Summary

The excitation and magnetic activity of the SPs on $Ag_{75}Co_{25}$ single layer films were investigated. The excitations of the SPs were confirmed on 35 - 50 nm-thick single layer films. The R_{max}-R_{min} and $|dR/d\theta|_{max}$ were become large with film thickness decreasing. The excitations of the SPs were confirmed on 35 nm-thick films which were as-deposited and annealed at 300 and 500 °C. The $|dR/d\theta|_{max}$ was increased with becoming longer λ, and the largest magnetic activity ΔR was obtained at wavelength of 700 nm. The ΔR of the SPs was obtained about 0.3 on 35 nm-thick as-deposited film, which was shown the large R_{max}-R_{min} and $|dR/d\theta|_{max}$ about 80% and 105 % respectively, at λ of 700 nm.

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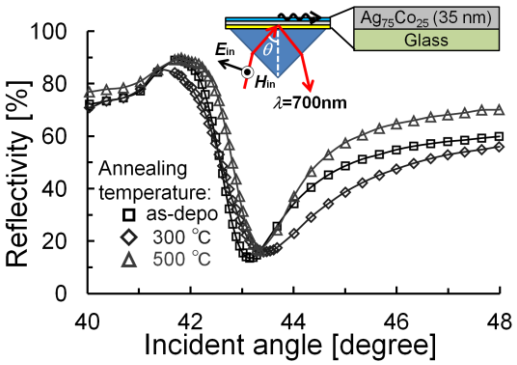

Figure 3. Reflectivity curves of the 35 nm-thick $Ag_{75}Co_{25}$ films as a function of incident angle. The samples are as-deposited and annealed at 300 and 500 °C .

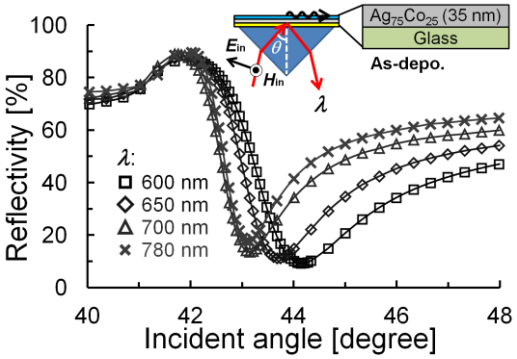

Figure 4. Reflectivity curves of the 35 nm-thick $Ag_{75}Co_{25}$ film with several wavelengths which are 600, 650, 700 and 780 nm as a function of incident angle.

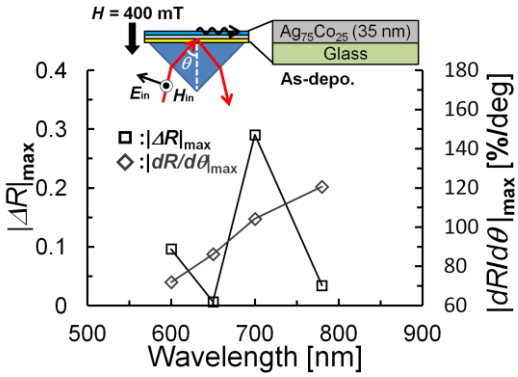

Figure 5. $|\Delta R|_{max}$ and $|dR/d\theta|_{max}$ in the 35 nm-thick $Ag_{75}Co_{25}$ film with several wavelengths which are 600, 650, 700, and 780 nm as a function of incident angle.

6. References

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