The controlling of transmittance and reflectance of a 2D metal periodic grating structure for cold filter application

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A cold filter that simultaneously achieves the reflection of infrared light and transmission of visible light was fabricated using a 2D metal periodic grating structure. A conventional dielectric multilayer film was used, which had abrupt filtering characteristics; however, there were problems with the incident angle, temperature, and polarization. To solve these problems, a 2D metal periodic grating structure was applied [1]. This type of structure has the advantage that it does not depend on polarization. In this study, the 2D metal periodic grating structure, comprising an Au layer and electron beam resist layer, was fabricated by electron beam lithography. The optical characterization of this structure in the visible light region was then conducted using a spectrometer.

The relationship between the optical properties and period of the double-layer, 2D grating structure was characterized. In particular, reflectance for the entire visible light spectrum decreased when the period was 800 nm and 1 μm. Figure 1 shows the reflectance spectra for various spacing. The measurement results suggested that by changing the spacing between upper and lower metal layers from 270 to 370 nm, the wavelengths with the minimum and maximum reflectance were shifted. This phenomena can be explained by the interference from the reflected light between upper and lower Au film layer. However, the peak shift cannot be wholly explained by the simple interference model, because the double-layer 2D metal grating structure has a subwavelength structure in the vertical direction. Thus, we examined the intensity of the magnetic field $|H_y|$ distribution by the RCWA method. From the simulation result, it can be considered that the surface plasmon resonance between the metal and resist layers occur simultaneously. Therefore, in the visible light region, the controlling reflectance and transmission spectra were controlled by the structure of the 2D metal periodic grating.

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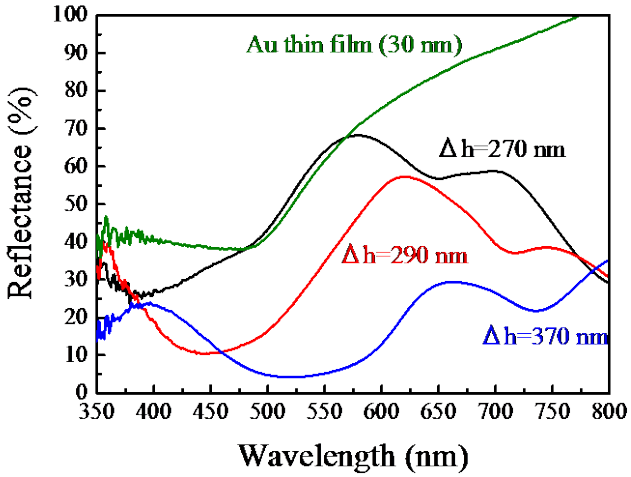

Figure 1. Reflectance spectra of double-layered metal gratings with different spacing Δ*h*.