GaMnAs の透過磁気円二色性スペクトルにおける干渉の効果

Interference effects on transmission magnetic circular dichroism spectra of GaMnAs

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Recent studies of GaMnAs have revealed that ferromagnetic and transport properties of GaMnAs are dominated by holes in the impurity band which is formed near the top of the valence band [1]. To investigate the spin-dependent impurity band structures, transmission magnetic circular dichroism (MCD) spectroscopy has been widely studied. In the previous studies, the band structure of GaMnAs was mainly discussed by the spectral shape of transmission MCD at around the photon energy E = ~1.5 eV where optical transitions from the impurity band to the conduction band are expected to be detected [2,3]. Meanwhile, one must be careful when interpreting the magneto-optical (MO) spectra, because they can be influenced by optical interference effects. Also, there is a large background in transmission MCD spectra of GaMnAs, which makes the interpretation of the MCD spectra difficult especially near the Γ-critical point [4,5]. Recently, we succeeded in deriving the off-diagonal element of the dielectric tensor of GaMnAs, which is intrinsic to the material and which can express the MO effects, from systematic reflection MCD measurements [6]. In this study, we calculated the transmission MCD spectra by considering the interference effects and found that transmission MCD spectra are strongly influenced by interference even in films as thin as 50 nm, although the thicknesses of the GaMnAs films were 50-300 nm in the previous studies [2-5]. Figure 1(a) shows the color contour plot of the transmittance of right handed circular polarized light $|T_+|$ of the d-nm-thick $Ga_{0.92}Mn_{0.08}As$ film and Fig. 1(b) shows that of the d dependence of transmission MCD, which are calculated by using the dielectric tensor of $Ga_{0.92}Mn_{0.08}As$ derived in our previous study [6]. In this calculation, we assume that the light is perpendicularly incident to the film at 5 K with an external magnetic field $\mu_0 H$ = 1 T applied perpendicular to the film plane. We see that the d dependence of MCD strongly correlates with that of $|T_+|$, and it is strongly influenced by the optical interference. When E < 2.5 eV, the peak (or dip) positions and even the spectral shape of MCD vary with d. We note that the d dependence of MCD is negligibly small when E > 2.75 eV due to the large extinction coefficient of GaMnAs. These results mean that we must be very careful when we discuss the band structure by raw transmission MCD spectra at E < 2.5 eV.

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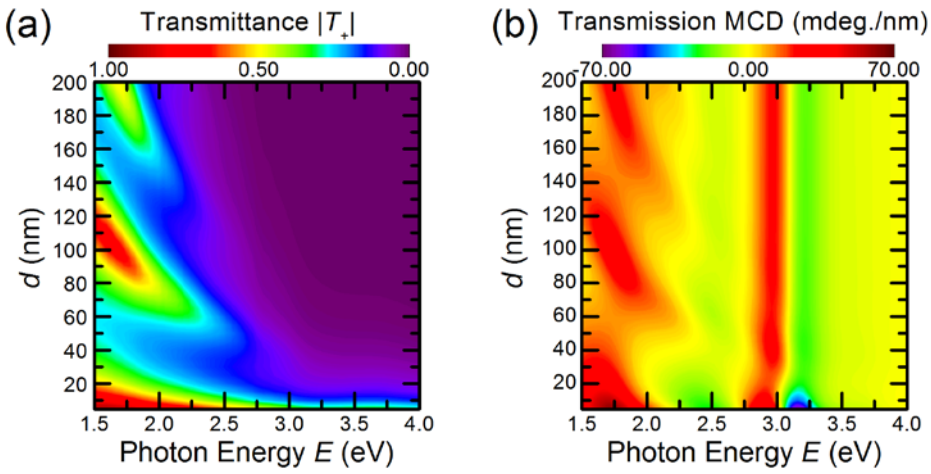

Fig. 1(a) Color contour plot of the d dependence of the calculated $|T_+|$ spectrum for $Ga_{0.92}Mn_{0.08}As$ thin films. (b) Color contour plot of the d dependence of the transmission MCD spectrum for $Ga_{0.92}Mn_{0.08}As$ calculated by using the data in Ref. [6].

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