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# 論 文 内 容 の 要 旨

氏　名　　Eva Jesenska

Recent decades have been characteristic by a massive technology development that completely transformed our society. Technology has become smaller, faster and more effective than ever. However, there is still a room for improvement, which has been demonstrated by a huge variety of novel devices proposed by scientific community (3D holographic displays, integrated non-reciprocal photonic devices etc.). This variety of highly specialized devices however requires materials with tunable optical, magnetic and magneto-optical (MO) properties. Therefore, we devoted presented thesis to the systematic study and analysis of the full permittivity tensors of such novel tunable materials. Namely, we focused on four groups of materials: CdZnTe, $Gd_xFe_{(100-x)}$, magnetic garnets ($Y_{3-x}Bi_xFe_5O_{12}$, $Nd_2BiFe_{(5-x)}Ga_xO_{12}$, $Nd_{0.5}Bi_{2.5}Fe_{(5-x)}Ga_xO_{12}$) and $Ce_{(0.95-x)}Hf_xCo_{0.05}O_{(2-\delta)}$. Systematic study was carried out by the combination of experimental methods of spectroscopic ellipsometry, MO Kerr effect spectroscopy and Faraday effect spectroscopy. We confronted experimental results with theoretical calculations based on Yeh 4x4 matrix formalism. As an outcome, full permittivity tensor spectra of presented materials were derived and analyzed in terms of microscopic theory in the measured spectral range from 1.5 to 5.5 eV.

When investigated CdZnTe, we found that absorption of this material increases with energy. We also observed absorption edge close to 1.5 eV and three optical transitions at 3.3, 3.9 and 5.2 eV. Finally, we found that smaller size of polishing abrasives results into thinner surface oxide layer which completely diminishes after etching.

Our investigation of $Gd_xFe_{(100-x)}$ optical properties showed that absorption of this material increases with energy. When investigating the effect of Gd substitution, we observed that higher Gd content decreases refractive index amplitudes. Moreover, it increases absorption coefficient amplitudes bellow 5 eV and has the opposite effect above. Perpendicular anisotropy of $Gd_xFe_{(100-x)}$ was confirmed for all samples. Finally, we observed change in the magnetization direction to the opposite site when reaching the compensation concentration.

When investigating $Y_{3-x}Bi_xFe_5O_{12}$ thin films, we found that Bi substitution increases refractive index and absorption amplitudes of this material. We observed optical transitions at 2.5, 3.2 and 4.4 eV and the absorption edge near 2.1 eV. As expected, we observed that Bi substitution leads to the enhancement in MOKE and Faraday effects. We attributed this positive impact of Bi to the increase in super-exchange interaction caused by the enhancement of electronic exchange for Dia transitions at 2.5 eV and 3.3 eV associated with t2(Fe3+) → t2g(Fe2+) and eg(Fe3+) → e(Fe2+) transitions. TEM measurement confirmed that $Y_{3-x}Bi_xFe_5O_{12}$ films prepared by metal-organic decomposition grow uniformly and epitaxially on GGG.

When researching $Nd_2BiFe_{(5-x)}Ga_xO_{12}$ and $Nd_{0.5}Bi_{2.5}Fe_{(5-x)}Ga_xO_{12}$ thin films, we found that Ga substitution decreases refractive index amplitudes for $Nd_2BiFe_{(5-x)}Ga_xO_{12}$ bellow 4 eV and increases them above. On the other hand, it does not significantly influence refractive index of $Nd_{0.5}Bi_{2.5}Fe_{(5-x)}Ga_xO_{12}$. We also observed that Ga substitution increases absorption for $Nd_2BiFe_{(5-x)}Ga_xO_{12}$, however on a contrary decreases it for $Nd_{0.5}Bi_{2.5}Fe_{(5-x)}Ga_xO_{12}$. Furthermore, the absorption of $Nd_{0.5}Bi_{2.5}Fe_{(5-x)}Ga_xO_{12}$ is almost 30% stronger than absorption of $Nd_2BiFe_{(5-x)}Ga_xO_{12}$. We attribute this to the higher Bi concentration. When looking at MO properties, we found that Bi substitution increases and Ga substitution decreases amplitudes of MO effects. This is in accordance with the assumption, that Ga is mostly substituted for Fe3+ tetrahedral, which is crucial for main transitions t2(Fe3+) → t2g(Fe2+) and eg(Fe3+) → e(Fe2+). We also found that Ga substitution lowers energy of much smaller Dia transition at 4.65 eV which is in accordance with the assumption that Ga is in a smaller percentage also substituted per Fe3+ octahedral.

Finally, we focused on $Ce_{(0.95-x)}Hf_xCo_{0.05}O_{(2-\delta)}$ thin films. We found that Hf content decreases refractive index amplitudes of this material. We observed shift of optical bandgap from 3.21 to 4.1 eV and decrease in absorption when Hf content increased. We attributed this to Hf substitution acting against optical vacancies from isolated Ce4f states localized within the optical bandgap. Absorption tail bellow 3.2 eV was attributed to the effect of midgap defects. We also observed that Hf substitution shifts Faraday rotation extreme from 2.9 eV to higher energies and decreases its amplitudes. Moreover, it decreases off-diagonal elements of the permittivity tensor and shifts their maxima to higher energies. We attributed this to magnetoelastic effects that originate from distortions caused by in-plane compressive strain and vary with Ce-Co content. Finally, we found that the main MO contribution comes from Dia transitions at (1.5-1.65 eV) which refer to localized 4f states in the band gap and at (3.75-4.3 eV) which refer to the oxygen electronic transitions.