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Optical Bands Splitting in $Tm_3Fe_5O_{12}$ Thin Films

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Abstract : Nano-scaled magnetic systems that can have both magnetic and optical transitions controlled and manipulated by external means have received enormous research attention for their potential applications in magneto-optics and spintronic devices. Among several ferrimagnetic insulators, the $Tm_3Fe_5O_{12}$ (TmIG) has become a prototype material displaying huge perpendicular magnetic anisotropy. Nevertheless, the optical properties of nano-scale TnIG films have not yet been investigated. We report the observation of giant splitting in the optical transitions of high-quality thin films of $Tm_3Fe_5O_{12}$ (TmIG) grown by rf sputtering on gadolinium gallium garnet substrates (GGG-111) substrate. The optical absorbance profiles measured with optical absorption spectroscopy show a dual optical transition in visible frequency regimes attributed to the transitions of electrons from the O-2p valence band to the Fe-3d conduction band and from the O-2p valence band to the Fe-$2p^5 3d^6$ excitonic states at the Γ-symmetric point of the TmIG Brillouin zone. When the thickness of the film is reduced from 120 nm to 7.5 nm, the 1st optical transition energy shifted from 2.98 to 3.11 eV (~130 meV), and the 2nd transition energy shifted from 2.62 to 2.56 eV (~ 60 meV). The giant band splitting of both transitions can be attributed to the population of excited states associated with the atomic modification pertaining to the compressive or tensile strains.

Keywords : optical transitions, thin films, ferrimagnetic insulator, strains
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