Room Temperature Photo-induced Magnetization of Spinel $(Mn,Zn,Fe)_3O_4$ Thin Films

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Abstract Body: The conversion of photonic signal into a magnetic response is of interest both fundamentally and technologically. The spinel ferrites with multiple Fe valences have been identified as a promising class of photomagnetic materials. We report on the observation of photo-induced magnetism in textured thin films of the spinel $Mn_xZn_yFe_{3-x-y}O_4$ ($0.225 \leq x \leq 0.525$, $0.5 \leq y \leq 0.6$). Samples with nanocrystalline grain sizes of approximately 15-70 nm were grown by PLD at room temperature on Si substrates. Coupling a 633 nm HeNe laser into a SQUID magnetometer, we have performed magnetization vs. temperature and applied magnetic field measurements with and without illumination to determine the extent of the photo-induced magnetization relative to the sample's field-dependent magnetization. The samples show a room temperature photomagnetic effect that appears to be strongly correlated to the zero crossing of the magnetocrystalline anisotropy at approximately room temperature.[1] Epitaxial films of the same stoichiometry deposited on $MgAl_2O_4$ substrates do not exhibit this photomagnetic effect since their magnetic anisotropy is dominated by magnetostrictive effects.

We attribute the photomagnetic effect to an optically induced inter-valent charge transfer (IVCT) between a magnetically hard Fe^{2+} and a magnetically easy Fe^{3+} on octahedral sites,[2,3] which serves to increase the magnetic moment at low fields. This effect is enhanced when the magnetic anisotropy is easily perturbed, such as a zero crossing of the magnetic anisotropy. Additionally, we have also measured soft X-ray magnetic circular dichroism spectra with and without incident HeNe laser light to determine the relative distribution of Fe^{2+} and Fe^{3+} on the octahedral and tetrahedral sites. We observe an enhanced dichroism at the Fe^{2+} and Fe^{3+} in octahedral sites indicating the importance of the IVCT mechanism to the photomagnetism of these samples.

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