TiO_2 based diluted magnetic semiconductor thin films grown by liquid-delivery metalorganic chemical vapor deposition

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Dilute magnetic semiconductors have received considerable attention because of their combined magnetic and transport properties, which are desirable for spintronics applications[1-5]. Recently, it has been reported that ferromagnetic state exists in Co-doped anatase TiO_2 semiconductors at room temperature.[6] Room temperature ferromagnetism has also been indicated when rutile, another common structure of TiO_2, is doped with Co[7-8] or Fe.[9]

Here, we have used liquid-delivery metal-organic chemical vapor deposition (LD-MOCVD) to grow Co-doped TiO_2 and Fe-doped TiO_2 thin films for various Co concentration, and have measured the elemental distribution, magnetic properties, and chemical bonding states of the resulting films. High spatial resolution Auger electron spectra and elemental mapping images from the Co-doped TiO_2 film have been obtained by a scanning Auger microscope (SAM). The existence of Co-rich complex oxide compound clusters from elemental distribution of the annealed film was identified. Surface morphologies and magnetic distribution from the film have been investigated using atomic force microscope (AFM) and magnetic force microscope (MFM). The ionic states of Co in ferromagnetic Co-doped TiO_2 films have the +2 formal oxidation states. Co-rich clusters on the $Ti_{1-x}Co_xO_2$ film surface were formed above the limit of solubility of approximately x=0.05. Co-rich clusters formed in $Ti_{1-x}Co_xO_2$ films decreased the value of H_c (coercive) field and increased the value of M_s (saturation magnetic field). The M_s and H_c of $Ti_{0.97}Co_{0.03}O_2$ thin films are estimated to be higher than 300 K.

References

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