Article

Far-Infrared–Ultraviolet Dielectric Function, Lattice Vibration, and Photoluminescence Properties of Diluted Magnetic Semiconductor $Sn_{1-x}Mn_xO_2$/*c*-Sapphire Nanocrystalline Films

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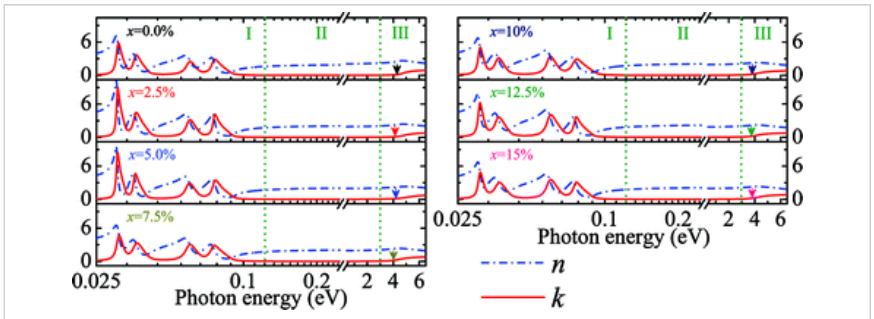
Section: Optical, Electron, and Mass Spectroscopy and Other Related Properties

Abstract



Optical properties of $Sn_{1-x}Mn_xO_2$ (*x* from 0.0 to 0.15) nanocrystalline films grown on *c*-plane sapphire substrates have been investigated at room temperature by ultraviolet-infrared transmittance, far-infrared reflectance, and photoluminescence spectra. The X-ray diffraction analysis indicate that the films are of tetragonal rutile structure except for 5% Mn doping, in which the slight orthorhombic phase appears due to the presence of defects and strain. The dielectric functions are successfully determined from 0.025 to 6.5 eV using the Adachi and Lorentz multioscillator dispersion models in the high and low photon energy regions, respectively. The fundamental absorption edge is found to shift toward a lower energy side with increasing Mn composition. The refractive index of pure SnO_2 film is estimated to be the lowest among the $Sn_{1-x}Mn_xO_2$ system. On the other hand, the low E_u transverse optical (TO) phonon frequencies slightly increase with the Mn composition. However, the highest E_u(TO) and A_{2u}(TO) vibration modes present an opposite change trend. Compared with SnO_2 single crystal, four corresponding longitudinal optical (LO) phonon frequencies decrease for the films

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owing to the variation of the lattice constants and destruction of the crystal symmetry. Photoluminescence spectra of doped SnO_2 films show the remarkable intensity changes and a blue-shift trend compared to pure SnO_2 film. Moreover, a novel emission peak of about 1.56 eV associated with the Mn dopant can be observed. It can be concluded that the Mn incorporation effects are the main contributions because the replacement of Sn with Mn ion can induce the 2p−3d hybridization and result in the electronic band structure modification of the $Sn_{1-x}Mn_xO_2$ films.

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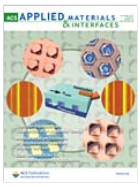

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