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Electrical conduction mechanisms in thermally evaporated tungsten trioxide (WO_3) thin films

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Abstract

Thin films of amorphous tungsten trioxide, a-WO_3, have been thermally evaporated onto glass substrate held at 350 K. Annealing at 723 K caused the formation of polycrystalline tungsten trioxide, c-WO_3, with a monoclinic structure. The dark DC electrical conductivity of both a-WO_3 and c-WO_3 was studied over a temperature range from 298 to 625 K in two environmental conditions (air and vacuum). A simple Arrhenius law, a polaron model and a variable range hopping model have been used to explain the conduction mechanism for a-WO_3 films. Using the variable range hopping model, the density of localized states at the Fermi level, $N(E_F)$, was found to be 1.08×10^{19} eV^{-1} cm^{-3}. The mechanism of electrical conduction in c-WO_3 films is explained by means of the Seto model. The Seto model parameters were determined as the energy barrier ($E_b = 0.15$ eV), the energy of trapping states with respect to the Fermi level ($E_t = 0.9$ eV) and the impurity concentration ($N_D = 4.05 \times 10^{15}$ eV^{-1} cm^{-3}). The thickness dependence of resistivity of c-WO_3 films has been found to decrease markedly with increasing film thickness, which is explained on the basis of the effective mean free path model. Using this model, the mean free path of electrons in c-WO_3 films was evaluated. The temperature dependence of the thermoelectric power for a-WO_3 films reveals that our samples are n-type semiconductors.

PACS
73.50.Pz Photoconduction and photovoltaic effects

73.50.Lw Thermoelectric effects

73.50.Gr Charge carriers: generation, recombination, lifetime, trapping, mean free paths

68.55.-a Thin film structure and morphology

73.61.Le Other inorganic semiconductors

68.55.Ln Defects and impurities: doping, implantation, distribution, concentration, etc.

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