Study of sputtered NiO and $NiAl_2O_4$ spinel thin films deposited in oxygen deficient plasma

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Nickel oxide (NiO) is an attractive material for use as an antiferromagnetic layer, p-type transparent conductive film, as an active electrode in electrochromic devices and as a functional sensing layer for gas sensor devices. NiO exhibits p-type semiconducting nature with wide band gap energy in the range of 3.5-4.0eV. Stoichiometric NiO is an insulator but Ni vacancies, interstitial oxygen atoms and Ni ions with different valences can modify its electrical and optical properties. Li, Al and Cu have been reported recently as possible dopants in NiO which might enhance its properties.

In this work, NiO and Ni-Al-O thin films were prepared by R.F. sputtering from metallic Ni and Ni-Al targets, in $Ar+O_2$ atmosphere. The RF power was 300W while the total pressure was 5mTorr. The structural, surface morphology and optical properties of thin films were studied by XRD, AFM, SEM, EDX and UV-NIR transmittance respectively. All measurements were performed on as-prepared films as well as after annealing in vacuum from 200°C to 600 °C.

NiO thin films were indicated as polycrystalline having the (200) preferred orientation, grain size about 4nm and the RMS roughness was 1.64nm.The highest visible transmittance (20-35%) was observed for as-deposited film in 2.8% O_2 in plasma with optical band gab at 3.64eV. The surface morphology was compact and homogeneous. After annealing at 500 °C the transmittance increased to 75% for the films with 2.8%O_2 in plasma.

Films deposited from Ni-Al composite target showed a completely different structure than that of NiO, with diffraction peak of XRD corresponding to the (311) peak of $NiAl_2O_4$ spinel phase. EDX confirmed the existence of Al in the structure (4,5 at.%).The RMS roughness was 2.87nm with compact and smooth surface morphology. Only the films deposited in plasma containing 2.8% O_2 showed high visible transmittance at 45-60%, with optical band gab at 3.76eV. As-deposited $NiAl_2O_4$ spinel films in 2.8% oxygen plasma were 20-25% more transparent than the respective NiO film. In addition, the transmittance of $NiAl_2O_4$ increased even more after annealing at 600 °C recording an average value of 75-80% in visible spectrum.

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