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Mechanical and Optical Properties of Doped Aluminum Nitride Thin Films

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Abstract : Aluminum nitride (AlN) is a potential candidate for semiconductor industry due to its wide band gap (6.2 eV), high thermal conductivity and low thermal coefficient of expansion. A-plane oriented AlN film finds an important role in deep UV-LED with higher isotropic light extraction efficiency. Also, Cr-doped AlN films exhibit dilute magnetic semiconductor property with high Curie temperature (□300 K), and thus compatible with modern day microelectronics. In this work, highly a-axis oriented wurtzite AlN and Al1-xMxN (M = Cr, Ti) films have synthesized by reactive co-sputtering technique at different concentration. Crystal structure of these films is studied by Grazing incidence X-ray diffraction (GIXRD) and Transmission electron microscopy (TEM). Identification of binding energy and concentration (x) in these films is carried out by X-ray photoelectron spectroscopy (XPS). Local crystal structure around the Cr and Ti atom of these films are investigated by X-ray absorption spectroscopy (XAS). It is found that Cr and Ti replace the Al atom in AlN lattice and the bond lengths in first and second coordination sphere with N and Al, respectively, decrease concerning doping concentration due to strong p-d hybridization. The nano-indentation hardness of Cr and Ti-doped AlN films seems to increase from 17.5 GPa (AlN) to around 23 and 27.5 GPa, respectively. An-isotropic optical properties of these films are studied by the Spectroscopic Ellipsometry technique. Refractive index and extinction coefficient of these films are enhanced in normal dispersion region as compared to the parent AlN film. The optical band gap energies also seem to vary between deep UV to UV regions with the addition of Cr, thus by bringing out the usefulness of these films in the area of optoelectronic device applications.

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