ABSTRACT

Zinc oxide (ZnO) is a non-toxic and relatively inexpensive (Transparent Conducting Oxide) material. Modification, optimization or tailoring of different properties of ZnO can easily be achieved via doping process. This flexibility makes ZnO the most suitable candidate to be used in many applications e.g. optoelectronic devices, photo-catalytic, UV lasers etc. Depending upon the nature of the target application, element/s from different group/s of periodic table can be doped in ZnO in order to achieve the desired characteristics. Group II elements e.g. Mg, Ca etc. are considered promising dopants in zinc oxide especially for its use in optoelectronic applications. These include, but not limited to, the fabrication of light emitting diodes, dye sensitized solar cells and sensing devices.

The zinc oxide thin films synthesis at simple and low cost plays a significant role in the advancement of opto-electronic applications. Among many processing techniques, solution processed technique (sol-gel spin coating and chemical bath deposition process) has significant advantages over other techniques in terms of low cost and feasible mass production.

Doping of Group II elements magnesium and calcium etc. are vital to alter e.g. Particle size, Band-gap etc. of ZnO which leads to the modification of structural and optical properties.

Literature survey reveals that the efficacy of Mg and/or Ca doped ZnO thin films for wetting, anti-icing, photo-catalytic and UV sensing applications have not been well explored. Especially for the case of film synthesis using Sol-Gel and Chemical Bath Deposition method.

In this work, magnesium and calcium doped zinc oxide thin films synthesized by i) sol-gel spin coating and ii) chemical bath deposition method were investigated and optimized.

In case of sol-gel method, magnesium and calcium doped and co-doped zinc oxide thin films were prepared by spin coating. Resulting films were characterized by X-ray Diffraction Spectroscopy (XRD), Scanning Electron Microscopy (SEM), Field Emission Scanning Electron Microscopy (FESEM), Energy Dispersive Spectroscopy (EDS), UV-visible spectrophotometry (UV-vis), Spectroscopic Ellipsometry (SE), and contact angle measuring (CA) system. The effects of ambient temperature during pre-heating and solvent variation on the synthesized films were also investigated. The effect of ambience during pre-heating was studied for hot plate and oven setups. The results showed the oven setup using temperature ramps yield the better surface morphology of ZnO thin films. The FESEM showed surface, XRD revealed c-axis orientation and optical

results (transmittance 94 % and band gap 3.36 eV) revealed 2-Methoxyethanol solvent is the best compared to others. The influence of concentration variation of magnesium and calcium on various properties like optical, wetting (hydrophilic and hydrophobic), UV induced wettability, photo-catalytic and anti-icing were explored. The results showed that the magnesium doping level at 2.5% produced better results for optical (transmittance >90%), hydrophilic (contact angle 20°) and UV induced super-hydrophilic (contact angle 0°) properties. The calcium doping level at 2.5% produced better results for optical (transmittance >80%), hydrophobic (contact angle 100°), UV induced super-hydrophilic (contact angle 0°) and photo-catalytic (MB decomposition efficiency 30%) properties. UV sensing response was observed in the range 0.035 to 0.05V for 2.5 and 5% all doped samples. The co-doping (Mg, Ca) level at 2.5% produced better results for hydrophobicity (contact angle 104.06°) and anti-icing properties. The anti-icing behaviour like freezing on-set and freezing delay was -15.1 °C and 900 seconds with the temperature set-point -5 °C respectively. Likewise, freezing delay with temperature set point -10 °C was 630 seconds.

In case of chemical bath deposition method, magnesium and calcium doped zinc oxide thin films (nano-structures i.e. nano-rods) were prepared. Synthesized films were also characterized by XRD, SEM, FESEM, EDS, UV-vis and CA system. The feature (solvent for seeding) that affect the Mg doped ZnO nano-structure was explored. The seeding procedure has been done by sol-gel spin coating. The surface morphology and XRD revealed better alignment of nano-rods along c-axis. Moreover, optical results (maximum transmittance 90% and band gap 3.3eV) showed 2-Methoxyethanol solvent is the best solvent for ZnO seed layer. The effects of concentration variation of Mg and Ca on properties like optical, wetting (hydrophilic and hydrophobic) and UV induced wettability were explored. Furthermore, UV sensing performance (UV sensor) has been investigated for different magnesium and calcium concentrated ZnO nano-structures. The magnesium doping level at 5% produced better results for c-axis orientation of nano-rods, optical (maximum transmittance 90%), super-hydrophobic (contact angle 152°), UV induced super-hydrophilic (contact angle 10°), and UV sensing (better photo-response in terms of voltage 0.35V) performance. The calcium doping level at 5% produced better results for hydrophobic (contact angle 90°) and UV induced super-hydrophilic (contact angle <5°) properties.