INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: Studies on Third Order Optical Nonlinearity, Photoluminescence and Random Lasing in Pulsed Laser Deposited $Zn_{1-x}Al_xO$ ($0 \leq x \leq 0.10$) and $Zn_{1-x}Ti_xO$ ($0 \leq x \leq 0.05$) Thin Films

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SHORT ABSTRACT

The present thesis was aimed to look into the optimum impurity content of Al and Ti in the host ZnO thin film for improved photoluminescence, nonlinear optical response and random lasing.

Both types of films, $Zn_{1-x}AlxO$ ($0 \leq x \leq 0.10$) and $Zn_{1-x}Ti_xO$ ($0 \leq x \leq 0.05$), were deposited onto fused silica as well as silicon substrates via pulsed laser deposition technique. The best crystalline quality and preferred c-axis orientation was exhibited by the film grown at x=0.05 and x=0.02 compositions for $Zn_{1-x}AlxO$ ($0 \leq x \leq 0.10$) and $Zn_{1-x}Ti_xO$ ($0 \leq x \leq 0.05$) thin films respectively. The optical band gap energies were observed to be blue shifted from 3.26 to 3.64 eV and 3.26 eV to 3.44 eV for $0 \leq x \leq 0.5$ and $0 \leq x \leq 0.02$ in $Zn_{1-x}AlxO$ ($0 \leq x \leq 0.10$) and $Zn_{1-x}Ti_xO$ ($0 \leq x \leq 0.05$) thin films respectively. The photoluminescence of the $Zn_{1-x}AlxO$ ($0 \leq x \leq 0.10$) thin films showed dominance of UV-blue emission and suppression of broad green-red emission while $Zn_{1-x}Ti_xO$ ($0 \leq x \leq 0.05$) films exhibited clear UV dominance along with a weak green-red emission. In addition, the $Zn_{1-x}Ti_xO$ ($0 \leq x \leq 0.05$) films grown at x=0.02, showed complete quenching of broad green-red band emission. The low temperature photoluminescence in all the films showed dominance of neutral donor bound exciton (D^0X) line over free exciton (FX) line. All the films showed reverse saturation absorption (RSA) and negative nature of optical nonlinearity. The third order nonlinear optical (NLO) coefficients (β, n_2 and $\chi^{(3)}$) were found to be increased with Al concentration upto x=0.05 while for higher values it decreased slightly. Similarly the NLO coefficients in $Zn_{1-x}Ti_xO$ ($0 \leq x \leq 0.05$) thin films were also found to be dependent on x. The two photon absorption induced photoluminescence of the film was studied under an optical excitation of continuous wave (cw) He:Ne laser operating at a wavelength of 632.8 nm. The maximum two photon absorption conversion was achieved at x=0.05 and x=0.02 in $Zn_{1-x}AlxO$ ($0 \leq x \leq 0.10$) and $Zn_{1-x}Ti_xO$ ($0 \leq x \leq 0.05$) thin films respectively.

Finally, the Random lasing action in $Zn_{1-x}Al_xO$ ($0 \leq x \leq 0.10$) thin films was performed. The lasing emission in films were attributed to three different types of mechanisms; closed loop random lasing (RL), fabry-perot (FP) and whispering gallery mode (WGM) cavities. The lasing threshold in pure ZnO film was estimated to be 3.2×10^2 MW/cm^2. The quality factors in these films were observed to be increased with Al content and the maximum value of quality factor (1004) was obtained for x=0.05 sample.