INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Programme of Study : Ph.D.

Thesis Title: Pulsed Laser Deposited Indium Tin Oxide and its Indium-rich Composite Thin Films as Efficient Material Platforms for Probing Epsilon-near-zero Plasmon and Lossy Mode Resonance via Kretschmann-Raether Geometry.

Name of Thesis Supervisor(s) : Prof. Ashwini Kumar Sharma

Thesis Submitted to the Department/ Center : Physics

Date of completion of Thesis Viva-Voce Exam : 7th March 2022

Key words for description of Thesis Work : Pulsed Laser Deposition (PLD), Indium Tin Oxide (ITO), Lossy Mode Resonance (LMR), Epsilon-near-zero (ENZ), Anisotropic Bruggeman Effective Medium Approximation (ABEMA), Transfer Matrix Method (TMM), Perfect Absorption, Refractive Index Sensing.

SHORT ABSTRACT

In the present thesis work, epsilon-near-zero (ENZ) plasmon resonance and lossy mode resonance (LMR) properties of pulsed laser deposited indium tin oxide (ITO) thin films and metallic indium-rich ITO thin films are studied experimentally with the help of Kretschmann–Raether geometry. Wide tuning of the ENZ wavelength over the wavelength range of 900 – 1700 nm is achieved for ITO thin films deposited under background gases such as O2, N2, Ar and He. The variation of ENZ plasmon resonance position is connected with the ENZ wavelengths at different background gases and the observed reflection spectra is understood through local field intensity enhancement factor analysis. The effect of surface roughness on the ENZ plasmon resonance is also studied for pulsed laser deposited ITO thin films deposited at different deposition times under a vacuum environment and near-perfect absorption is demonstrated experimentally for the film deposited at the highest deposition time. Such a high value of absorption just above the ENZ wavelength is corroborated by the strong electric field enhancement inside the film layer, while in terms of absorption loss, surface roughness leads the way and contributes immensely toward the occurrence of perfect absorption in the collective media. The LMR response of vacuum-deposited ITO thin film is compared to the films deposited under different background gases and the vacuum-deposited film is established as the material of choice due to their extremely high LMR response. Such a high degree of LMR response is attributed to the metallic indium generated interbands, leading to a high extinction coefficient in the visible range. The effect of overall film thickness on the LMR properties is investigated by depositing several ITO thin films at different deposition times under a vacuum environment. LMR attenuation value as high as -20 dB for transverse electric and -10 dB for transverse magnetic polarization is obtained for the ITO film with the highest film thickness. As an application of the LMR study, refractive index sensing is demonstrated in the RI range 1.3325 – 1.4459 for the ITO film with the highest thickness. A modified transfer matrix method algorithm, which takes the surface roughness of the films into account through the application of anisotropic Bruggeman effective medium approximation, is developed and, using this algorithm, the experimentally observed reflection spectra for ENZ plasmon resonance and LMR is resolved numerically.