

Highlights

RESEARCH AREA 2 - Functional and Complex Materials for Innovative Electronics and Sensing - 2022

“In-Operando Optical Spectroscopy of Field-Effect-Gated Al-Doped ZnO”

Maria Sygletou¹, Stefania Benedetti², Alessandro di Bona,² Maurizio Canepa,¹ Francesco Bisio³, and Emilio Bellingeri³

¹OPTMATLAB, Dipartimento di Fisica, Università di Genova, 16146 Genova, Italy;

² CNR-Istituto Nanoscienze, 41125 Modena, Italy

³CNR – SPIN Genova, Corso Perrone n.24, 16152 Genova, Italy

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Transparent conductive oxides (TCO) have the unique characteristics of combining optical transparency with high electrical conductivity; such a property makes them uniquely alluring for applications in visible and infrared photonics. One of their most interesting features is the large sensitivity of their optical response to the doping level. We performed the active electrical manipulation of the dielectric properties of aluminum-doped ZnO (AZO), a TCO-based on Earth-abundant elements. We actively tuned the optical and electric performances of AZO films by means of an applied voltage in a parallel-plate capacitor configuration, with SrTiO₃ as the dielectric, and monitored the effect of charge injection/depletion by means of in-operando spectroscopic ellipsometry (Fig.1 right). Calculations of the optical response of the gated system allowed us to extract the spatially resolved variations in the dielectric function of the TCO and infer the injected/depleted charge profile at the interface (Fig.1 center, right). We observed that good agreement between experimental data and calculations is achieved assuming an exponential decay of the injected charge density with a characteristic decay length of 4 nm.

This work demonstrates the possibility of accessing “in operando” the out-of-plane charge-density profiles in insulator/semiconductor interfaces under field effect by means of advanced optical spectroscopy.

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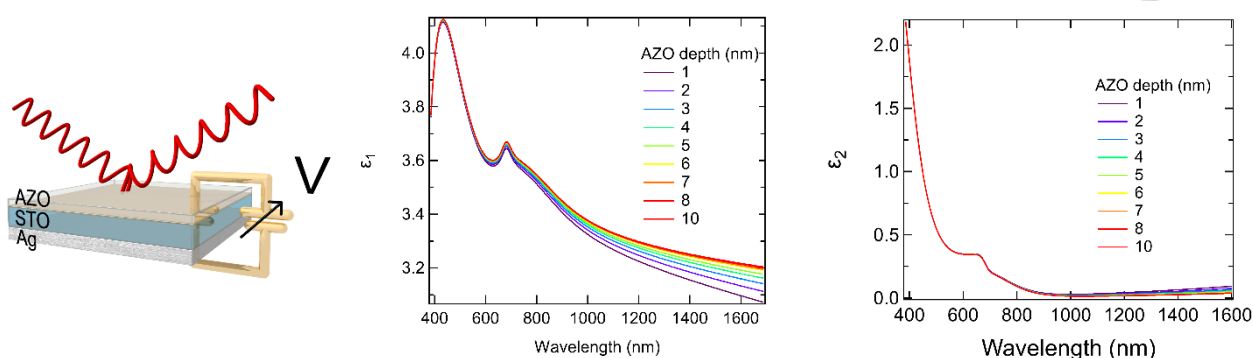


Fig. 1: Left: Schematic drawing of the field-effect device geometry for in-operando optical characterization. Center: the dielectric constants ϵ_1 and ϵ_2 of 0.2 at. % AZO film at various depth values from the AZO/BTO interface.