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SMART OPTICAL MATERIAL, ALUMINUM DOPED-ZINC OXIDE INVESTIGATED BY MODIFIED VASE FOR SPACE EXPLORATION

Abstract

Smart Optical Materials exhibit a dynamic tunable change in their optical properties with the application of an external field.

Research of SOM initially was conducted at NASA (National Aeronautics and Space Administration) Langley's Research Center (LaRC) in Hampton, Virginia and known as Field Controlled Smart-Active Optics (FCSAO). Research at NASA LaRC investigated fundamental materials and fabrication technology needed to develop SOMs for industrial use, military, medical applications, and space applications for NASA and the Department of Defense (DoD) for membrane optics, filters for LiDAR, windows for sensors and probes, telescopes, cameras, light valves, light switches, flat panel displays, etc. LiDAR is an example of SOM application that can be found in self-driving technology which is useful for space exploration.

Initial research investigated sputtered films of ScN, AlN, and Er-doped ALN thin films on 2-inch quartz substrates. With optical measurements made with a modified setup of a Variable Angle Spectroscopic Ellipsometer to apply an electric field at high voltages of 0, 1000, and 1500 V to show a lowered shift in refractive index by application of an electric field.

Here we look to build upon initial investigative work done in SOMs (Smart Optical Materials) with a gradient thin film of Aluminum-doped Zinc Oxide (AZO) fabricated at Norfolk State University. AZO is a transparent conducted oxide (TCO), plasmonic meta-material (PM), gradient thin film fabricated by alternating precursors of trimethylaluminum (TMA), diethylzinc (DEZ), and water (H2O) by Atomic Layer Deposition (ALD) to create a controlled doping gradient stack of AZO. Thin films of AZO are characterized by a modified setup of a Variable Angle Spectroscopic Ellipsometer to apply a tunable electric field between 0-12 V, and a tunable change in the real and imaginary permittivity in the Infrared (IR) range from VASE (Variable Angle Spectroscopic Ellipsometry). The tunability is ascribed to the carrier concentration, and voltage induced thermal effects that eventually diminish the carrier concentration and mobility above 12 V.

Here we analyze further the gradient thin film and investigate its usefulness for possible transformative applications (telecommunications, solar cell, lasers, etc.) space exploration. These observations could be useful as a SOM for telecommunications, possible solar cell configurations, and flat panel displays for space exploration.