This research focuses on the study of the refractive index and bandgap behavior in ultrathin multilayer films of Al$_2$O$_3$- ZnO system grown via atomic layer deposition technique (ALD) on Si (100). The multilayer configuration stack consists in alternate layers of Al$_2$O$_3$ with constant thickness (2 nm) and ZnO layers with varying thickness grown on Al$_2$O$_3$ in order to reach a total thickness desired. A set of 10 samples based on bilayers with different thickness ratio (2:X) were prepared, X refers to the ZnO layer thickness (in nm), which is proportional to the number (N) of cycles (1, 3, 5, 7,10, 20, 30, 50, 75 and 100) for the ZnO precursor. Refractive index (n) and optical bandgap (E$_g$) of each multilayer were studied via spectroscopic ellipsometry (SE). Images of the scanning electron microscope (SEM) were made in cross-sectional mode for the sake to verify the multilayer total thickness and corroborate the accuracy of the model used in the SE measures. The morphological properties were studied via Atomic Force Microscopy. The results from AFM images analysis showed that the surface roughness of the multilayers increases of 0.2 to 1.2 nm, as the ZnO layer thickness increases, these values were less than 2% as compared to the total thickness of the ultrathin multilayer. Ellipsometry data treated through the General Oscillator optical model reveals that the refractive index decreases for thinner bilayers, i.e. for samples with less number N cycles of ZnO precursor (1 to 7), the refractive index profiles, not showed marked peaks in UV region (200-400 nm), this behavior indicated that transparency for this bilayers increased. In addition the optical bandgap energy E$_g$ determined using a Tauc – Lorentz model, allows make evident that, when the bilayer thickness begins to increase, the optical bandgap gradually decreases and exhibits a variation of ?E$_g$ ~ 1.5 eV. The maximum and minimum energy bandgap value E$_g$ obtained for this material was 4.86 eV, and 3.32 eV respectively. These results reveal that the refractive index and optical bandgap in this material can be modulated systematically as a function of bilayer thickness. This behavior has great importance for optical applications, suitable in the development of devices with response in the UV spectral range; for example in optoelectronics area.

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Keywords: Tunable refractive index, Optical bandgap modulation, Ultrathin multilayers

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