Study of effect of deposition temperature of Surface Acoustic Wave devices on Aluminum Nitride thin films obtained by Pulsed Laser Deposition

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Abstract

This document describes the relationship between surface acoustic wave (SAW) designed on thin films of aluminum nitride (AlN) grown on Si_3N_4 substrates by using a Pulsed Laser Deposition and optical properties. Moreover the dependency of both properties with temperature of deposition. The thickness measured by profilometer was 150 nm for all films. Moreover Surface Acoustic Wave (SAW) devices with a Mo/AlN/Si3N4 configuration have been fabricated, employing AlN-buffer and Mo Channel. The morphology and composition of the films were studied using Atomic Force Microscopy (AFM), Scanning Electron Microscopy (SEM) and X-ray Photoelectron Spectroscopy analysis (XPS), respectively. The value of binding energy obtained for the Al2p peak was 73.9 eV and the higher value for Al2p was 75.6 eV, respectively. According to the literature [1-3] for the Al2p peak, the first one (73.9 eV) and the second one (75.6 eV) can be assigned to Al–N and Al O bonds. The appearance of the peak at 73.9 eV clearly shows that Al has reacted with N; therefore, it can be assigned to Al N. In Fig. 1, N1s peak is composed of spin doublets, each separated by 2.9 eV. The XPS spectrum of N1s, well fitted by two Gaussian functions, depicts the N1s spectrum with values at 397.3 eV and 400.2 eV characteristic for N-N and Al-N bonds, respectively [4]. The magnification image showed in Fig. 2 exhibits that Mo lines are continuous, without any interruption or short circuit. After electrical measurements, it was possible to deduce an insulator behavior for our AlN structures, a good prerequisite for using them as surface acoustic wave (Mo/AlN/SAW) devices. The optical reflectance spectra and color coordinates of the films were obtained by optical spectral reflectometry technique in the range of 400 – 900 cm^{-1} by an Ocean Optics 2000 spectrophotometer. In this work, a clear dependence in morphological properties, reflectance, dominant wavelength color purity, frequency response and acoustic wave velocity in terms of the applied temperature to the substrate was found. It was observed a reduction in reflectance of about 10% and the increase of acoustic wave velocity of about 1.2 % when the temperature was increased from 200 to 630°C. Therefore, the AlN films deposited around 450 ºC offer the best synergy for optical and acoustic properties with good reflectance and an acceptable acoustic wave velocity. Furthermore, the nanometric grain size and in thickness of such thin films AlN/Si_3N_4 a low surface roughness (≤120 nm), the nucleation side is characterized by a relatively small grain size (≤70 nm), which can be decreased with increased substrate temperature improving processes nucleation, hence enhancing the propagation of elastic waves.

References

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Figures

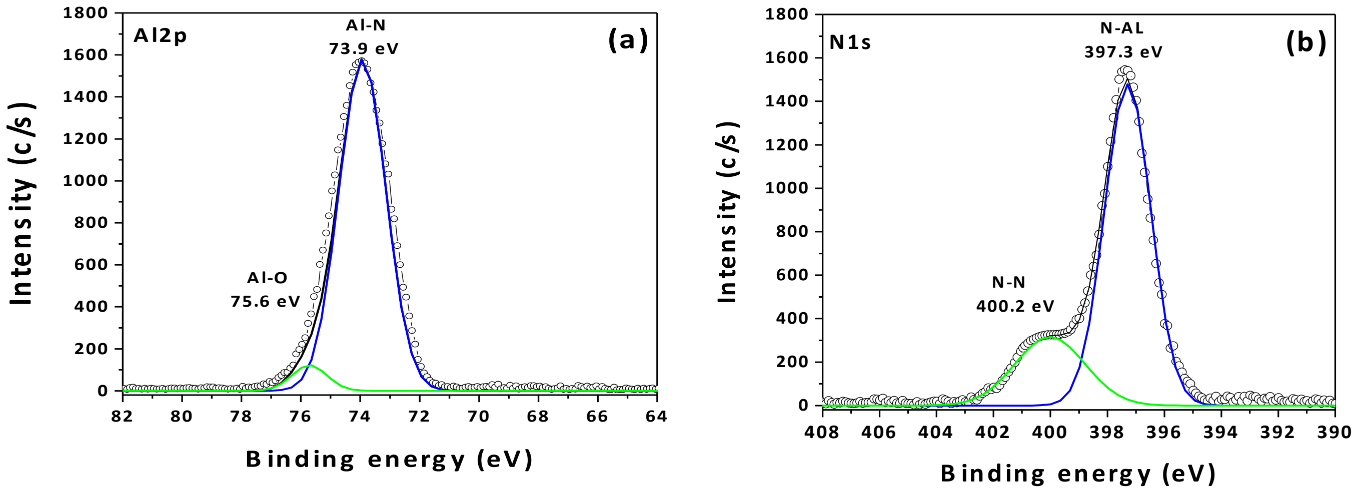

Figure 1. High-resolution XPS spectrum of: (a) Al2p and (b) N1s of Al-N film is around 300 °C

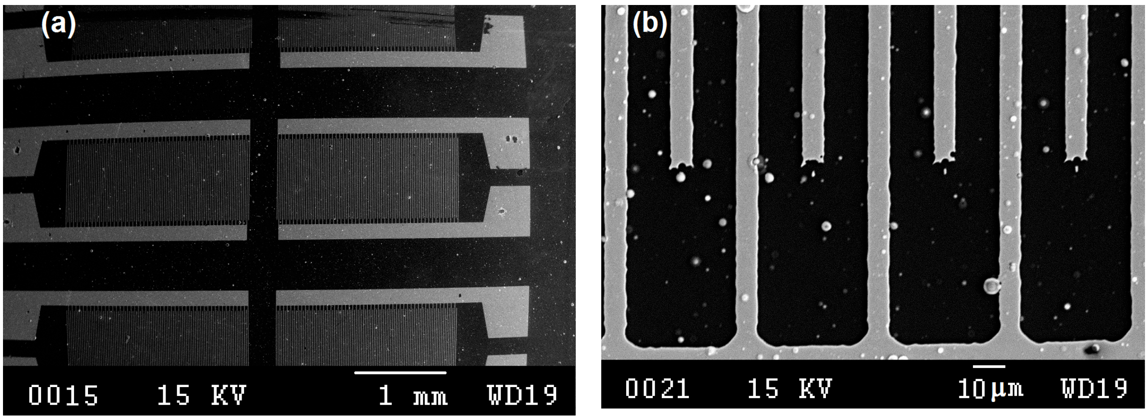

Figure 2. SEM micrographs showing the interdigital structure of Mo coating on AlN films obtained by PLD: **(a)** general interdigital structure, **(b)** magnification images where it is possible to observe the width and distribution of lines that conform the interdigital device.

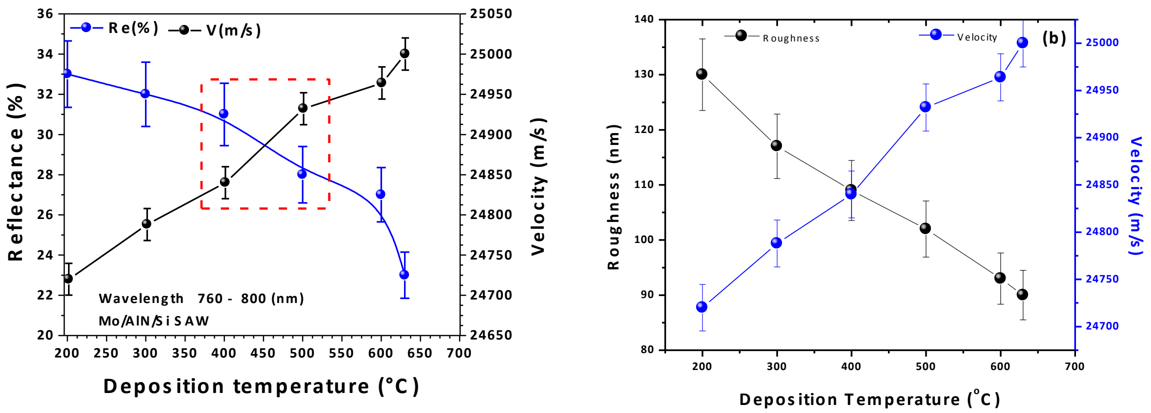

Figure 3. Correlation between optical properties (Reflectance) and acoustic wave velocity in Mo/AlN SAW devices. In Figure 14b. There is a correlation between roughness and Rayleigh velocity as a function of temperature deposit AlN thin films.