Optimization of AlN Film Purity Using Atomic Layer Annealing

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Aluminum nitride (AlN) combines a high band-gap with good thermal conductivity making it an excellent material for several applications. AlN films are being considered as passivation and dielectric layers for power devices and other compound semiconductor devices such as RF, VCSEL, LED and Light Sensor. Both bulk film and boundary impurities affect the device performance. This study presents observations of Atomic Layer Annealing (ALA) on PEALD AlN film and interface impurities Less examined hydrogen impurity level was also measured from the films.

Atomic layer annealing is a method where additional thermal energy is introduced after each ALD cycle. In this work the ALA step was done using an additional plasma pulse. Earlier studies indicates that epitaxial growth can be reached with plasma ALA step **[1-3].** Although this method has been demonstrated earlier the effect of ALA step on atomic concentrations and especially film hydrogen concentration are published for the first time.

This research work also presents slightly different simplified process using only N_2 gas in the ALA step instead of Ar or Ar/N_2 mixture. The difference of AlN films deposited with and without ALA steps were investigated using X-ray diffraction (XRD) and Time-of-flight elastic recoil detection analysis (TOF-ERDA) spectrometer for elemental analysis.

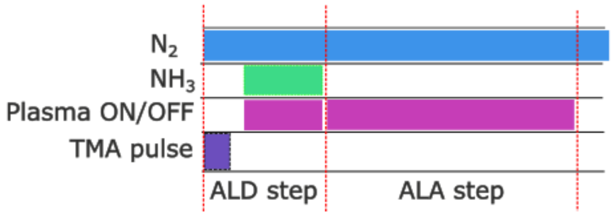

Figure 1. Representation of an ALA cycle for AlN deposition.

AlN purity variation within wafer was also investigated. Atomic concentrations were measured from 200 mm wafers. Three measurement points were taken at precursor flow direction.

Beneq TFS 200 and Transform™ reactors equipped with direct CCP plasma were used in this work. Plasma frequency was 13.56 MHz. Ammonia plasma was used in ALD step but ALA step was done using N_2 as presented in Fig. 1. Various plasma times and reactor temperatures were investigated.

ALA step had clear effect on the crystalline structure of the AlN film. All films were polycrystalline hexagonal wurtzite aluminum nitride layers but the films deposited with ALA step had stronger (002) preferential orientation.[1,3]

TOF-ERDA elemental analysis indicated that the atomic concentration of hydrogen decreased from 12 to 7 at.-% with the ALA step. This improvement was obtained for the bulk of the film. Oxygen impurity was optimized below 0.5 at.-% and carbon impurity always lower than 1.2 at.-%.

References:

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