Studies on Novel SOI-Structure with AlN Film as Buried Insulator

Chenglu Lin, Ming Zhu, Chuanling Men, Zhenghua An and Miao Zhang
State Key Laboratory of Functional Materials for Informatics, Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, Shanghai, 200050

The silicon-on-insulator (SOI) devices have an inherent self-heating effect, which limits the applicability of SOI materials in electronics where high power dissipation is expected. This is a consequence of the low thermal conductivity of the buried oxide layer in SOI devices. In this paper, aluminum nitride as a potential candidate for buried insulator material in SOI-structure is investigated owing to its attractive properties including excellent thermal conductivity, high thermal stability, high electrical resistance and the coefficient of thermal expansion closes to that of silicon, and so on. In our experiments, aluminum nitride films were deposited on 4 inch silicon wafers by ion beam enhanced deposition (IBED) with the electron beam evaporation of Al and simultaneous bombardment of nitrogen ion beam. The wafers were implanted with 20KeV N_2^+ and N^+ (60%N_2^+, 40%N^+) with the ion flux density of 25μA/cm^2. The evaporation rate of Al can be adjusted from 0.5 to 5Å/s. A base pressure of 1×10^{-3} Pa was achieved prior to deposition. The wafers were maintained at 700℃ during implantation. The synthesized films were characterized by X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), spreading resistance profile (SRP), and atomic force microscopy (AFM). Experimental results indicated the best quality aluminum nitride film was obtained at the Al evaporation rate of 0.5 Å/s, it has excellent dielectric property and a smoother surface with roughness RMS values of 0.13 nm. Figure 1 shows the AFM image of the film synthesized at 0.5 Å/s rate of Al evaporation. Then the deposited film was bonded directly to a silicon wafer that was implanted with hydrogen. Heat treatment (400-600℃) of the two bonded wafers was subsequently carried out. During this phase, implanted wafer split into two parts giving rise to an SOI structure and a remainder. Once splitting had occurred, high-temperature annealing was performed at 1100℃ for 1h to form the SOI structure taking the aluminum nitride thin film as buried layer. Cross-sectional TEM was adopted to investigate this structure (showed in Fig.2) and it gave a direct evidence of the formation of SOI structure. In order to study the electrical properties of the top silicon of SOI, the spreading resistance profile of SOI was also measured and the experimental results are shown in Fig.3 Three layers of SOI, including the top silicon layer, buried aluminum nitride and substrate, can be clearly distinguished. In general, the presented results show that we made SOI structures successfully with aluminum nitride as buried insulator by means of the Smart-cut process for the first time.

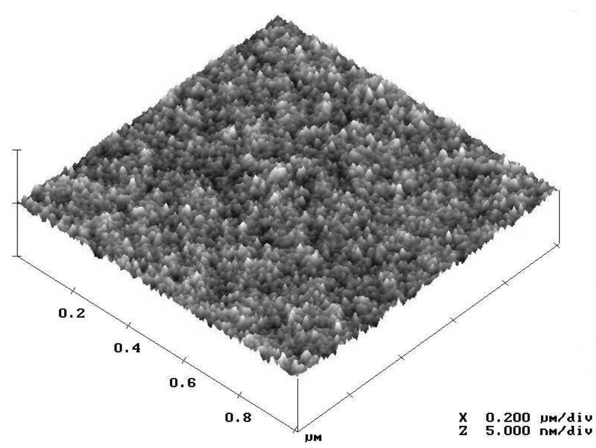

Fig.1 Surface topography obtained by AFM of the AlN film formed at 0.5 Å/s evaporation rate of Al.

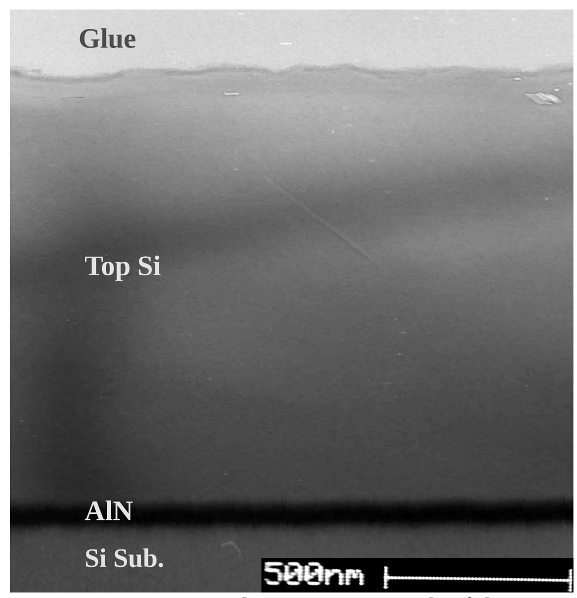

Fig.2 Cross-sectional TEM micrograph of the SOI structure using AlN film as buried layer.

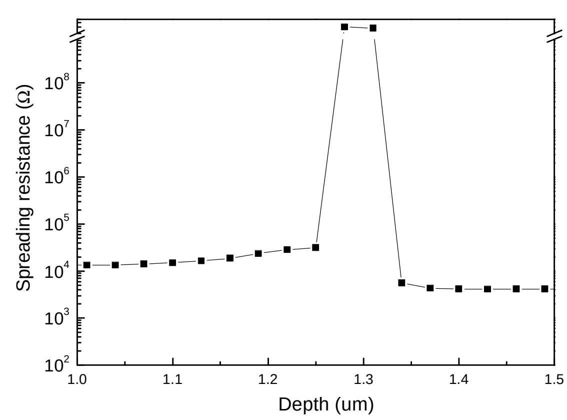

Fig.3 Spreading resistance profile of the SOI-structure using AlN film as buried layer.