RF sputtering of AlN on 3C-SiC (100) thin film: Parameters affecting the AlN crystal orientation and deposition rate

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Piezoelectric materials are available in various forms such as polycrystalline single crystal material, polymers and ceramics, but thin film has significant range of advantages such as low hysteresis, large deflections, high sensitivity and low power requirement[1]. For energy harvesting, lead zirconate titanate (PZT) and zinc oxide (ZnO) are two most commonly used piezoelectric material due to their high coupling and piezoelectric strain coefficients compared to aluminum nitride (AlN). However, at extreme environments the material performance of PZT and ZnO degrades significantly compared to AlN because of its wider band gap (6.2eV), higher thermal conductivity as well as better chemical and thermal stability[2]. Aluminum nitride has been sputtered on SiC by few groups[3,4], but none satisfactorily explain the role of sputtering parameters on deposition rate and crystal orientation.

In this paper we present the effect of sputtering parameters e.g. nitrogen concentration, deposition temperature and sputtering pressure on the AlN deposition and its crystal orientations. The highly oriented AlN (002) film is deposited on 3C-SiC (100)/Si(100) substrates using RF sputtering. The samples of size 15mm by 15mm was prepared via dicso wafer dicer and was cleaned via Piranha. An argon purge process was performed before the samples were loaded into the main chamber, and the samples were heated to 300°C with an IR heater for 3 mins after the low level vacuum is achieved.

The deposition parameters are optimized to improve the crystal quality and deposition rate. The XRD results of AlN deposited on 3C-SiC (100) samples are shown in Figure 1. The nitrogen concentration was varied from 40 % to 100 %, the maximum deposition rate was observed at 40 % as shown in Figure 2. The RF power was varied from 100 to 400 W and it was observed that the deposition rate increases with increase in RF power and vice versa. The thickness of AlN decreases as sputtering pressure decreases due to few particles reside in the chamber. The process temperature was varied about ±100°C but no significant change was observed. The AFM of ALN deposited on 3C-SiC is shown in Figure 3. The mean square roughness rms value of AlN layer is found as 8 nm, which conforms to the requirements of piezoelectric devices.

References:

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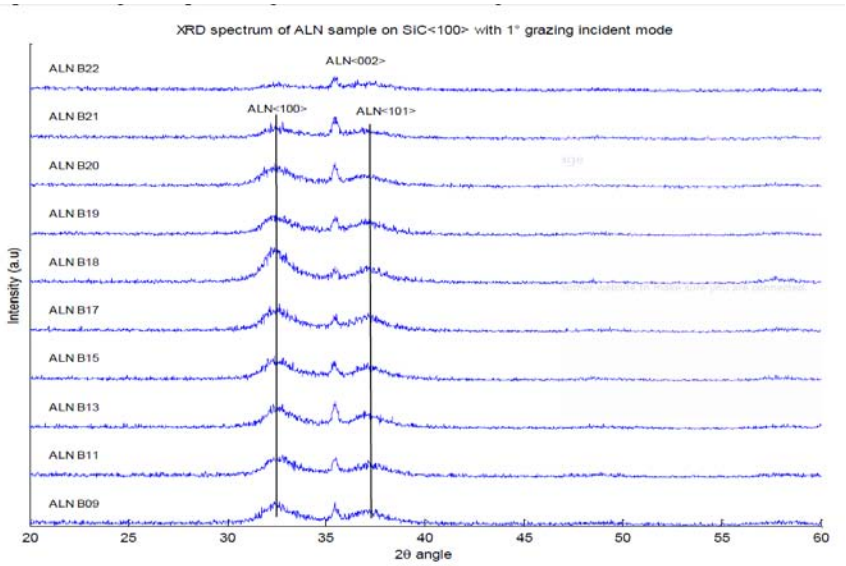

Figure 1: XRD result on 3C-SiC<100>

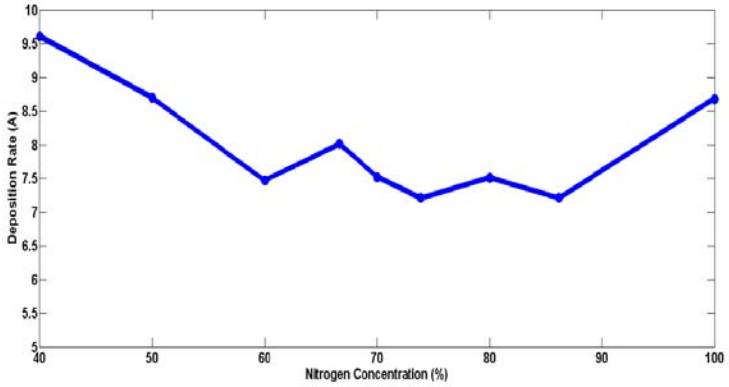

Figure 2: Deposition rate versus nitrogen concentration

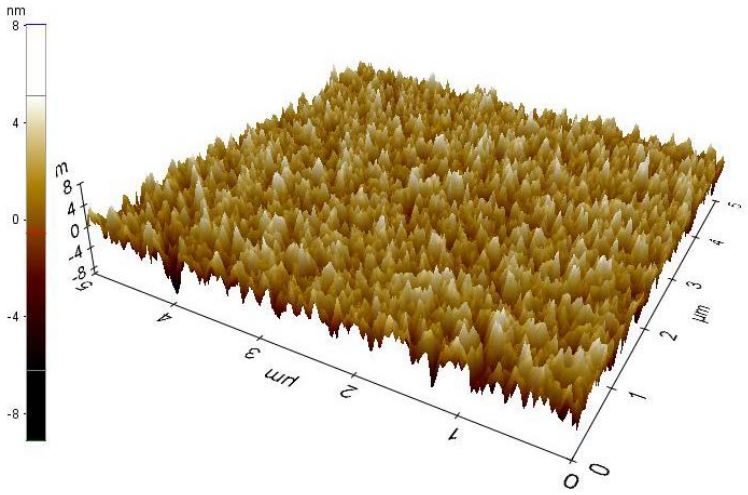

Figure 3: AFM of AlN sputtered on 3C- SiC