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In-situ x-ray scattering studies of AlN thin films on sapphire substrates by RF magnetron sputtering

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Aluminum nitride (AlN) thin films have many applications such as surface acoustic wave (SAW) devices and optoelectronic devices due to their attractive properties such as high ultrasonic velocity, high thermal stability and wide band gap (6.2eV). For high quality devices, AlN thin films have to be highly c-axis oriented with smooth surface. Up to now, many papers were focused on the optimum growth conditions to obtain highly c-axis oriented AlN thin films. The strain induced by the difference between the lattice parameter of the substrate and that of the film was serious problem. In this study, we investigate the misfit strain relaxation and the strain effect as the film thickness increases using *in-situ* x-ray scattering.

AlN thin films were grown on sapphire substrates by radio frequency (RF) magnetron sputtering technique. The target of 2-inch diameter was 99.999% pure Al. The substrate temperature and the RF power were kept at 400 ℃ and 200 W, respectively, during the film growth. The sputtering chamber was evacuated to 2.0×10^{-6} Torr by turbomolecular pump. As the sputtering gas, pure argon and pure nitrogen (99.9999%) were used; the working pressure was 2.0×10^{-3} Torr and N_2 /Ar ratio was 2. The structural properties and orientations of AlN thin films were obtained from *in-situ* x-ray scattering analysis. The incident CuKα x-rays were monochromatized by a graphite crystal. We used a modified *in-situ* x-ray scattering system consisted of two-circle goniometer and RF sputtering chamber with kapton windows which are transparent to x-rays.

Figure 1 shows the out-of-plane x-ray scattering profiles of AlN thin films of 200 Å and 600 Å thick. The thickness of AlN thin films was measured by the x-ray reflectivity. As the growth time increased, the thickness of AlN thin films increased. The shift of the (002) Bragg peak from low angle to high angle represents that the c-axis lattice constants of AlN thin films were slightly decreased as the film became thicker. From the *in-situ* x-ray scattering studies, we measure the peak shift quantitatively and explain the strain relaxation mechanism.

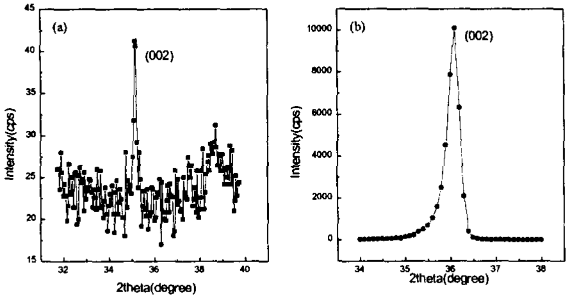

Figure 1. The x-ray scattering profiles in the out-of-plane direction. The growth time was (a) 1 hour and (b) 3 hours at 200W, respectively.