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Low-temperature epitaxial growth of GaN films on hafnium

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It has been believed that metal foil is a promising substrate for fabrication of large-area, low-cost, and flexible nitride devices based on Gallium nitride (GaN) such as LEDs, LDs, and FETs. Especially, hafnium (Hf) foil is an ideal substrate for epitaxial growth of group III nitride films because of the six-fold rotational symmetry of (0001) plane and small lattice mismatch with GaN (0.3%). However, conventional growth techniques for group III nitrides such as metal organic chemical vapor deposition (MOCVD) suffer from serious interfacial reactions between nitride films and metal substrates due to high growth temperatures of above 1000°C. We have recently developed a new growth technique named pulsed sputtering deposition (PSD), which allows us to reduce growth temperature of nitride films to RT and to suppress the interfacial reactions between them [1]. In this presentation, we will demonstrate successful epitaxial growth of group III nitrides on nearly lattice-matched Hf foil by the use of PSD.

After annealing of Hf foil in the vacuum chamber, we have found that contaminant atoms have been drastically reduced on the surface and those *c*-axis oriented grains of as large as 500μm have been observed. These results indicate that the vacuum annealing of Hf foil is a quite appropriate process before growth of nitride films.

Although we tried to grow Aluminum nitride (AlN) films as buffer layers at above 500°C, we have found formation of poly-crystalline AlN due to serious interfacial reactions between AlN films and Hf foil. Therefore, we reduced the growth temperature down to 430°C, which leads to epitaxial growth of AlN films on Hf foil. X-ray photoelectron spectroscopy (XPS) measurements for AlN surfaces revealed that no Hf4*f* peak in these spectra was observed, which indicates suppression of serious diffusion of Hf atoms into the AlN surface. These results indicate that AlN films on Hf foil work as barrier layers for the growth of GaN films. Therefore, we have tried growth of GaN on the AlN films. We obtained sharp streaks in reflection high energy electron diffraction (RHEED) pattern and clear peaks in X-ray diffraction (XRD) spectrum, as shown in Figs. 1 and 2, for nitride films on Hf foil, which indicates that we can successfully grow nitride films on the Hf foil with flat surfaces. EBSD pole figures for GaN$\langle 10\bar{1}1\rangle$ showed clear six-fold rotational symmetry, indicating that no 30° rotational domains exist in the GaN films. These results indicate that that low-temperature growth of III nitrides on nearly lattice-matched Hf foil by the use of PXD is quite promising for fabrication of future large-area, low-cost, and flexible III-nitride devices.

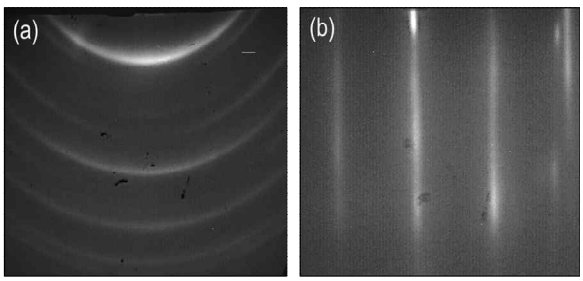

Fig. 1 RHEED pattern s of AlN films grown at (a) 780 °C and (b) 430 °C. The incidence of the electron beam is parallel to AlN [11$\bar{2}$0].

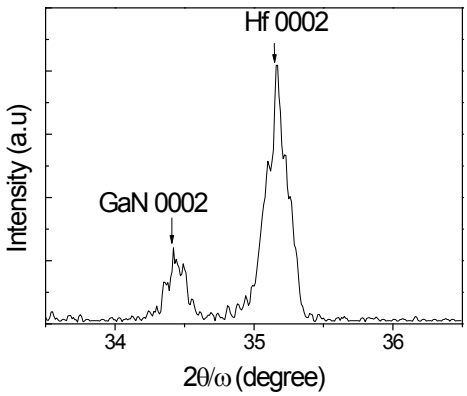

Fig 2. XRD spectrum for GaN films on flexible Hf metal foil.

Reference [1] K. Sato *et al*., Appl. Phys. Express **2** (2009) 011003.