# Characteristics of InN Grown Directly on Sapphire by Pulsed Laser Deposition

T. Honke[1], K. Mitamura[1], J. Ohta[2], H. Fujioka[2,3], and M. Oshima[1]
[1] Department of Applied Chemistry, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku Tokyo, 113-8656, Japan
[2] Kanagawa Academy of Science and Technology, 3-2-1 Sakado, Takatsu-ku Kawasaki Kanagawa, 213-0012, Japan
[3] Institute of Industrial Science, The University of Tokyo, 3-8-1 Komaba, Meguro-ku Tokyo, 153-8902, Japan

InN has attracted much attention because of their potential applications for infrared optical devices and high-speed electron devices. However, low dissociation temperature of InN limits the growth temperature to approximately 600°C, which makes growth of high quality films difficult. Pulsed laser deposition (PLD) is suitable for low temperature epitaxial growth because group III metal precursors arrive on substrate surfaces with high kinetic energies given by laser light. In fact, we have achieved successful epitaxial growth of AlN and GaN even at room temperature.[1-3] In this presentation, we will discuss the advantages in the use of PLD for the epitaxial growth of InN.

InN films were grown directly on sapphire (0001) substrates using an RF-plasma assisted PLD apparatus with a background pressure of $1.0\times10^{-10}$ Torr. The KrF excimer laser pulses ($\lambda$=248nm, $\tau$=20ns) ablated an In metal target (99.9999%) with an energy density of 2 J/cm$^2$. The growth of InN was *in-situ* monitored with reflection high-energy electron diffraction (RHEED) and the InN films were characterized with high resolution X-ray diffraction (HRXRD), glazing incidence X-ray reflectivity (GIXR), and transmission electron microscopy (TEM).

A RHEED image for the InN film directly grown on $Al_2O_3$ (0001) shows a streaky pattern as shown in Fig.1, which indicates that high quality InN grows with a flat surface. GIXD measurements and RHEED observations have revealed that the hetero-interface between InN/sapphire is rougher than that between GaN/sapphire, which is consistent with the small formation energy of InN. The full width of half maximum (FWHM) values for InN 0002 and 11-24 rocking curves are 0.14° and 0.26°, respectively, as shown in Figs. 2 and 3. It should be noted that dirct growth of InN on sapphire with conventional growth techniques results in formation of InN with poor crystalline quality. The small FWHM values for InN grown by PLD can be attributed to the high migration energy on the surface which is given by eximer laser light. These results indicate that the use of PLD makes it possible to grow high quality InN without using any special buffer layers or templates.

References:
[1] J. Ohta *et al.*, Appl. Phys. Lett. **81**, 2373 (2002).
[2] J. Ohta *et al.*, Appl. Phys. Lett. **83**, 3060 (2003).
[3] A. Kobayashi, *et al.*, Jpn. J. Appl. Phys. **43**, L53 (2004).

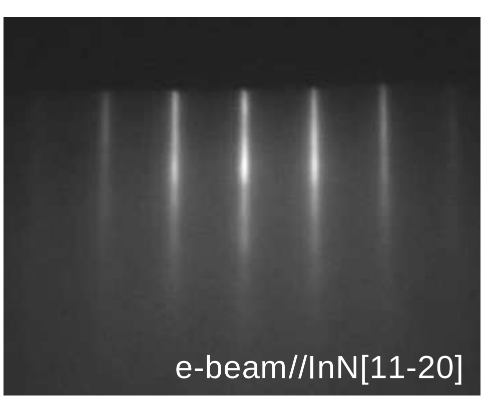


Fig. 1 A RHEED image for InN grown on the $Al_2O_3$ substrate by PLD.

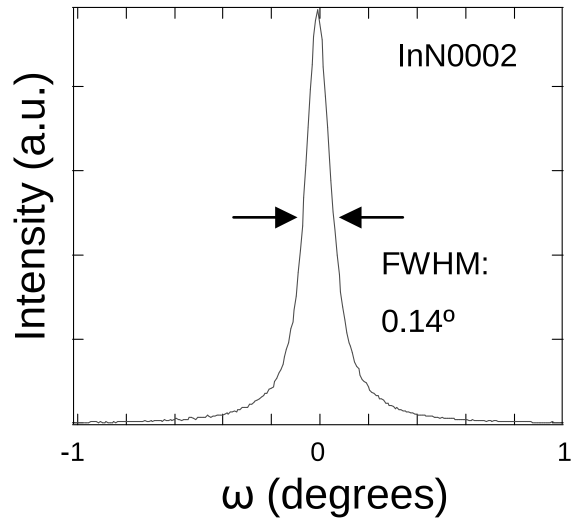


Fig. 2 XRD rocking-curve for InN 0002 diffraction.

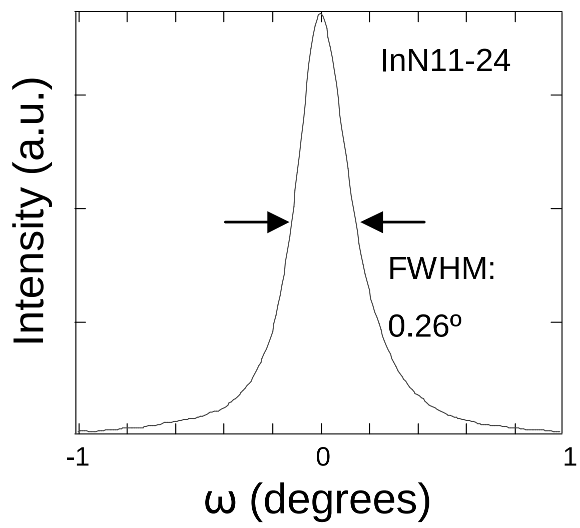


Fig. 3 XRD rocking-curve for InN 11-24 diffraction.