Electronic Supplementary Material (ESI) for RSC Advances.
This journal is © The Royal Society of Chemistry 2016

Supplementary information

Both symmetric and asymmetric $\omega\text{–}2\theta$ scans are taken with a Bruker D8 triple-axis diffractometer using Cu $K_{\alpha 1}$ radiation (λ = 0.15406 nm).

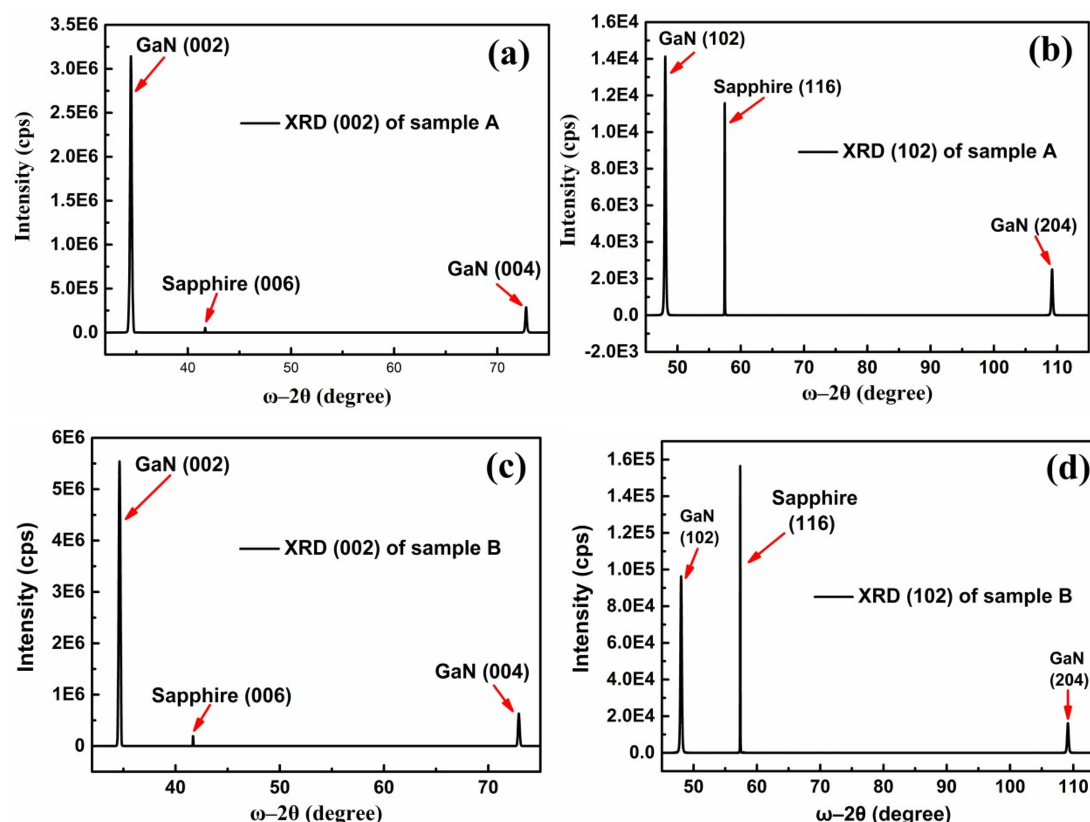

Fig. 7 HRXRD $\omega\text{–}2\theta$ scans for planes (a) (002), (004) and (b) (102), (204) (b) of sample A and sample B, respectively.

Fig. 7 shows the XRD $\omega\text{-}2\theta$ scans of samples A and B. The GaN (002), (004) and (102), (204) diffraction peak positions were used to calculate the lattice constants c and a by using the following equations:[1]

$$d_{hkl} = \frac{\lambda}{2\sin(\theta_{hkl} + \Delta\theta)} = \frac{2\lambda}{2\sin(\theta_{2h2k2l} + \Delta\theta)} \qquad (1)$$

$$d_{hkl} = \frac{1}{\sqrt{\frac{4}{3}\left(\frac{h^2 + hk + k^2}{a}\right)^2 + \left(\frac{l}{c}\right)^2}} \qquad (2)$$

where (h k l) are the indices of the diffraction plane, θ_{hkl} is the measured angular position of the (h k l) reflection, λ is the X-ray wavelength (0.154 nm for Cu $K_{\alpha 1}$ radiation), and $\Delta\theta$ is the zero error of the instrument.

The in-plane strain was obtained by using the formula:

$$\varepsilon_{//} = \frac{a - a_0}{a_0}$$

Hence, the residual stress in the films can be roughly estimated by using the formula:

$\sigma = M \times \varepsilon_{//}$

where σ is the in-plane stress, M (M_{GaN} = 202 GPa [2]) is the biaxial elastic modulus, and ε is the in-plane strain. The lattice constants of strain-free GaN are a_0= 0.31892 nm and c_0= 0.51850 nm.[1] The calculated lattice constants, strains and stresses are listed in Table Ⅰ:

Table Ⅰ The calculated lattice constants, strains and stresses of samples A and B.

	Sample A	Sample B
c (nm)	0.51898	0.51907
a (nm)	0.31836	0.31839
$\varepsilon_{//}$	-0.18%	-0.17%
σ (GPa)	-0.35	-0.34

According to the calculated results, it can be concluded that the in-plane stress in both samples are compressive stress in nature. Moreover, the calculated in-plane stress in sample A is almost same as that of sample B. There seems a discrepancy between the stress values from XRD results and Raman measurements. This discrepancy may come from the domain size characteristic of each technique.[3] According to ref.3, the X-ray beam is scattered by the crystalline and the effect of lattice distortion is averaged over a large sample area through the whole depth for XRD characterization. In contrast, micro-Raman spectroscopy is a local technique that probes only the spot-size area with a shallow depth. Another source of error in the stress evaluation may come from the variation of the elastic modulus with film quality, which may be a significant source of error resulting in the discrepancy between the values obtained by these two techniques. However, it is a topic of ongoing investigation.

Reference

1. L. Zhang, J. Yu, X. Hao, Y. Wu, Y. Dai, Y. Shao, H. Zhang and Y. Tian, *Scientific reports*, 2014, **4**.
2. K. Miwa and A. Fukumoto, *Phys. Rev. B*, 1993, **48**, 7897.
3. N. G. Ferreira, E. Abramof, E. J. Corat and V. J. Trava-Airoldi, *Carbon*, 2003, **41**, 1301.