BBr_3 as a B Source in Plasma Assisted MBE

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Boron is a difficult material to use in MBE due to its high melting point. Traditionally group III molecular beams are generated by vaporizing samples of pure metal at temperatures well above their melting points. For B which has a melting point of 2076° C this is not currently feasible as even high temperature effusion cells max out around 2000° C. Due to this limitation there is interest in exploring other B sources for MBE such as ion-beam, electron-beam, and gas sources including BBr_3. In this talk we will present BGaN growth experiments which serve as a proof of concept for BBr_3 as a B source for plasma assisted MBE.

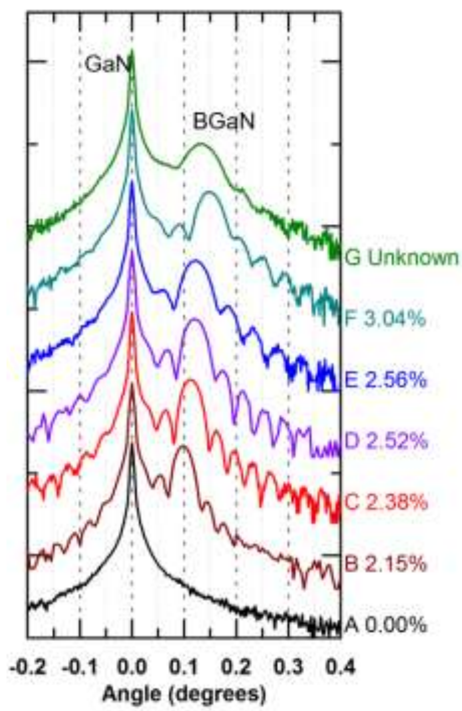

Figure 1. On axis XRD data for BGaN thin films of varying compositions[1]

We will present data from our experiments in which we grow fully coherent, random alloy, $B_xGa_{1-x}N$ thin films with x up to 3% and thickness up to 280 nm.[1] High resolution XRD was used to characterize the film quality and determine the strain state of the films. On axis ω-2θ scans were used to determine the c parameter of the films and the presence of thickness fringes in these scans is indicative of high crystal quality and was used to measure thickness (Fig. 1). Reciprocal space maps around off axis peaks were used to determine that the films were fully coherent to the GaN on sapphire substrates. Using the elastic coefficients of GaN and standard stress-strain relations we calculated the relaxed c parameter and from that the B composition using Vegard's law and theoretical values for wurtzite phase BN lattice constants.

Atom probe tomography (APT) was performed on samples to demonstrate that they had a random, binomial, distribution of B and Ga atoms and are therefore true random alloys.[2] APT and secondary ion mas spectroscopy (SIMS) results were also used to characterize the impurity levels in the films and it was found that our initial growth conditions lead to high levels of O, C, and Br impurities.

[1] R.C. Cramer, B. Bonef, J. English, C.E. Dreyer, C.G. Van de Walle, J. S. Speck, J. Vac. Sci. Technol. A 35, 041509 (2017)

[2] B. Bonef, R. Cramer, J.S. Speck, J. Appl. Phys. 121, 225701 (2017)