RF-sputter deposition of h-BN films on $Al_{0.7}Ga_{0.3}N$ template

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$Al_xGa_{1-x}N$ alloy is widely used in ultraviolet (UV) and deep-UV light emitters. One of the biggest challenges is the high resistivity and the difficulty to form good ohmic contact to high Al-fraction p-type $Al_xGa_{1-x}N$ due to the poor p-type doping efficiency. Hexagonal boron nitride (h-BN) is an emerging material that has a large bandgap ((E_g ~ 6 eV)) and is feasible for p-type doping. It is also compatible to AlGaN material, thus is proposed to serve as p-type layer. A high-quality h-BN has been demonstrated by high temperature metal organic chemical vapor deposition (MOCVD) on sapphire substrate.[1] Nevertheless, the high temperature can result in a degradation of the device. Furthermore, a buffer layer is required prior to the epi-growth of the h-BN film, which can bring a very high electrical resistance. RF sputtering is an approach that enables a significant reduction in the growth temperature over MOCVD growth, it is also possible to omit the growth of high-resistivity buffer layer.

In this talk, we report the successful deposition of the high deep-ultraviolet-transparent h-BN film on $Al_{0.7}Ga_{0.3}N$/sapphire templates by RF sputtering. The sputtering was carried out using a pure BN target in a mixed gas of Ar and N_2. The substrate was heated to about 300 °C during deposition. The hexagonal phase of BN layer was confirmed by both Raman spectra and X-ray diffraction (XRD) measurements. The valence band offset at h-BN/$Al_{0.7}Ga_{0.3}N$ heterointerface is determined to be almost near zero by X-ray photoelectron spectroscopy (XPS) measurement, indicating h-BN is an excellent material to sever as a layer for hole injection into $Al_{0.7}Ga_{0.3}N$. The transparency was strongly dependent on the ratio and pressure of mixed gas. It was found that the transmittance was extremely low in absence of N_2 gas. With an introduction of N_2 into Ar gas, the transparency in deep-ultraviolet (DUV) region could be significantly improved. This is possibly because N_2 plasma could suppress the dislocations of nitrogen vacancy, which is easily formed during sputtering in Ar. Although a high pressure is favorable to the high transmittance in DUV region, a post-annealing treatment can boost the transmittance of low-pressure-growth h-BN to a comparable level to that of high-pressure-growth sample. As a result, a high deep-ultraviolet-transparent h-BN film was achieved when the discharge gases of N_2/(Ar+ N_2) was in range of 25% to 75%. We also studied the electrical properties of Mg-doped h-BN. More details will be present at the conference.

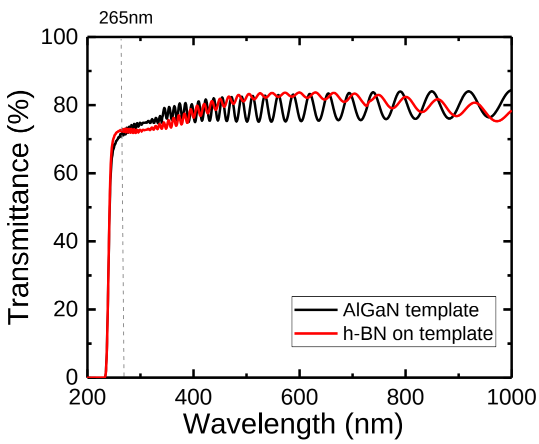

Fig. 1 Transmittance of AlGaN/sapphire template and h-BN film.

1.H. X. Jiang and J. Y. Lin, Semicond. Sci. Technol. 29, 084003 (2014).