Ambient temperature growth of mono- and polycrystalline NbN nanofilms and their rigorous composition and surface analysis

This paper reflects on the rigorous investigation of high-quality 5nm thin NbN films which were deposited by means of reactive DC magnetron sputtering at ambient temperatures. Monocrystalline NbN films have been epitaxially grown onto hexagonal GaN buffer-layers (0002) and showing a distinct, low defect interface as confirmed from HRTEM. The critical temperature (Tc) of those films reached 10.4K. Furthermore, a poly-crystalline structure was observed on films grown onto Si (100) substrates, exhibiting a Tc of 8.1K albeit a narrow transition from the normal to the superconducting state. The deposition at ambient temperatures offers major advantages from a processing point of view and motivates the in-depth characterization and comparison of present films with high quality films grown at elevated temperatures. X-ray photoelectron spectroscopy and reflected electron energy loss spectroscopy verified that the composition of NbN did not differ irrespectively of applied substrate heating. Moreover, the native oxide layer at the surface of NbN has been identified as NbO_2 and thus is in contrast to the Nb_2O_5, usually being formed at the surface of Nb when exposed to air. These findings are of great significance since it was proven the possibility of growing epitaxial NbN onto GaN buffer layer in the absence of high temperatures hence paving the way to employ NbN in more advanced fabrication processes involving a higher degree of complexity. Particularly low-noise THz receiver could benefit from the eased integration of e.g IF circuitry or general multi-layer structures which take advantage of lift-off techniques.