Improvement of epitaxial NbN tunnel junction quality developed on Si-substrate

情通機構　°丘　偉，寺井　弘高
NICT　°Wei Qiu, Hirotaka Terai
E-mail: qiuwei@nict.go.jp

Experiment and results

Recent progress of high quality (200)-oriented TiN films have drawn dramatical interest to develop new NbN-based superconducting devices on Si substrate. In this reported research, we have developed a fabrication process to develop high-quality NbN tunnel junctions on low-loss Si substrate by using a thin (200)-oriented TiN film as the buffer layer. X-ray diffraction (XRD) analysis of TiN film shows a single sharp peak at 42.66° and lattice constant a_0=4.23 Å. The superconducting transition temperature T_c and residual resistivity at 10 K are 5.3 K, and 3.7 μΩ cm, respectively. Following the TiN buffer layer deposition, tri-layer NbN/AlN/NbN/TiN films are deposited in-situ by dc magnetron sputtering method. X-ray diffraction analysis reveals excellent crystalline orientations for both base electrode NbN and tri-layer NbN/AlN/NbN with a barrier thickness of AlN up to 2 nm (Figure 1). Prior to the tunnel junction fabrication, the superconducting and electrical properties of the base electrode NbN film have been studied extensively at different sputtering conditions. At the optimized condition, the maximum T_c value of 15.3 K and minimum resistance value of 14.7 Ω corresponds to the lattice constant a_0=4.428 Å have been achieved. The properties of the fabricated NbN tunnel junctions, such as the gap voltage, I_cR_n product, as well as junction's quality factor R_{sg}/R_n, have been also examined from junction's I-V characteristics measured at liquid Helium temperature. As a result, the gap voltage V_g of tunnel junction has been improved to ~ 5.6 mV, comparable to that of epitaxial NbN developed on MgO substrate (Figure 2).

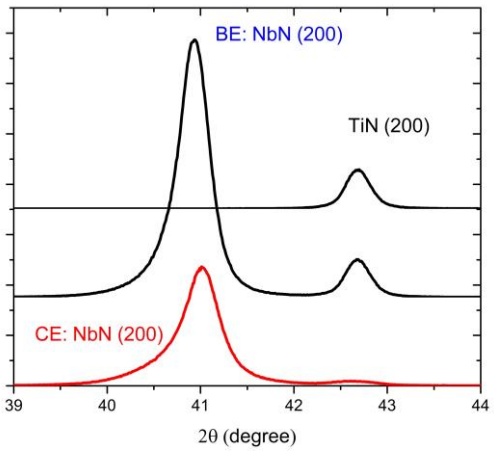

Fig. 1. X-ray diffraction of epitaxial grown films on Si substrate: (a) top: TiN (40nm), (b) middle: NbN (190 nm)/TiN(40nm), c) bottom: NbN(190nm/AlN(2nm)/NbN(20nm)/TiN(20nm) trilayer.

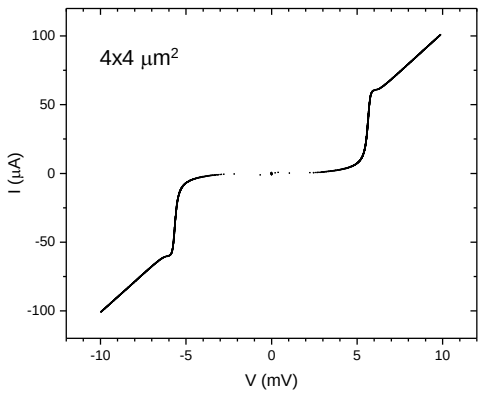

Fig. 2. I-V characteristic of epitaxial NbN tunnel junctions measured at 4.2 K with Jc ~ 129 A/cm².