反応性マグネトロンスパッタリング法により作製した超伝導MMIC用低温NbTiN薄膜抵抗器

Cryogenic NbTiN Thin Film Resistors for Superconducting MMICs Fabricated by Using Reactive Magnetron Sputtering

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Reactive magnetron sputtering has been applied for fabrication of NbTiN thin film resistors operating at liquid helium temperature. The resistivity of the NbTiN films at 4K can be tuned in a wide range from about 100 μΩcm to 10, 000 μΩcm with sputtering parameters such as discharge current and sputtering pressure. This broad tuning range greatly facilitates the design and fabrication of on-chip lumped-element resistors for millimeter and submillimeter integrated circuits. The NbTiN thin film resistors are found to be nitrogen-deficient, and the resistivity is strongly dependent on the nitrogen atom ratio, as shown in Fig.1 for example. A numerical model of reactive magnetron discharge has been utilized to understand the tuning mechanism. The details of this method have been presented in the 68th JSAP Spring Meeting however without providing sufficient experimental proofs. In this study, we applied the theory to reproduce the experimental results, and verified that the simulation results qualitatively meet well with the measured ones.

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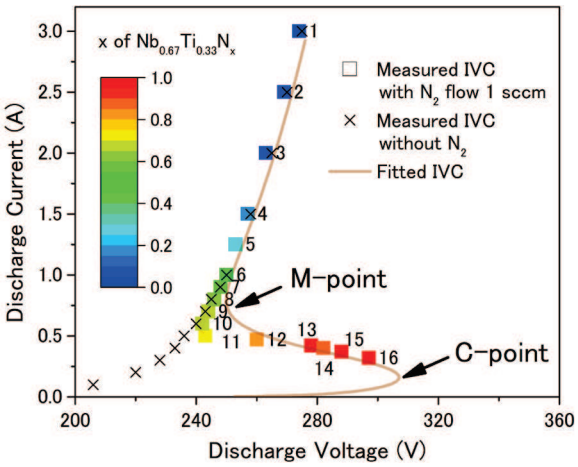

Fig. 1. Discharge current and voltage of sixteen samples labeled by number 1-16 along the discharge current-voltage curve (IVC). The nitrogen atomic ratio of those samples measured by using energy dispersive X-ray spectroscopy is show in color code. The following parameters are in common for all samples: argon and nitrogen flow rates are 50 sccm and 1 sccm respectively, and pressure is 1.7 Pa. The metallic IVC measured without injecting nitrogen is shown with cross symbols. A simulated IVC generated by our IVC model is compared with the measured one. The point M and C on the IVC indicate the positions where the differential of IVC changes in sign.