Cryogenic low-range resistors for advanced superconducting quantum electronics

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Abstract

Cryogenic thin-film resistors are components of various superconducting integrated circuits and devices. In rapid single-flux quantum circuits (RSFQ) and superconducting quantum processors the resistors are used for shunting Josephson junctions and for fabrication of RC filters [1]. In superconducting photon detectors [2], resistors provide impedance matching, which is required for the recovery of superconductivity in the detector with low kinetic inductance after photon absorption. Many applications require resistors as small as a few Ohms. For reproducible fabrication of such resistors, the electrical resistance of the superconductor/normal metal interface is critical [3, 4].

We present a study of thin-film Mo resistors for NbN electronics operating at cryogenic temperatures. The key step is the 0.5–1.5 keV ion cleaning–activation of NbN before Mo deposition, which allows us to obtain a high-quality Mo/NbN interface by removing the NbNOx layer. Using Ar plasma activation, we observed additional contact resistance as low 7–8 Ω at room temperature, which we attribute not to the resistance of the interface, but to the resistance of the Mo contact pad. To eliminate the contact pad resistance, we put an additional low-resistivity Al layer (‘bandage’) on top of the contact pads. In this case, the contact resistance is below the accuracy of our measurement, which is about 1 Ω. Although the NbN/Al and Mo/Al boundaries feature thin oxide layers, it does not affect the interface resistance in all the studied ranges of contact areas from 30 µm × 30 µm to 3 µm × 3 µm. The quality of the interfaces is confirmed by transmission electron microscopy and x-ray reflectometry. We believe that our results are useful for the design of NbN-based superconducting electronics such as photon-number resolving detectors and SNSPD arrays.

Bibliography

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