Superconducting $Mo_{1-x}Re_x$ Films: terahertz electrodynamics and use as Reflectors for High-Q Terahertz Fabry-Perot Resonators

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High-Q Fabry-Pérot resonators are made by depositing SC $Mo_{0.6}Re_{0.4}$ films (10, 20, 30 nm thick, T_c=7-8 K) on both sides of plane-parallel slabs of highly resistive silicon. Performance of resonators, as well as films parameters (SC energy gap, London penetration depth, SC condensate plasma frequency) are characterized by measuring transmissivity of resonators at frequencies 3–50 cm^{-1} and at temperatures 2.5–300 K. The obtained frequency and temperature dependences of the conductivity and permittivity spectra are well described by the BCS theory. We extract and analyze the temperature dependencies of the superconducting energy gap, the London penetration depth, and the superconducting condensate plasma frequency. The ratio $2\Delta(0)/k_BT_c \approx 4.05$ is found to be slightly higher than the BCS weak-coupling value of 3.52, indicating a moderately strong coupling regime in the studied $Mo_{0.6}Re_{0.4}$ films. The critical temperature T_c and the zero-temperature superconducting energy gap $2\Delta(0)$ are found to decrease with decreasing film thickness, a behavior that can be associated with either the polycrystalline structure of the films or the reduction of the superconducting order parameter due to the contribution of surface states to the free energy. Dramatic increase in reflectivity of the films and drop in losses in SC state lead to record values of quality factor Q and finesse F of interferometric peaks at T=2.5 K: Q=830 (peak at ≈6 cm^{-1}), F=580 (peak at ≈3 cm^{-1}; FWHM=150 MHz, Fig.1. Despite the need for deep cooling, due to compactness (8*8 mm^2 area, 0.5 mm thickness) and simple design, the resonator is promising for applications in THz technology, especially in situations with stringent weight and size constraints.

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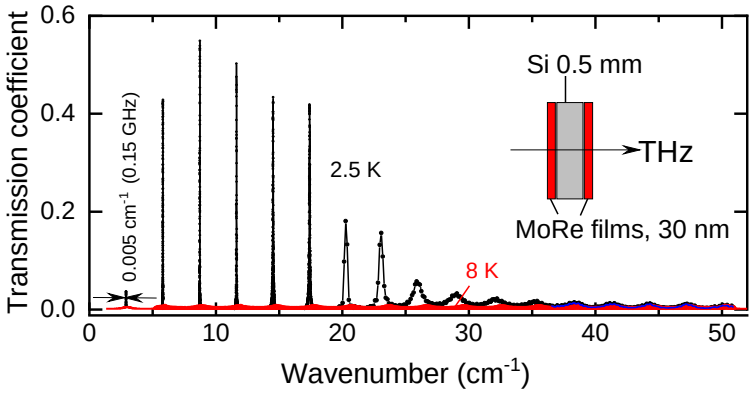

Fig.1. THz transmission coefficient of a Fabry-Pérot resonator with SC $Mo_{0.6}Re_{0.4}$ films as reflectors measured above (8 K) and below (2.5 K) T_c≈8 K.