Thermalization of cryogenic attenuators

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Abstract

While commercial dilution refrigerators offer a base plate at less than 10 mK, thermalizing the microwave modes themselves turns out to be more challenging than just anchoring the superconducting circuit to the plate. Effectively, superconducting qubits are coupled to a heat bath that is often in the 50-100 mK range [1], which drastically downgrades their coherence time [2]. A key element to getting lower effective temperatures is the microwave attenuator that is the closest to the quantum circuit. Recent progress has been made by using NiCr for the resistive thin films [3] or using a brass 3D cavity [4].

At low temperature (i.e below 1K), the conduction of heat is done by the electrons whereas it is done by the phonons at room temperature, this phenomena together with the Wiedemann-Franz law which links the electrical conductivity and the thermal conductivity of electrons in a normal metal [5] explain the unperfect thermalization of the attenuators at 10 mK.

The idea proposed here is to better thermalize attenuator at low temperature is based on a coplanar waveguide (CPW) geometry together with a choice of materials enabling good thermalization of the modes and compact solution. It has the advantage to go over the Wiedemann-Franz law and decouple the thermal and electric currents.

In this poster, the fabrication process of the attenuator, simulations and measurements of the attenuation will be presented

References

[1] F. Yan et al., Phys. Rev. Lett. 120, 260504 (2018)
[2] Gambetta et al., Phys. Rev. A 74, 042318 (2006)
[3] Yeh et al., Journal of Applied Physics 121, 224501 (2017)
[4] Wang et al., Phys. Rev. Applied 11, 014031 (2019)
[5] Ekin, Jack (2006), Experimental Techniques for Low-Temperature Measurements

Figures

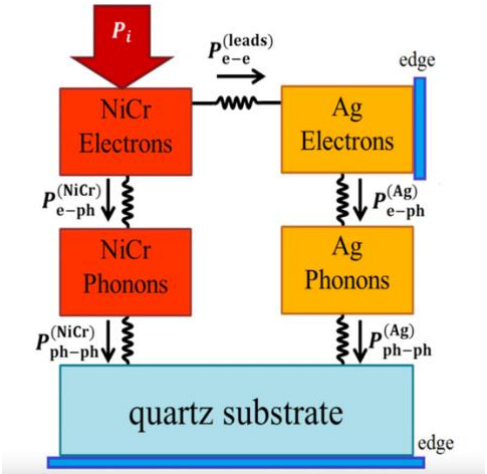

Figure 1: Thermalization process at low temperature from [3]

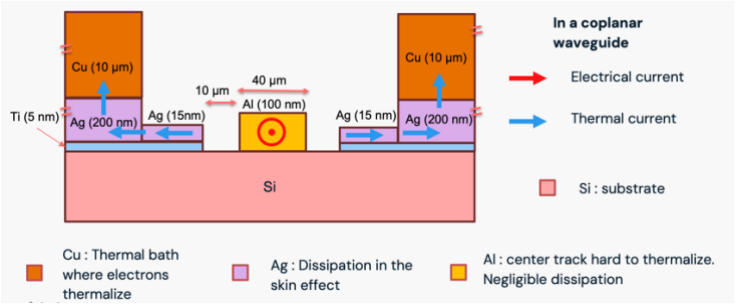

Figure 2: Cut view of the attenuator with the materials used