Slot Antenna SIS Mixers for Submillimeter Wavelengths

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We are developing improved versions of a slot antenna SIS mixer which we have previously described [1]. The initial work demonstrated a double sideband noise temperature of 420 K for a 500 GHz quasi-optical SIS mixer employing a twin-slot antenna on a quartz dielectric substrate. A quartz hyperhemispherical lens is used to focus the incoming radiation onto the twin-slot antenna. The advantages of a twin-slot antenna include a low impedance (35 Ω) and a clean, symmetric beam pattern into the dielectric with a 70% efficiency. In our original mixer, the radiation was coupled from the two slot antennas onto superconducting microstrip lines which fed the SIS junction. By performing an impedance transformation using tapered lines and by feeding the radiation from the two slots to the junction in parallel, the effective (real) impedance seen by the junction was reduced to just 4 Ω. This very low impedance allowed a junction area of 2.3 μm^2 to be used at 500 GHz, which was manufactured using optical lithography. However, no attempt was made to tune out the junction capacitance. We estimate that this capacitance reduces the impedance coupling efficiency to $\eta_Z \approx 0.23$, for our junction with $\omega R_N C = 5.3$ at 500 GHz.

The recent development [2] of techniques using electron-beam lithography to manufacture junctions with very small areas ($\approx 0.1\ \mu m^2$) now allows considerably more flexibility in the design of SIS mixer circuits. We have redesigned the slot-antenna mixer to take advantage of this possibility. In particular, we have included a novel circuit which allows the junction capacitance to be tune out over a broad bandwidth. For instance, mixers designed for 800 GHz using NbN/MgO/NbN junctions with realistic parameters achieve a 3 dB impedance bandwidth of nearly 400 GHz. Furthermore, our circuit uses only short lengths of microstrip and should therefore be less sensitive to RF losses than other designs. The improved impedance match should give a large reduction in noise temperature as compared to our previous mixer. The new devices are currently under fabrication. Further details of the design and any available experimental results will be discussed.

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[1]J. Zmuidzinas and H. G. LeDuc, "Quasi-optical Slot Antenna SIS Mixers," *IEEE Trans. Microwave Theory Tech.*, in press, 1992.

[2]H. G. Leduc, A. Judas, S. R. Cypher, B. Bumble, B. D. Hunt, and J. A. Stern, "Submicron Area NbN/MgO/NbN Tunnel Junctions for SIS mixer Applications," *IEEE Trans. Magn.*, MAG-27, 3192, 1991.