Quasi-Optical SIS Mixer with a Silicon Lens for Submillimeter Astronomy

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We have designed and tested a quasi-optical low-noise SIS receiver for the submillimeter band. The radiation is focused onto a twin slot antenna by a hyperhemispherical silicon lens. The forward coupling efficiency for silicon (ε_r=11.7) is 91% compared to 70% in quartz (ε_r=4.5). However the relatively high dielectric constant of silicon would cause a reflection loss of ≈30% at the front surface of the lens compared to ≈15% in quartz. We have eliminated this reflection loss by antireflection coating the lens with an alumina loaded epoxy (ε_r=4.0). A uniform epoxy thickness of 68μm (=λ/4 at 550 GHz) over the hemispherical lens is obtained by diamond machining the surface. The twin slot antenna has good directivity and a low impedance which is well matched to the rf impedance of the SIS junctions. The mixer circuit consists of two SIS junctions separated by a superconducting microstripline acting as the tuning inductance. The area of the tunnel junctions ranges between 0.56-1.56 μm^2, with a current density of 10,000A/cm^2, and R_{sg}/R_n≈15. Preliminary results indicate typical receiver noise temperatures ranging from 130 K to 160 K in the 500 to 600 GHz band. The spectral response of the mixer agrees well with the direct detector response obtained by a Fourier transform spectrometer. The measured input beam pattern is well collimated and has a Gaussian distribution. This receiver is being used for radio-astronomical observations aboard NASA's Kuiper Airborne Observatory.

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