Implanted Silicon Resistor Layers for Efficient Terahertz Absorption

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Broadband absorption structures are an essential component of large format bolometer arrays for imaging GHz and THz radiation. We have measured electrical and optical properties of implanted silicon resistor layers designed to be suitable for these absorbers. Implanted resistors offer a low-film-stress, buried absorber that is robust to longterm aging, temperature, and subsequent metals processing. Such an absorber layer is readily integrated with superconducting integrated circuits and standard micromachining as demonstrated by the SCUBA II array built by ROE/NIST (1). We present a complete characterization of these layers, demonstrating frequency regimes in which different recipes will be suitable for absorbers.

Single layer thin film coatings have been demonstrated as effective absorbers at certain wavelengths including semimetal (2,3), thin metal (4), and patterned metal films (5,6). Astronomical instrument examples include the SHARC II instrument is imaging the submillimeter band using passivated Bi semimetal films and the HAWC instrument for SOFIA, which employs ultrathin metal films to span 1-3 THz. Patterned metal films on spiderweb bolometers have also been proposed for broadband detection. In each case, the absorber structure matches the impedance of free space for optimal absorption in the detector configuration (typically 157 Ohms per square for high absorption with a single or 377 Ohms per square in a resonant cavity or quarter wave backshort). Resonant structures with ~20% bandwidth coupled to bolometers are also under development; stacks of such structures may take advantage of instruments imaging over a wide band.

Each technique may enable effective absorbers in imagers. However, thin films tend to age, degrade or change during further processing, can be difficult to reproduce, and often exhibit an intrinsic granularity that creates complicated frequency dependence at THz frequencies. Thick metal films are more robust but the requirement for patterning can limit their absorption at THz frequencies and their heat capacity can be high.

We describe implanted silicon resistor layers suitable for absorber coating and patterned absorber structures that offer low heat capacity, absence of aging, and uniform, predictable behavior at THz frequencies. We have correlated DC electrical and THz optical measurements of a series of implanted layers and studied their frequency dependence of optical absorption from .3 to 10 THz at cryogenic temperatures. We have modeled the optical response to determine the suitablity of the implanted silicon resistor as a function of resistance in the range 10 Ohms/Sq to 300 Ohms/sq.

References:

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