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Design, simulation and fabrication of highly sensitive cooled silicon bolometer for millimetre wave absorption

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Silicon bolometers feature a remarkably high sensitivity when cooled at very low. These devices can be used as polarization sensitive detectors in the field of millimetre-wave radiation imaging and polarimetry, typically in the range 200 to 500 GHz. The radiation absorption is based on Ti/TiN superconducting thin films with an adapted critical superconducting transition temperature (Tc) for mm-wave absorption. This absorber is deposited on a doped silicon thermometer fabricated on silicon-on-insulator (SOI) wafers with Phosphorus or Arsenic doping and Boron compensation. The absorber and thermometer are suspended above an optical cavity in order to have good electrical and optical performances. This device should give a high responsivity (S=dV/dP), typically around 1E11 V/W and a very low noise equivalent power (NEP) of 1E-18 W/Hz^1/2 between 50 and 100 mK. Doped silicon thermometers present non-ohmic behaviors at very low temperature, described by the "hot electron model"(HEM). This model assumes that electron-electron thermal coupling is stronger than thermal coupling between electrons and phonons (lattice), which means that applied electrical power is directly deposited on electron systems rising their temperature compared to the lattice. In this paper, we investigate the simulation of ion implantation and diffusion of dopants profiles in silicon thermometers and compared them to Secondary Ion Mass Spectrometry (SIMS) measurements, then we performed electrical resistance measurements as a function of applied electrical powers "R(P)"at low temperature on fabricated devices showing a good fit with the hot electron model. We show that the HEM is governing the electrical characteristics of the doped silicon thermometer and we show its impact on the electrical sensitivity at very low temperature. Finally, simulation results of absorption, responsivity and NEP are presented for pixels with a pitch of 500 and 1200µm under weak and moderate optical power illumination.

Less than 5 years of experience since completion of Ph.D

N

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N

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