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Versatility of superconducting Hafnium for transition edge sensor bolometers.

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Several current and next generation cosmic microwave background (CMB) polarimetry experiments employ transition edge sensor (TES) bolometers whose operating temperature is ~100 milli-Kelvin, requiring a critical temperature (Tc) around 170 milli-Kelvin. Aluminum Manganese (AlMn) has been successfully used as the superconducting metal by several groups for CMB experiments. However, achieving a repeatable and stable Tc requires careful thermal management that puts bounds on fabrication processes. We studied an alternative superconducting metal –Hafnium (Hf) is an attractive alternative as its bulk Tc is well matched to our needs and can also be deposited as a thin film as demonstrated by the microwave kinetic inductance detector (MKID) community. One critical differentiation between past Hf MKID fabrication processes and our own, is our use of a heated sputter deposition that enables us to finely tune the Tc to our desired target. Furthermore, the Tc remains robust against subsequent exposure to heat as long as the initial deposition temperature is not exceeded. As the deposition temperatures are high (ranging from 300℃ - 550℃, depending on the desired Tc), there is ample thermal budget for continued fabrication processes while maintaining a stable Tc. Additionally, by using an interdigitated geometry we are able to precisely design the normal resistance of the TES to anywhere between 1 Ohm and 10 milli-Ohm, making these TESs compatible with CMB experiments that use both time-domain as well as frequency-domain and microwave multiplexing readout systems. We present our findings of a Hf based TES bolometer designed for CMB experiments.

Early Career

Yes

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