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Development of Iridium Platinum Bilayer-based Athermal Phonon Detectors

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A large area superconducting Athermal Phonon Detector (APD), which consists of Aluminum phonon/photon collection fins and Transition-Edge Sensors (TESs), is an advanced particle detection technology which enables light dark matter searches with a sub-eV resolution. While it is well known that a lower transition temperature (Tc) in a TES enhances detection sensitivity, recent experimental data suggest the presence of intrinsic low energy excess background events, which may be associated with stress in the detectors. We have been developing an Ir/Pt bilayer TES and integrating it with Al fins as an ultra-sensitive low-stress APD. The Tc of an Ir/Pt bilayer is tunable down to 20 mK simply by changing the films'relative thicknesses. More importantly, its stress can be independently minimized by controlling film deposition parameters. By fabricating Ir/Pt TESs with varying control parameters, we have conducted experimental studies of the TESs with different film thicknesses, stresses, and transition temperatures. We also integrated Ir/Pt TESs with Al fins to create two types of functional APDs: One has Ir/Pt TESs directly connected to Al fins. Another uses Ir quasiparticle reservoirs between Ir/Pt TESs and Al fins to explore technical paths for increasing quasiparticle collection efficiency from Al fins. Our measurements include superconducting-to-resistive transition profiles, complex impedances for Ir/Pt TES dynamic parameters, I-V curves at a variety of bath temperatures for the thermal properties of Ir/Pt TES, thermal conductance optimization of APDs, stress-induced event counting, and preliminary measurements of APDs. We will report on the detailed fabrication processes and experimental results of the Ir/Pt TESs and the integrated APDs.

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