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A time- and amplitude-controllable technique for measuring energy resolution and other properties of KID-based phonon-mediated particle detectors

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We present a novel technique for characterization of devices in which energy deposited by a particle interaction is measured by sensing athermal phonon creation in an array of kinetic inductance sensors (KIDs) on the substrate's surface (Moore+ 2012; Aralis+ this conference). We combine a standard KID array readout frequency comb with a strong, monochromatic RF pulse, whose frequency is chosen to lie within the resonator bandwidth of a particular resonator with proper detuning. The large power deposited in the chosen KID breaks Cooper pairs, with the resulting quasiparticles (QPs) recombining and emitting athermal phonons into the substrate. The total QP number created can be straightforwardly calibrated, thus yielding a well-known energy deposition (modulo 43% sub-gap phonon energy loss, Kurakado+ and Kozoretsov+). This monochromatic source thus provides a means to measure the energy resolution of the other individual KIDs and the combined energy resolution of the array. The rise times seen in other KIDs measure the phonon travel time, while the fall times measure the larger of the KID film QP lifetime and the substrate phonon decay/absorption lifetime. We observe that the pulsed KID shows a decay consistent with a QP lifetime evolution due to recombination in the regime where the pulse has perturbed the QP density by order of its value. This decay time yields the recombination constant in the KID film. This aspect of the technique is applicable to any KID. For the array architecture we use, one can excite different KIDs in the array in this fashion to check for uniformity of recombination time and for sensible behavior of phonon pulse characteristics (rise time, decay time, received energy) with the position of the energy deposition. The technique may also enable a measurement of the efficiency for generation of QPs by readout power (Goldie and Withington 1988). We present results for our array of 80 Al KIDs on a 75-mm diameter, 1-mm-thick silicon substrate.

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

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Student (Ph.D., M.Sc. or B.Sc.)

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Primary authors: Mr CHANG, Yen-Yung (California Institute of Technology); Mr ARALIS, Taylor (California Institute of Technology); Dr GOLWALA, Sunil (California Institute of Techonology)

Presenter: Mr CHANG, Yen-Yung (California Institute of Technology)

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