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W. K. H. Panofsky Prize Talk: The Search for WIMP Dark Matter: CDMS Detectors

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As described in the accompanying talk by Bernard Sadoulet, the CDMS (cryogenic dark matter search) program has succeeded in pushing down by several orders of magnitude the sensitivity in the search for dark matter in the form of weakly interacting particles or WIMPs. In this talk we describe the technology that has enabled the CDMS detectors made of Ge and Si crystals to discriminate on an event by event basis electron recoils (most backgrounds from gammas) from nuclear recoils (the expected WIMP signal and neutrons). This rejection is accomplished by simultaneously measuring the ionization (electrons and holes in the semiconductor) and the phonons (lattice heat). To achieve the phonon measurement, the crystals are cooled to 0.05 K which allows the use of ultra low noise superconducting circuits. The phonon energy is collected at the surface of the crystals using Al films which absorb athermal phonons and produce quasiparticle excitations from the dissociated Cooper pairs. These excitations diffuse until the are trapped in superconducting tungsten transition edge sensors (TESs). The major advance of voltage biased TESs which are self biased in their transition region through negative feedback has been adopted very successfully for xray spectroscopy, gamma ray spectroscopy and CMB (cosmic microwave background) instruments. The most recent advance detectors called iZIPs (interleaved z-dependent ionization and phonon) provide a large improvement in surface electron rejection and remove that background for the next 200 kg Ge experiment and even for future ton scale experiments.