Superconducting Delay Line Detector for Time of Flight Spectrometry and Atom Probe Tomography

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There is considerable interest in the design and manufacture of superconducting detectors for ion detection which can overcome the shortcomings of existing microchannel plate technology. Many different varieties of superconducting detectors have been developed within the past several decades, each with its own strengths and weaknesses. Many of these detectors are inherently slow, require complex multiplexing schemes to attain position sensitivity, or require complex readout electronics. In response to the rigorous demands of atom probe tomography, and with the goal of developing an elegant, simple to use solution, we have developed a novel superconducting delay line detector (SCDLD). This architecture is best understood as an extension of the superconducting stripline ion detector (SSID), which has been used previously to detect both heavy [1] and lighter monoatomic species [2]. The principal of detection is to use the kinetic energy of incoming ions to break Cooper pairs and generate excess quasiparticles in the stripline. The detector system consists of a long, meandered superconducting microstrip with both sides connected to bias-tees. The inductive ports of the bias-tees are used to bias the microstrip with a constant current while the capacitive ports are connected to high speed digitizers. In normal, avalanche-type operation, the detector is biased with a current close to its critical current. The ion breaks a sufficient fraction of the Cooper pairs such that the entire width of the detector reverts to a normal state. This increases the local resistivity of the detector, shunting a portion of the bias current out through the readout ports. By measuring the timing of the output signals from either side of the delay line, we are able to measure the time of flight for the ion and the position of its impact on the detector. This detector architecture can simultaneously achieve large active areas and position sensitivity with no inherent need for multiplexing. Here we describe our implementation of such a detector and its characterization in a home-built field ion microscope.

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References:

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