Single-Crystal Heteroepitaxial Diamond Detectors for Heavy Ion Beam Tracking

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One of the major experimental challenges of radioactive beam facilities of the newest generation is secondary beam diagnostic at rates up to 10^8 particles per second. In many experiments it would be desirable to track particle positions and measure timing properties of these intense beams on a event-by-event basis. Such high rates lie beyond the capabilities of conventional detection technologies. Diamond detectors provide the most promising solution to such fast tracking problems because they have the virtue of being radiation resistant and extremely fast.

Heteroepitaxial single-crystal diamond detectors as thin as 20 microns grown at Michigan State University's Keck Microfabrication Facility on a 150 nm thick Ir buffer layer have been developed. Substantial progress in achieving semiconductor-grade epitaxially-grown diamond has been occurring over the past few years [1]. Heteroepitaxy represents an efficient means of generating large-area thin films, because relatively inexpensive, large area growth substrates can be used.

Used in a transmission mount those detectors have been successfully tested with a ^{76}Ge beam with 100 MeV/u at beam intensities of up to 10^7 particle/(s-mm^2) at the Coupled Cyclotron Facility. A signal rise times of less than 0.5 ns have been obtained with fast low-noise, broad-band preamplifiers (see Figure 1). The single pulses correspond to an energy loss of $\Delta E = 46$ MeV. A time resolution of 21 ps was achieved with two heteroepitaxial diamond crystals with thicknesses of 20 and 35 microns placed in tandem.

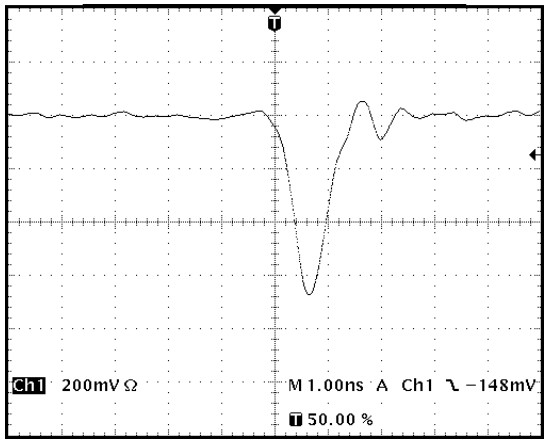

Figure 1: Preamplifier signal for a single-particle event. 100 MeV/u ^{76}Ge ions were used to irradiate the detector.

[1] C. Bednarski, Z. Dai, A.-P. Li, B. Golding, *Diamond and Related Materials* **12**, 241 (2003).