Project name

Development of thin, fast, radiation hard, 3d-electrode array, silicon radiation sensors

Classification (accelerator/detector:subsystem)

Accelerator (part of a possible beam monitor system)
Detector subsystem (tracking close to the beam pipe)

Institution and personnel

University of Hawaii, Department of Physics:
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Project Overview

Working in collaboration with Christopher J. Kenney of the Molecular Biology Consortium and Cinzia Da Via, Jasmine Hasi (currently stationed at the Stanford Nanofabrication Facility), Angela Kok, and Gennaro Ruggiero of Burnel University, we have fabricated and tested thin (120 micron-thick) silicon sensors with closely spaced electrodes that penetrate the silicon substrate, forming a three dimensional array of n^+ and p^+ electrodes. Several of these sensors have recently been combined with the fast, low-noise amplifiers provided by Pierre Jarron and Giovanni Anelli of CERN. Both calculations and experiment show low depletion voltages (5-10V), great speed and radiation resistance. ^{90}Sr beta rise times, limited by the amplifier speed, have been measured at room temperature to be less than 3.5 ns, with full widths at half max of less than 8 ns, using the relatively slow hole signals and with only 40V bias, even after irradiation by 10^{15} 24 GeV protons/cm^2). We are now fabricating sensors that should also be sensitive to within several microns of their physical edges.

This sensor technology should be ideal for small angle detectors that must work close to the beam of a future linear collider. Its fast charge collection should enable it to resolve particles from individual bunches. When bump-bonded to specially designed, deep sub-micron, commercial CMOS readout chips, they should be easily able to survive intense radiation environments close to the beam. Since these detectors should be sensitive to within a few microns of their edges and can have edges of any shape, they can record tracks that are much closer to the beam than can conventional silicon sensors.

Description of first year project activities

Fabrication runs, following the current one, will be split into (1) ones using thin silicon, to reduce multiple Coulomb scattering, with most designs having relatively closely spaced electrodes to provide radiation hardness and speed, and (2) for x-ray detectors, intended for studies in structural molecular biology, where such properties are not so important. Such radiation hard, thin, and fast sensors might be used in beam monitors or in vertex detector end-cap elements.

Both the initial fabrication run, and the one currently underway, have featured multiple designs for units intended for different tasks. After consultation with other linear collider collaboration members, we would propose adding to the next fabrication run, specific sensor designs specialized for tasks where this technology will produce better results than any other.

In the future, we plan to alternate fabrication runs with lab and beam tests, both to further improve the technology, and to provide specialized devices for future experiments. The next beam tests, using existing devices, are currently planned to take place at CERN this year.

Budget

The proposed budget assumes about one quarter of each of the processed 10 cm diameter wafers would be devoted to this project, and that the costs would be shared with other ongoing projects. There is also the possibility, in the future, of sharing personnel time, with work on the thin wafers taking place while the NIH x-ray wafers are undergoing processes not needing continuous supervision, such as furnace runs, and vice-versa.

Institution	Item	Cost
Hawaii	Stanford Nanofabrication Facility machine charges	$ 3,000
Hawaii	1.5 months time, fabrication engineer	$15,000
Hawaii	silicon float zone wafers, lab supplies	$ 1,500
Hawaii	Indirect costs (20.6%)	$ 4,017
Hawaii	Hawaii total	$23,517

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