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Channeling for Advanced Electronic Materials Research

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Channeling for Advanced Electronic Materials Research

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History: Ion channeling as applied to electronic materials research dates from the 1970s (1). This development was a fortuitous coincidence of needs and discovery. Classical channeling had reached a peak of understanding with extensive and worldwide experimental research and the theoretical treatment of J. Lindhard. Fundamental experiments required high quality single crystals, most easily found in the electronics community. Channeling applications were an ideal fit to the semiconductor technology needs of the time. Ion implantation was replacing diffusion as the source of dopants. Channeling provided the keys to dopant profiles, dopant atomic sites, and implantation damage annealing. The surface interaction of channeling was recognized and understood more quantitatively. This understanding was applied to the most important materials interface in technology, namely that of Si/SiO2—the material couple that has allowed the miraculous development of Si technology for the last 60 years. Channeling has accompanied silicon semiconductor development to the present day, with studies of strained layers used in current technology, exploration of "alternate dielectrics" and development of semiconductor/dielectric interfaces for III-V/Si semiconductors.

Current status: Two factors drive current electronic materials research: (1) recognition that (plain old) silicon cannot sustain its amazing evolution and (2) silicon cannot do all we desire of a semiconductor device. Ion beam technology continues to contribute to the research addressing these issues, in coordination with many other materials probes. The development of the silicon carbide (SiC) power MOSFETS, discussed in this talk, is one recent example. I will make some comments on the newest ion beam probes at the sub-nano-meter regime—a significant advance in ion beam nano-technology, necessary to contribute to the forefront efforts in materials science.

SiC MOSFETS: Modern technology, particularly energy applications, requires devices that operate at higher voltages and at higher temperatures than can be sustained in silicon. SiC, with its 3.3 eV band gap, compared to silicon, (Eg=1.1eV) is a candidate. The limiting issue for a successful device is the semiconductor/dielectric interface which limits electron transport and mobility. Channeling, along with a myriad of additional electronic and physical probes, has revealed the characteristics and the deficiencies of the critical dielectric/semiconductor interface. Results and improvements have led to a SiC commercial technology creating more efficient energy systems spanning photovoltaic technology to motor drives. .

Reference: (1)"Materials Analysis by Ion Channeling: Submicron Crystallography", L.C. Feldman, J.W. Mayer, S.T. Picraux, Academic Press (1982)
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