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Crystal Growth and Crystal Technology

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The invention of the germanium transistor in 1947 and subsequently the silicon transistor in 1954 initiated the solid-state electronics revolution based synthetic crystal and epitaxial layer (epilayer) production including crystal machining (sawing, polishing etc.). This crystal technology allowed the development of all aspects of modern communication, global commerce, medical technology and energy production.

In connection with the discovery of new materials, for instance ferroelectric materials at ETH Zurich with Paul Scherrer and Georg Busch who, in 1935, discovered ferroelectric KDP, crystals of high quality were required for research. Also, ferromagnetic, laser, superconducting materials and compound semiconductors were of interest, and phase transitions in general developed as a topical research field with the need for crystals. Not only universities, but also industrial research laboratories and national and military research laboratories established crystal growth facilities in the 1960s.

Initial crystal growers often kept their process secret. A problem with many crystal growers was, and still is, that often they apply a crystal growth method which is not optimum leading to unsatisfactory results with respect to size and quality of crystals. Only with high-quality crystals and their sufficient characterization can reproducible physical properties be achieved.

The science of crystal growth developed slowly and was assisted by the Journal of Crystal Growth and by national and international conferences. The first ICCG met in Boston in 1966 and the second in Birmingham, UK in 1968. National and international crystal growth societies were formed, in Switzerland as a joint Society of Crystallography and Crystal Growth 1969 with initiators Nowacki in Berne, Laves and Kaldis in Zurich, and Hans Schmid in Geneva. In 1970 the first International Conference on Vapor Growth and Epitaxy was organized by E. Kaldis, myself and others at a time when at least 12 crystal growth laboratories already existed in Switzerland. The first European Conference on Crystal Growth in 1976 was again organized by Kaldis and myself, when I introduced poster sessions for the first time which were then widely accepted. After 1980, short-term profits in industry became dominant so that, unfortunately, most crystal growth laboratories with their long-term developments were terminated.

The industrial production of crystals of silicon, GaAs, InP, SiC, sapphire/ruby, quartz, Li-niobate, CdTe, garnets etc. developed slowly because there had been, and still is, no education of crystal technologists. Companies had to hire a chemist, physicist, or materials engineer and train him for up to 10 years to become an independent crystal producer/engineer working without supervision. Most companies would be happy if they could hire crystal technologists. How much faster could silicon technology have been developed if there had been well-educated crystal technologists?

The problem of educating crystal engineers is multi-disciplinary. It involves, besides crystal growth mechanisms and crystal technology, chemical and materials engineering/thermodynamics, mechanics, including hydrodynamics and aerodynamics, aspects of crystallography and of solid-state physics, machine and process engineering, and of course computer simulation and informatics, of the latter fields the basics so that the crystal technologists can discuss and collaborate (details in WHITE PAPER in Project 16 of the homepage). This education would prevent the application of ten or more different methods to produce silicon solar cells instead of one optimum technology with respect to crystal quality and cell performance, economics, efficiency of process, and ecology. Similar arguments can be applied to laboratory crystal growth for research samples, and to epitaxial deposition processes.

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