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My Long-Held Dream Realized by Virtue of Grants-in-Aid

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From the latter half of the 1960s through the beginning of the 1970s, I carried out research on the phenomenon of ion implantation in semiconductors. It was still the dawn of integrated circuits and basic research was being carried out around the world on new technologies for accurately doping impurity atoms with well defined number and position, which govern the electrical properties of semiconductors. Ionizing dopant atoms and implanting them in semiconductor crystals inevitably caused crystal defects. As this negatively affected transistor characteristics, research was mainly being carried out on the relationship between thermal treatment to anneal the crystal defects and the semiconductor's electrical properties. At that time when researchers with master's degrees received a starting monthly salary of only about 30-40 thousand yen, the most university research laboratories were poorly financed, and they had little choice but to concentrate their work on assessing the electrical properties of semiconductors.

When I attended an international conference to present our research results, I was astonished by the works of American and Canadian research teams, who, by taking advantage of Rutherford backscattering spectroscopy(RBS), investigated precisely the quantity and distribution of the crystal defects, and the exact sites of the implanted ions in the crystal lattice after annealing. They presented epochal data that far outstripped those confined to an assessment of electrical properties. Since the earliest stage of my research career, I was acutely aware of differences in my research vis-à-vis others, comparing their level of work and research facilities with my own. It was as if this anxiety had been etched upon my mind. Therefore, when I saw the advanced work being done by the other researchers at the conference, what I felt was more than awe—it was trauma. It became my dream to sometime also acquire powerful research tools like the RBS.

In 1972 when I secured a position on Waseda University's faculty, the sense of trauma I had experienced still lingered. Then, in the mid-1980s the university decided to purchase a RBS. I can vividly recall the exhilaration at learning this news. By that time, however, ion-implantation technology had already matured, so the era of producing data using a RBS had come and gone. To make up for 20 years of lost time, it was necessary to seek new ways of using the accelerator that comprised the RBS core. In that pursuit, we worked together with Japan Atomic Energy Agency in Takasaki to develop an ion microprobe capable of micron-precision focusing the ion beam, allowing three-dimensional analysis of minute solid specimens. We completed the work around 1990; however, we found ourselves still lagging behind as it turned out others had already accomplished the same task five or six years earlier.

The ion microprobe community had been working to increase beam intensity to enhance the microprobe's performance as an analytical device. This stronger beam, however, caused the sample to be pulverized into fine particles, and obviously retrogressed to the non-destructive property indispensable for analytical devices. As we were not apt at raising our microprobe's beam intensity, we came up with an idea of how to take advantage of that weakness by implanting ions one at a time into the sample. In 1992, we succeeded in developing a single-ion microprobe (SIMP). At that point, we had finally managed to be the "only ones" in the world. Just then, a problem surfaced with integrated circuits—radioactivity discharged from the environment caused them to malfunction. Unrivaled, we embarked upon research to evoke property changes and malfunctions in transistors by implanting one alpha particle at a time into the heart of their circuitry.

At that time, however, the smallest transistor size had already been reduced to below one micrometer. Given the need for a smaller beam radius, we got the idea of redesigning a focused ion beam device, already rendered effective for transistor microfabrication, into a single-ion implantation (SII) device. As, however, the device would cost in the neighborhood of 100 million yen with an additional 50 million yen to add a single-ion extraction function, we began to give up on our idea, it seeming to have become once again a mere dream.

As a last hope, we applied for a Grant-in-Aid under the “Specially Promoted Research” category. This category awarded grants for research of very high quality—research with a high level of international recognition and an exceptionally large funding requirement. Of the various Grant-in-Aid categories, it was by far the most difficult. Applying for it might be likened to trying to pluck a flower from a soaring peak. Reconciled to be being rejected, we nevertheless decided to challenge it. Applying under the FY1993 call for proposals, we were fortunate to be selected on our first attempt. This was Waseda’s first splendid success in grant acquisition, so the university was extremely pleased. Using the university funds, it built a laboratory for “specially promoting research” in single-ion implantation and a soundproof room for a scanning tunneling microscope used to observe the solid surfaces in nm scale modified by single-ion implantation. Thanks to this super-large research funding and the research environment, we were able to accelerate our research, pushing it forward toward raising the curtain on an era of nano-technology.

When funding under our Grant-in-Aid for Specially Promoted Research ended, we began applying for grants under the targeted support to the creation of world-standard research and education bases (original centers of excellence, COE) program. We were finally selected on our fifth attempt in FY 2001. This was at the start of the Japanese government’s second S&T Basic Plan, which included among its four priority areas nano-technology and materials. That is to say, we were selected at the dawning of the nano-technology era. We formed an 11-member team to investigate and develop molecular nano-engineering and micron-scale systems, and rallied experts in related areas of nano-electronics, nano-chemistry, material physics and biophysics to carry out a 5-year interdisciplinary research project. This provided the impetus for Waseda University to establish its Institute for Nanoscience & Nanotechnology, which functions as a receptacle for various large-scale grants. Coupled with the establishment of the university’s Faculty of Science and Engineering in 2003, Waseda now exudes a strong presence as a center of excellence for nano-science and engineering education and research.

Looking back, it was the Grant-in-Aid program that made it possible for me to realize the dream I embraced as a fledgling researcher.