ATTACHMENT 1: Profile and Detailed Achievements of the Group A Recipient of the 2016 C&C Prize

Prof. Hideo Ohno

Current positions

Professor, Research Institute of Electric Communications, Tohoku University

Personal History (born in 1954)

1977: Graduated from Faculty of Engineering, the University of Tokyo
1982: Earned Doctor of Engineering, the University of Tokyo
1982: Lecturer, Faculty of Engineering, Hokkaido University
1983: Associate Professor, Faculty of Engineering, Hokkaido University
1988: Visiting Scientist, IBM T J Watson Research Center
1994: Professor, Faculty of Engineering, Tohoku University
1995: Professor, Research Institute of Electric Communications (RIEC), Tohoku University
2004: Director, Laboratory for Nanoelectronics and Spintronics, RIEC, Tohoku University
2010: Director, Center for Spintronics Integrated Systems, Tohoku University
2012: Principal Investigator, Advanced Institute for Materials Research, Tohoku University
2013: Director, Research Institute of Electric Communications, Tohoku University
2014: Professor, Center for Innovative Integrated Electronic Systems, Tohoku University
2016: Director, Spintronics Research and Education Promotion Office, Tohoku University

Major awards:

1998: Japan IBM Science Prize
2003: The IUPAP Magnetism Prize
2004: Fellow, Institute of Physics
2005: Agilent Technologies Europhysics Prize
2005: Japan Academy Prize
2005: Presidential Prize for Research Excellence, Tohoku University
2007: Fellow, The Japan Society of Applied Physics (JSAP)
2008: IEEE Magnetics Society Distinguished Lecturer for 2009
2011: Thomson Reuters Citation Laureate
2012: Outstanding Achievement Award (Research), The Japan Society of Applied Physics

2012: IEEE David Sarnoff Award
2013: Fellow, American Physical Society
2015: Compound Semiconductor Electronics Achievement Award, JS AP
2016: Leo Esaki Prize

–Achievements–

It goes without saying that large-scale integrated semiconductor circuits constitute a core technology of information and communications technology (ICT). They also support the evolution and development of society as the foundation of information-processing systems, which continue to experience strong growth with the on-going expansion of the Internet. In addition, such integrated circuits are essential for all kinds of industrial products. However, their products and fields are major energy users. This is because the amounts of information dealt with by Big Data and the IoT continue to expand. Moreover, as processing becomes increasingly sophisticated, high-level integration of high-performance and energy-saving capabilities is a key requirement for the integrated circuits and components.

Anticipating such societal development and a rise in requirements, Professor Hideo Ohno thought of applying the electron spin of magnetic materials to electronics technology. He then went on to develop spintronics technologies one after the other with the aim of creating innovative high-performance components. He also conducted applied research focused on the excellent energy efficiency offered by spintronics technologies. This opened up new research areas and trends. Notably, he himself played a leading role in the creation and development of the field of spintronics technology research. He achieved the crystal growth of III-V ferromagnetic compound semiconductors, which was a world first. His achievement was possible by building models of ferromagnetic expression in compound semiconductors, controlling phase transitions between ferromagnetism and paramagnetism, and proposing and demonstrating many different new components consisting of ferromagnetic semiconductors, among other things.

In collaboration with Dr. Hiroo Munekata and others, Prof. Ohno also succeeded in growing InMnAs crystals, another world first, in 1989. Then, in 1992, he demonstrated that this material has ferromagnetic properties. In addition, in 1996, he successfully grew GaMnAs crystals with ferromagnetic properties. Moreover, in 2000, he built a model shedding light on the origin of ferromagnetism in these compound semiconductors in collaboration with Dr. Tomasz Dietl and others. This series of achievements became the fundamental material and design guide for later ferromagnetic compound semiconductor research. In fact, they formed the cornerstone of development in this field.

Based on the fundamental achievements in material science research above, Prof. Ohno proposed and demonstrated many new functional elements using ferromagnetic semiconductors based on the new principles he discovered. For example, he demonstrated control of the magnetic phase transition between ferromagnetism and paramagnetism by an external electric field using a field-effect transistor structure incorporating a thin film of ferromagnetic semiconductors in the channel layer, and control of magnetic anisotropy. These discoveries suggested the possibility of tremendous power savings compared with existing methods such as the external magnetic field and spin-polarized current in the control of critical magnetization vectors for promoting the integration of elements. This opened the way for the attainment of ultra-low-power integrated semiconductor circuits. These revolutionary findings were made possible by Prof. Ohno's creative inspiration that semiconductor-related knowledge can be combined with ferromagnetism knowledge because the materials he investigated, such as GaMnAs, are structurally compatible with other well-known III-V group elements.

Moreover, Prof. Ohno played a pioneering role in proposing and demonstrating new types of integrated circuits that combine semiconductor elements and metal-based spintronic elements. He did this by focusing on the fact that the spin-tunneling effect helps achieve low power compared with charge transfer in electronics owing to its non-volatile characteristics. Additionally, as one of the thirty principal investigators selected from all fields in the Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST) of Japan, Prof. Ohno worked on demonstrating power-saving spintronic logic integrated circuits to help create a super energy-saving society. He also directed his attention to combining nonvolatile spintronic elements with integrated semiconductor circuits. As a result, he succeeded in realizing improving the performance of CoFeB/MgO perpendicularly magnetized magnetic-tunnel junction device that has become the key spintronics nonvolatile device for integration with semiconductor integrated circuits. Another result was achieving magnetization inversion control of the tunnel-junction element using the same material. Combining the power of spintronics devices with integrated circuit technology, he opened the way to creating the ultra-high integration of magnetic memory (MRAM) and logic circuits. In addition, he is currently a project leader in the Impulsing Paradigm Change through Disruptive Technologies Program (ImPACT). The program aims to develop extraordinary ecological IT equipment that can be used without charging for extended periods. Consequently, he worked on industrial applications for attaining an ultra-low-power spintronics-based integrated circuit that can be operated by harvesting energy from our living environment.

In the process of leading research programs and projects including the above, Prof. Ohno also devoted himself to the establishment of research and development systems. Through these endeavors, he contributed to the fostering of superior researchers in his field by constructing a spintronic-device fabrication-equipment infrastructure, by establishing international research centers for the creation of spintronic elements based on new concepts, and more. Prof. Ohno's pioneering activities have generated an overwhelming number of citations of his work in papers numbering in the tens of thousands, attesting to the tremendous impact he has had, and is continuing to have, in the development of his own and related fields.

In summary, in addition to the creation of fundamental research results in the physics of ferromagnetic compound semiconductors, Prof. Ohno's many years of work and achievements in the area of magnetic semiconductors have opened up new areas of research. These have led to further proposals and demonstrations of a wide variety of new electronic devices that leverage electron spin for existing electronic technologies. His many pioneering research results in the area of semiconductor spintronics, in particular, have attracted the participation of many researchers worldwide, thus contributing to the development of this field. Moreover, his achievements have gone well beyond the academic realm. They significantly contributed to industry as well. Industry desperately needed his new technologies. Therefore, they were deployed as soon as possible to make the technological breakthroughs for industrial applications needed by the society of the future. This is particularly true in the area of integrated logic circuits, which need to be more power-efficient. In consideration of Prof. Ohno's pioneering work on spintronics technology, which forms the foundation of high-performance, energy-saving semiconductors for sustainably supporting a C&C society, Prof. Ohno highly deserves the C&C Prize.