The 8th JSAP Research Achievement Award

Yoshihiro Hamakawa

Development of Advanced Research in Amorphous Silicon Solar Cells

From the late 1970s, which could be considered the dawning of Amorphous Silicon (a-Si) solar cells, through to the 1990s, Yoshihiro Hamakawa conducted advanced research aimed at increasing the conversion efficiency of these cells, and achieved outstanding results. Of particular note are his introduction of heterojunctions into amorphous solar cells and his proposal of a tandem structure combining amorphous Si and crystalline Si.

In the early stages of the development of a-Si solar cells, junctions used a p-i-n structure comprised rather than of a-Si alone. Dr. Hamakawa proposed using microcrystal SiC (μc-SiC) and SiC (a-SiC) in which carbon is added to the p-layer, based on his judgment that the optical absorption of p-type a-Si was a limiting factor in conversion efficiency. He later developed pn control technologies and film production technologies for these "wide gap" materials, created an element that demonstrated an outstanding wide gap window effect in the p-type a-SiC and μc-SiC layers, and verified the effectiveness of these elements. This pioneering research in the introduction of heterojunctions into amorphous Si solar cells led to significant developments in the field of amorphous heterojunction element research.

The conversion efficiency of amorphous Si solar cells is around 10%, but Dr. Hamakawa proposed the world's first amorphous Si tandem (multi-junction) solar cell with multiple a-Si p-i-n junctions as a new technology for dramatically improving more than 13% conversion efficiency. This proposal was the starting point for extensive basic research and applied research regarding amorphous Si alloys such as a-SiGe.

Dr. Hamakawa also proposed heterojunction solar cells combining crystalline Si and p-type and n-type a-Si/μc-Si, and tandem structures combining amorphous and crystalline Si solar cells.

The results of this basic research conducted by Dr. Hamakawa has been adopted by related companies, and has promoted improvements in production technologies and technology development leading to increased efficiency, larger cell surface areas, and greater mass productivity. This has in turn facilitated the creation of a wide range of new products, including a-SiC/a-Si solar cells, a-Si/a-SiGe two-layer and three-layer tandem solar cells, and a-Si/μc-Si tandem structure thin-film solar cells. Nearly all a-Si solar cells in use today have adopted a-SiC/a-Si heterojunctions. Low-cost, high-efficiency a-Si/μc-Si tandem thin-film solar cells have gained attention as the most promising candidate for next-generation thin film solar cells, and have been gaining recognition in the solar power industry, but it was Dr. Hamakawa who laid the foundations for these technologies through his pioneering basic research.

Based on these creative ideas, Dr. Hamakawa has led the world in research and development on a series of innovative amorphous Si solar cells. These elemental structures were unprecedented and revolutionary at the time of their development, but since then, the evolution of these technologies has borne much fruit. Dr. Hamakawa's achievements have made substantial contributions to developments in the field of solar power generation.

His exceptional achievements are truly worthy of the JSAP Achievement Awards (research achievements).

Masataka Hirose

Basic and leading research on amorphous semiconductor superlattices and silicon integration technologies

Masataka Hirose has been involved in research on semiconductor engineering since the latter half of the 1960s, most notably in leading research related to the characterization, processes, and integration of silicon semiconductors. He has made significant contributions to the evolution of silicon technologies.

In 1984, Dr. Hirose formed a superlattice structure by alternately laminating two types of amorphous semiconductor membranes with irregular atomic arrangements, and measuring, for the first time, the optical and electrical properties induced by confined carriers in an ultra-thin well layer. He also produced a double barrier tunnel structure and verified the quantization of the electron state in the amorphous semiconductor ultra-thin membrane, thereby opening up the field of research in amorphous semiconductor superlattices. He conducted research in low-temperature growth and low-temperature doping of amorphous silicon membranes using photoexcitation and magnetic field application to silane plasma. He demonstrated that high hydrogen dilution is effective in plasma growth for microcrystal silicon using monosilane, and at the same time showed how the electrical and optical characteristics changed as a function of crystallinity. These results had a significant impact on later research in amorphous semiconductors.

Later on, Dr. Hirose conducted a range of leading research in silicon MOS transistors and the integration of these transistors. Notably, he was one of the first to focus on the ultra-thin silicon oxide film with a thickness of 1-4nm, and the SiO_2/Si interface, which are the key to achieving extremely fine MOS devices. He conducted quantitative investigations of the concentration, energy distribution, and capture cross section of the interface skates, and systematically evaluated and analyzed the tunnel leak current of the ultra-thin gate dielectrics, demonstrating that it is possible to describe this tunnel leak current in the form of an analytical approximation. He also conducted research from both a basic science and an applied physics perspective on themes including layer-by-layer oxidization mechanism on the surface of hydrogen terminated Si (111) and the accelerated oxidization process on silicon surfaces, the chemical bonding state of interfaces and the interface stress, and the deterioration mechanisms of ultra-thin gate insulator, and conducted leading research aimed at controlling ultra-thin gate insulators and MOS interfaces.

In 1986, Dr. Hirose established the Research Center for Integrated Systems (currently the Research Center for Nanodevices and Systems (RCNS)) at Hiroshima University, which has a silicon LSI prototype production line. In 1992, he successfully produced what at the time was the world's smallest transistor, with a gate length of 70nm, and later conducted research and development in ultra-fine transistors with ultra-thin gate insulators. Under Dr. Hirose's direction, this Research Center has thus acquired a track record as one of the world's foremost research bases in the field of integrated devices.

Dr. Hirose has demonstrated outstanding leadership in terms of both manpower training and leading research in the field of semiconductor engineering, and has achieved exceptional results that have contributed dramatically to establishing the scientific foundations for the evolution of semiconductor technologies. His achievements are therefore worthy of the JSAP Achievement Awards (research achievements).