Isamu Akasaki in memoriam

The 2014 Nobel laureate, Isamu Akasaki, sadly passed away in April at the age of 92. He was highly regarded for his work on the invention of efficient blue light-emitting diodes and research into new semiconductor materials.

Isamu Akasaki, a long-standing professor at Meijo University in Nagoya, Japan, passed away on the morning of 1 April 2021. It is with great regret that we announce the passing of this great scientist. Akasaki was born in Chiran City, Kagoshima Prefecture, Japan, on 30 January 1929 and initially studied at the Faculty of Science in Kyoto University, where he graduated in 1952. After joining Kobe Kogyo Co. (now Denso Ten Ltd), he became a research associate at Nagoya University in 1959, and after working for Matsushita Electric Industrial (now Panasonic Co.), he became a professor at Nagoya University in 1981 and a professor at Meijo University in 1992 (Fig. 1).

In 1989, during his time at Nagoya University, Akasaki succeeded in developing the world's first high-efficiency blue light-emitting diode (LED) based on the gallium nitride (GaN) material system. The achievement was considered a revolutionary invention and resulted in Akasaki sharing the 2014 Nobel Prize in Physics together with his student, Hiroshi Amano (now a professor at Nagoya University), and also Shuji Nakamura, a researcher at the Japanese company Nichia Chemicals (now a professor at the University of California, Santa Barbara)[1].

The success came because Akasaki had continued to relentlessly pursue research into GaN, after many other researchers around the world had given up. Eventually he succeeded in growing high-quality crystals, which was said to be impossible by many, opening up a new era for semiconductor light sources and ultimately commercial white LED lighting. His way of life, based on his strong conviction, was epitomized by his solitary spirit of "I, alone, will go into the wilderness" (Fig. 2).

Akasaki began full-scale research into LEDs in 1973, nine years after joining Matsushita Electric Industrial, when he was working at the company's Tokyo Research Laboratory.

Red and green LEDs had already been commercialized, and there was fierce worldwide competition to develop an LED capable of directly emitting the remaining primary colour — blue. At that time, the wide-bandgap semiconductors zinc selenide (ZnSe) and GaN were expected to be the most likely candidates for success.

Fig. 1 | Isamu Akasaki at a press conference for the Nobel Prize in Physics that he received in Stockholm on 10 December 2014. Credit: Newscom/Alamy Stock Photo

However, it was proving extremely difficult to produce a high-quality GaN crystal, which is necessary for controlling the material's electrical properties, and the world's mainstream view was that ZnSe was going to triumph in the race. Nevertheless, Akasaki continued to persevere with GaN. He said, "GaN is much more stable physically and chemically than ZnSe and has many advantages." He was convinced that if he could improve the quality of the crystals the blue LED would be realized.

In the 1950s, before he joined Matsushita, he had worked on the successful single crystallization of high-purity germanium (Ge) at Nagoya University and I think this earlier success gave him confidence.

After deciding to continue to focus on GaN research, Akasaki faced a lonely battle: at an international semiconductor conference in 1981 he presented his research results but received no response or questions from the audience[2]. At that time, he murmured, "I'm going into the wilderness alone", and vowed to never stop his research on GaN. With a strong determination, he kept at it and finally succeeded in producing high-quality crystals in 1985 by introducing a method of growing a thin buffer layer of aluminium nitride (AlN) on a sapphire substrate surface, following an idea based on his "empirical intuition"[3,4].

Fig. 2 | At the summer seminar trip of the Akasaki laboratory of Nagoya University in 1985. Centre left: Professor Isamu Akasaki, upper left: Professor Hiroshi Amano, and lower right: the author.

Akasaki's fierce determination to succeed was likely linked to his experiences in life during the Second World War. He survived an air raid in Kagoshima during the Pacific War, his house was completely burnt down, and he managed to escape machine-gun fire from a fighter plane. He spent 16 years developing the high-brightness blue LED, which was a great achievement and his perseverance came from his mental strength to survive the war.

I presently work at the National Institute for Materials Science (NIMS) in Tsukuba City as a special-mission researcher, where I am engaged in research on wide-bandgap semiconductor materials and devices. After completing my master's degree at Toyohashi University of Technology, I joined the Akasaki laboratory at the Nagoya University as a doctoral student in April 1984, and worked there as an assistant professor until June 1988.

Looking back on my time as a student, Akasaki asked me to do two things when I first started my research: one was to start a new research theme on aluminium gallium nitride (AlGaN), and the other was to build a new metal–organic vapour phase epitaxy (MOVPE) system when we moved the laboratory to a new clean room. I assume that the decision was based on the experience I had gained at Toyohashi University of Technology. To start up the apparatus, I made a list of piping parts, reaction tube parts, used parts and various design drawings, and discussed them with Akasaki. After all the parts were in place, I consulted with Hiroshi Amano, who was a second-year master's student at the time and one year below me, about the piping and assembly policy based on the design concept and drawings, and the two of us started to fabricate the MOVPE system.

The features of the system were as follows: (1) leak-tight piping using all O-ring seal fittings and valves; (2) stainless steel piping; (3) the controlled introduction of organometallic compounds, ammonia and hydrogen gas, using a self-made system featuring electronically controlled solenoid valve-driven pressure valve operation; (4) appropriate flow meters; and (5) a high-frequency oscillator for substrate heating (a second-hand one used by Nishinaga, Akasaki's colleague in research, for halide vapour phase growth of boron phosphide (BP))[5]. The equipment was completed around the end of August, and we started crystal growth experiments in turns of two weeks in September, sharing the equipment with Amano. The results of our subsequent research are as introduced by Nobel lectures of Akasaki and Amano[6,7].

Looking back on it now, I think it was a wonderful experience for me because this kind of handmade equipment was very effective in the research of fabricating completely new and unexplored materials, and I could easily modify the equipment as necessary.

Akasaki was very strict in his research, and I am grateful to him for his sincere guidance to the students as well as for diligence in checking my doctoral thesis after seven or eight rounds of corrections. Akasaki's attitudes of determination and tenacity to never give up were so inspirational that I have tried to follow them myself in my research life since then. I hope he rests in peace, and as his student, I am determined to devote myself to the continued development of group-III nitride semiconductors. ❐

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