Development of GaN based devices and future prospects

Hiroshi Amano

Graduate School of Engineering, Nagoya University,
C3-1 Furo-cho, Chikusa-ku, Nagoya 464-8603, Japan
amano@nuee.nagoya-u.ac.jp

Historically, research on GaN as a luminescent material started in the late 50s. Professor Grimmeiss and his group submitted a patent for a GaN luminescent system in 1960. In 1971, Professor Pankove developed the first GaN-based blue LEDs, which were of the metal-insulator-semiconductor (MIS) type LED. Following his success, many research groups unsuccessfully tried to commercialize Pankove-type LEDs in the 70s. Polish research group greatly contributed in understanding the thermodynamic properties of GaN, especially how difficult it is to grow GaN from solution.

In the 80s, the accumulation of several breakthroughs, such as the growth of high-quality crystals on a foreign substrate, p-type conduction by Mg doping followed by a special treatment, and the growth of InGaN layers led to the commercialization of GaN-based blue LEDs. It is worth explaining how blue LEDs have changed our lives. Portable games machines such as Game Boys and cellular or smart phones are very familiar items, especially to young people. Until the end of the 90s, all the displays of portable games machines and cellular phones were monochrome. Therefore, it should be emphasized that the younger generation can now enjoy full-color portable games and cellular or smart phones because of the emergence of blue LEDs. At the same time, some people are concerned about the increase in cellular phone or smart phone addiction.

The turning point came in 1996. In combination with phosphors, blue LEDs came to be used as a white light source and also used in general lighting. For general lighting, I would like to explain how InGaN LEDs can contribute to improving the electricity situation and saving energy, especially in Japan. Many people remember the great earthquake of east Japan and the meltdown of the nuclear power plants in 2011. Currently, none of the 48 nuclear electricity generators in Japan are in operation. Before 2011, about 30% of Japan's electricity was generated by nuclear reactors. Thus, we have to find a way to adopt the loss of 30% of Japan's electricity generating capacity. A research company in Japan has predicted that by 2020 more than 70% of general lighting systems will have been replaced with LED lighting, by which we can reduce Japan's total electricity consumption by about 7%. More importantly, we can develop and supply compact lighting systems to the younger generation, especially children in remote areas without access to electricity. Using an LED lighting system with a solar cell panel and a battery, children can read books and study at night.

In this presentation, I would like to outline the history of the development and future prospects of nitride-based light-emitting devices, especially devices using the visible long-wavelength and UV regions. Also, applications to power devices will be discussed.