# GaN as a key material for realizing Internet of Energy

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ABSTRACT

Gallium nitride (GaN) and related compound semiconductors, the so-called group III nitrides, are thought to be among the most important key materials for next-generation high-power and high-frequency devices. In this presentation, by considering a system based on these materials, I would like to discuss how to establish a sustainable, smart, safe, and secure society through the "Internet of Energy" for connecting people at any time and any place. The meaning of this phrase, "Internet of Energy", is simple. With the use of a ubiquitous energy transmission system, we do not need to worry about a shortage of electric power.

One of the most important items for establishing a sustainable society is electric vehicles, so-called EVs. One of the problems of EVs is their short driving range owing to the insufficient capacity of the battery. Another is their long charging time. To solve these problems, we are trying to establish a new wireless electricity transmission system using high-power and high-efficiency GaN-based devices. If EVs can be recharged while driving, they will run like trams but with more freedom as they can be driven anywhere.

In TV programs, images of beautiful scenery taken from flying drones are becoming increasingly common. Drones have the same problem as EVs, that is, a short range on a single charge. If drones can be recharged while flying, we can expect them to fly all day, increasing their applicability to, for example, the inspection of old bridges, roads, and buildings. In Japan, logistics has the problem that the increasing average age of drivers is gradually decreasing the capacity of logistic systems. If we can apply autonomous drones that can fly 24 hours a day for logistics, the capacity of logistical systems will be drastically improved. In times of catastrophic emergencies, drones can also play a key role in carrying emergency items to victims.

We will no longer need to worry about electricity shortages not only for EVs and drones, but also for any electronic system. We can connect electronic systems at any time and any place, thus achieving the "Internet of Energy".

To realize such a future wireless electricity grid, we should try to seamlessly connect the research, development, and commercialization of new systems in which GaN-based high-frequency and high-power devices are to be used. In the case of GaN-based blue LEDs on a sapphire substrate, it took 30 years from the first fundamental success to their innovation. Investors cannot wait 30 years. Innovation should be achieved within 10 years. We are trying to establish new social infrastructures using GaN-based devices on GaN substrates. In our university, we have established a new research consortium connecting all the stages from fundamental science to commercialization. For example, we are now trying to develop killer-defect-free bulk-GaN-substrate growth technology, epitaxial growth technology for vertical and horizontal devices, ion implantation technology, etching technology, and packaging technology at the Nagoya University campus. Up to now, 47 private companies, 20 universities,

and three national research institutes have joined and are starting to collaborate toward the practical realization of wireless electricity transmission systems.

We are also starting a new program for graduate students, which is called the DII Collaborative Program. Three different specialists, deployers, innovators, and investigators form a team to respond to social crises such as climate change. The Japanese government has targeted an 80% cut in greenhouse gas emission by 2050 from the current level. To realize this challenging goal, we need pioneers who can lead research, development, and commercialization. We believe that our program will foster a large number of future leaders who will help establishes a sustainable, smart, secure, and safe society.

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## BIOGRAPHY

Hiroshi Amano received his BE, ME, and DE degrees in 1983, 1985, and 1989, respectively, from Nagoya University. From 1988 to 1992, he was a research associate at Nagoya University. In 1992, he moved to Meijo University, where he was an assistant professor, associate professor, and professor from 1998 to 2010. He moved to Nagoya University, where he was a professor of Graduate School of Engineering from 2011 to 2015. On October 1, 2015, he became the director of the Center for Integrated Research of Future Electronics, Institute of Materials and Systems for Sustainability, Nagoya University. He has also been the director of the Akasaki Research Center, Nagoya University since 2011.

He is currently developing technologies for the fabrication of high-efficiency power semiconductors and new energy-saving devices at Nagoya University. He has 577 publication, and 251 patents. He shared the Nobel Prize in Physics 2014 with Professor Isamu Akasaki and Professor Shuji Nakamura "for the invention of efficient blue light-emitting diodes, which has enabled bright and energy-saving white light sources".