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Materials Science and Engineering

Cohen Lecture

Shuji Nakamura

Professor
Materials & Electrical & Computer Engineering
Solid State Lighting and Energy Center Director
University of California, Santa Barbara

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4:00pm, Ryan Auditorium

"The Invention of High Efficient Blue LEDs and Future Lighting"

In 1970's and 80's, an efficient blue and green light-emitting diodes (LED) were the last missing elements for solid-state display and lighting technologies due to the lack of suitable materials. By that time, III-nitride alloys was regarded the least possible candidate due to various "impossible" difficulties. However, a series of unexpected breakthroughs in 1990's totally changed people's view angle. Finally, the first high efficient blue LEDs were invented and commercialized at the same time of 1993. Nowadays, III-nitride-based LEDs have become the most widely used light source in many applications. The LED light bulbs are more than ten times efficient than incandescent bulb, and they last for 50 years! At their current adoption rates, by 2020, LEDs can reduce the world's need for electricity by the equivalent of nearly 60 nuclear power plants. The history of the invention of blue LED and future lighting will be described.

Biography: Shuji Nakamura's development of nitride-based semiconductors represents one of the most important achievements in semiconductor materials science of the last 30 years. Specifically, his discovery of p-type doping in Gallium Nitride (GaN) and his invention of blue, green, and white light-emitting diodes (LEDs) and blue laser diodes (LDs) has enabled the development of energy-efficient lighting and displays. <I would omit this sentence as TMI: Nakamura discovered that p-type GaN films could be obtained by doping GaN with Mg coupled with successive post-thermal annealing in a nitrogen ambient at temperatures above 400° C.> Nakamura also developed InGaN films of the highest crystal quality, which enabled the realization of bright blue double heterostructure light-emitting devices. These achievements have greatly benefited humanity through their application in devices for energy-efficient solid-state lighting displays, medicine, and the next generation of Blu-Ray optical storage. Today's scientific consensus is that Nakamura's inventions are so reliable and energy efficient that they are destined to replace Thomas Edison's light bulb and save the world billions of dollars in energy costs.

Shuji Nakamura obtained his B.E., M.S., and Ph.D. degrees in Electrical Engineering from the University of Tokushima, Japan in 1977, 1979, and 1994, respectively. He joined Nichia Chemical Industries Ltd in 1979. In 1988, he spent a year at the University of Florida as a visiting research associate. In 1989, he started the research of blue LEDs using group-III nitride materials. In 1993 and 1995, he developed the first group-III nitride-based blue/green LEDs. He also developed the first group-III nitride-based violet laser diodes (LDs) in 1995.

The development of nitride based semiconductors by Prof. Nakamura represents one of the most important achievements in the materials science of semiconductors in the last 30 years. Specifically, the discovery of p-type doping in Gallium Nitride (GaN) and the development of blue, green, and white light emitting diodes (LEDs) and blue laser diodes (LDs) has enabled energy efficient lighting and displays. Prof. Nakamura discovered that p-type GaN films could be obtained by doping GaN with Mg coupled with successive post-thermal annealing in a nitrogen ambient at temperatures above 400°C. Prof. Nakamura also developed InGaN films of the highest crystal quality which enabled the realization of bright blue double heterostructure light emitting devices. These achievements have resulted in great benefits to mankind through their use in devices for energy efficient solid-state lighting, displays, medicine, and the next generation of Blu-Ray optical storage. The general conclusion among scientists at this time is that Prof. Nakamura's inventions are so reliable and energy efficient that they are destined to replace Thomas Edison's light bulb and save the world billions of dollars in energy costs.

Professor Nakamura had received numerous awards for his work, including the Nishina Memorial Award (1996), the Materials Research Society Medal Award (1997), the Institute of Electrical and Electronics Engineers Jack A. Morton Award, the British Rank Prize (1998), the Benjamin Franklin Medal Award (2002), the Millennium Technology Prize (2006), the Czochralski Award (2007), the Prince of Asturias Award for Technical Scientific Research (2008), The Harvey Award (2009), and the Technology & Engineering Emmy Award (2012) awarded by The National Academy of Television Arts & Sciences (NATAS). He was elected as a fellow of the U.S. National Academy of Engineering in 2003. He is the 2014 Nobel Laureate in Physics for the invention of efficient blue light-emitting diodes which has enabled bright and energy-saving white light sources. Prof. Nakamura received the 2014 Order of Culture Award in Japan. He was inducted into the National Inventors Hall of Fame in 2015. He received the 2015 Charles Stark Draper Prize for Engineering and the 2015 Global Energy Prize in Russia.

Since 2000, he has been a professor of Materials and Electrical & Computer Engineering at the University of California, Santa Barbara. He holds more than 200 US patents and over 300 Japanese patents. He has published over 550 papers in his field. Prof. Nakamura is the Research Director of the Solid State Lighting & Energy Electronics Center and The Cree Chair in Solid State Lighting & Displays. He co-founded Soraa, Inc. in 2008, which operates vertically integrated fabrication facilities in California's Silicon Valley and Santa Barbara.