Japan-Sweden Science, Technology & Innovation Symposium 2014

Biography of Isamu Akasaki (as of April, 2014)

Isamu Akasaki received B.S. in 1952 from Kyoto University and Dr. Eng.(Electronics) in 1964 from Nagoya University. In 1964 he became the Head of Basic Research Lab. IV at Matsushita Research Institute Tokyo, Inc. In 1981 he was appointed a professor, in 1992 a Professor Emeritus and in 2004 a University Professor of Nagoya University. Since 1992 he has been a professor at Meijo University, where in 2010 he was appointed a Lifetime Professor.

In 1986, he and his group created semiconductor-grade high-quality single crystal of GaN, and in 1989 developed GaN p-n junction blue LED, both for the first time. In 1989 to1991 they succeeded in conductivity control of p- and n-type GaN and nitride alloys of excellent-quality as world firsts, allowing the use of heterostructures and multiple quantum wells(MQWs) in the design of more efficient p-n junction light-emitting structures. In 1990 they achieved the stimulated emission from the high-quality GaN first at room temperature with one order of magnitude lower optical power than before. In 1996 they developed a laser diode (LD) with AlGaN/GaN/GaInN QW device at 376nm, which was the shortest wavelength at that time.

They verified in 1991 quantum size effect, in 1997 quantum confined Stark effect in the nitride system. In 2000 they succeeded in crystal orientation control to reduce or even completely eliminate the polarization fields showing the existence of non-/semi-polar nitride crystal planes. This has triggered recent world-wide efforts to grow those crystals, which brought high-power blue LEDs and green LDs.

An honorary member of the Chemical Society of Japan, Akasaki is an IEEE Life Fellow, an honorary member of the Physical Society of Japan, the Japan Society of Applied Physics, the Japanese Association for Crystal Growth, the Institute of Electrical Engineers of Japan, the Institute of Electronics, Information and Communication Engineers of Japan, and a member of Engineering Academy of Japan.

He was elected a Foreign Associate of the US National Academy of Engineering (NAE), and acknowledged as a Person of Cultural Merits by the Japanese Government.

He was awarded Honoris Causa Doctorate from the University of Montpellier and from Linkoeping University. He is an Honorary Citizen of Montpellier, and of Minami-Kyushu.

His major awards include Heinrich Welker Gold Medal (1995), the Japanese government's Medal with Purple Ribbon (1997), IOCG's Laudise Prize (1998), IEEE Jack A. Morton Award (1998), Rank Prize (1998), ECS's Solid State Science and Technology Award (1999), Toray Science and Technology Award (2000), Asahi Prize (2001), the Japanese Government's Order of the Rising Sun, Gold Rays with Neck Ribbon (2002), Fujihara Prize (2002), TMS's John Bardeen Award (2006), Kyoto Prize in Advanced Technology (2009), IEEE Edison Medal (2011), JST's Special Award for Intellectual Activities (2011), and SID's Karl Ferdinand Braun Prize (2013).

In 2011 he was awarded the Order of Culture from the Emperor of Japan in person. He will be awarded the Imperial Prize and the Japan Academy Prize in July, 2014.

He has authored and coauthored more than 730 international journal/conference papers, edited 30 books, and has been awarded 233 patents, which are related to nitrides.

Development of GaN-based Semiconductors of Excellent Quality and Their p–n Junction Blue-Light-Emitting Devices

Isamu Akasaki
Meijo University / Nagoya University

In the 1960s, red and yellow-green light-emitting diodes (LEDs) and infrared semiconductor lasers (LDs) had already been realized, but there was no prospect of practical blue- light-emitting devices even in the 1970s.

Both of the two essential requirements for creating high-performance blue-light-emitting devices, (1) the growth of high-quality single crystals of direct-transition type semiconductors with wide-bandgap energies, such as gallium nitride (GaN), and (2) the formation of their p-n junctions, were extremely difficult to achieve. In 1973, the author resolved to develop novel devices including high-performance blue-light-emitting devices based on GaN p-n junctions.

He and his group at Nagoya University created in 1986 the first electronic-grade high-quality GaN single crystal. Using the high-quality crystal, they succeeded in conductivity control of both p-type and n-type GaN-based semiconductors, and developed a GaN p-n junction blue/UV LED, all in 1989 to1990,as world firsts. These successes triggered the opening up of an entirely new field of electronics. R and D in this field have rapidly been accelerated, so that new products have been commercialized one after another, including high-brightness blue and green LEDs, and high-performance blue-violet LDs.

The development of blue LEDs has allowed us to complete the set of light's three primary colors with semiconductors. GaN-based blue/green LEDs are much brighter than incandescent lamps. Coupled with available high-brightness red LEDs, they are leading to the development of completely solid-state full-color displays, traffic lights, signage, and specialized lighting applications. The efficiency of white LEDs composed of blue/UV LEDs exceeds those of fluorescent lamps, and, as such, white LEDs are now being used in TVs, cellular-phones and computer displays. Moreover, white LED lamps are heading toward use in general lighting applications in houses, offices, factories as well as outdoor illuminations. The blue LEDs, together with available red LEDs, are also being applied as agricultural lighting sources. The white LEDs and UV-LEDs will be used in bio-medical applications such as sterilization, microscopic level diagnoses, and medical treatment.

The GaN-based violet LDs are being used for reading/writing data in optical disc systems. Coupled with available red LDs, blue and green LDs will be used in mini-projectors.

As well as these optoelectronic uses, GaN-based semiconductors are also promising for high-speed/high-power electronic devices, due to their high electron-saturation-velocities and high breakdown-voltages. These devices are important to the mobile telecommunications industry, for energy savings in transportation facilities such as trains and automobiles, and also for home electrical appliances such as air conditioners and refrigerators.

All of these GaN-based devices are robust in harsh environments, and they enable us to save a significant amount of energy, and provide a route to avoid the use of hazardous materials. The use of these devices will be one of our major weapons in the fight against global warming.

Biography of Lars Samuelson

Lars Samuelson is since 1988 Founder and Director of the Nanometer Structure Consortium at Lund University (www.nano.lu.se). He has published about 600 papers (h-index≈71) and given >250 invited/plenary talks at international conferences.

He is Fellow of Inst. of Physics and American Physical Society (Materials Physics) and is Member of the Royal Swedish Academy of Sciences (Physics) and the Royal Swedish Academy of Engineering Sciences.

In 2008 he was awarded "Einstein Professor" by the Chinese Academy of Sciences and in 2013 the IUVSTA Prize for Science. He is founder and CSO of the companies QuNano AB, GLO AB and Sol Voltaics AB.

Major Activities

1972~1977	Ph.D. in Physics, Lund University
1977~1978	Post-doc at IBM Research in San Jose, California
1979~1986	Researcher at Lund University (Docent in 1981)
1986~1988	Professor at Göteborg University/Chalmers
1988--present	Professor at Lund University
1990~present	Director of the Nanometer Structure Consortium at Lund University
1995~present	Founder and Chief Scientific Officer (CSO) of a set of spin-out companies, Qunano AB, Sol Voltaics AB and Glo AB

Research Interests

Materials Physics: Growth of low-dimensional semiconductor heterostructures.
Quantum Physics: Studies of quantum transport and optics of nanostructures.
Device Physics: R&D related to electronics, opto-electronics and energy applications.

Nanowire-based LEDs: from Materials Science to Applications

Lars Samuelson
Solid State Physics Division/Nanometer Structure Consortium, Lund University
also with Glo AB, Lund Science Park & Sunnyvale, CA

Nanowires offer a powerful approach to realize high-quality semiconductor structures for science as well as for applications. Also for this field of semiconductor nanowires, the original break-through came from Japan, with the pioneering work done by Dr. Kenji Hiruma in the early 1990's at Hitachi Central Research. Among important advantages of the nanowire approach in comparison with traditional planar technology is the tolerance for combining materials having different lattice-constants and the ability to epitaxially form III-V and III-nitride materials, also on silicon wafers, thus adding opto-electronic capabilities to the silicon industry. In this presentation I will describe principles and advantages of the growth of semiconductor nanowires, specifically as applied to fabrication of GaN-based light-emitting diodes for display and solid state lighting applications. I will also mention recent progress in the growth of III-V nanowire arrays for the realization of high-performance solar cells.

Biography of Bo Monomar

Prof Bo Monemar obtained his Dr Techn degree at Lund University, Sweden, in 1971. He was docent at Lund University 1976-1982, and was appointed as professor and Head of the Materials Science Division at Linköping University, Sweden in 1983. Since 2009 he is working as emeritus professor at Linköping University as well as at Lund University. He was visiting scientist at IBM T J Watson Research Center, USA 1974-75, at CENG Grenoble, France 1982-83 and at The Max Planck Institut fur Festkörperforschung, Stuttgart, Germany, 1989-90.

Monemar was a member of the IUPAP Semiconductor Physics Commission 1987-1993, and the secretary of that Commission 1993-1999. His research interests cover a broad range of semiconducting materials, more concentrated to the III-nitrides during the last two decades.

Monemar has published more than 1100 papers in international journals, books or proceedings for international conferences (h = 45).

Properties of GaN and Related Materials, and The Relevance for Visible Light LEDs

Bo Monemar
Semiconductor Materials Division, Linköping University,
and Solid State Physics Division
Lund University

The potential of GaN for optical devices was realized already in the 1960´s, but adequate material for LEDs could not be produced at the time (no p-type GaN). Only in the late 1980´s sufficiently good epitaxial layers of GaN could be grown, and both n- and p-type doping could be controlled (Prof Akasaki´s group). A steady improvement of the performance of GaN-based LEDs and LDs has followed, and this now represents an important worldwide industry. Many material properties of the III-nitride family are favorable for this development, others have to be controlled. Some important optical, mechanical and electronic material properties will be discussed, with reference to critical issues in the presently available nitride based light emitting devices.