ACCMS-Global Research Center
SRMIST, Chennai India

Webinar #30

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Title: New Developments in Nitride Semiconductors Focusing on Wurtzite Structure

Registration link: https://tinyurl.com/3jxm7jnz

**Zoom details will be shared with the registered participants*

August 27th 2024,
11.30 am – 1.00 pm Indian Standard Time

Short biography

Prof. Takashi Matsuoka has been an Emeritus Professor at Tohoku University since April 2019. He has also been an Academic Researcher at the New Industry Creation Hatchery Center (NICHe) of Tohoku University since the same date. He began his career at Nippon Telegraph and Telephone Corporation (NTT) Photonics Laboratories in 1978, became a Senior Research Engineer in 1989, and transferred to Basic Research Laboratories in 1997. In February 2005, he moved to Tohoku University as a professor in the Division of Physics of Electronic Materials at the Institute for Materials Research (IMR). His research contributions span a broad spectrum of topics in optoelectronic materials and devices, including nitride semiconductors, distributed feedback (DFB) lasers used worldwide as light sources in optical communication systems, II-VI materials, and their light-emitting devices.

He has published more than 100 scientific papers and given over 120 invited lectures, including plenary talks, at international conferences. His scientific papers on DFB lasers and nitride semiconductors have been cited over 700 and 3000 times, respectively. He holds 46 Japanese patents and 12 international patents including those in the US and Europe. Recently, he discovered that the band-gap energy of wurtzite InN which is an explored material in InGaAlN is about 0.8 eV, opening the door to the application of nitride semiconductors in optical communication devices. He has received numerous awards from several Agencies in Japan (JSAP, JJAP, JACG,and so on) for his research contributions. His is a lifetime member in MRS.IEEE. SPIE. IEICE. ISAP. and IACG.

Abstract

My semiconductor research has spanned from materials to devices, starting with Si and moving to GaAs and then InP. Since the proposal of InGaAlN and the successful development of InGaN as a blue emitter in 1989 [1], nitride semiconductor InGaAlN with a wurtzite structure has been extensively utilized in commercial products such as blue light-emitting diodes (LEDs) and high electron mobility transistors (HEMTs). This material exhibits crystalline polarity along the c-axis., distinguishing it from conventional semiconductors. The polarity arises from the hexagonal structure of wurtzite, contrasting with the cubic structures of diamond and zinc-blende. The strong polarity in InGaAlN generates the polarization within a crystal because the electronegativity of a nitrogen atom is the highest among group-V atoms. The growth mode also depends on polarity because the capture efficiency of nitrogen atoms differs. To date, all materials employed in these devices have been inadvertently grown with Ga-polarity. The incorporation rate of indium atoms is also polarity-dependent because of the highest nitrogen equilibrium pressure of InN among three end materials. Indium atoms are readily incorporated in N-polarity. Utilizing N-polar growth, the successful epitaxial growth of the single-crystalline InN was achieved, and its band-gap energy was corrected [2]. Hence, it has been demonstrated that InGaAlN is capable of covering a range from ultraviolet to infrared. Moreover, recent advancements have enabled the calculation of the band-gap energy with an accuracy of 0.1 eV without any parameters [3]. Consequently, it can be anticipated that epitaxially grown films with N-polarity will pave the way for new opportunities. In the presentation, as applications considered polarity of nitride semiconductors, we will discuss an inverted HEMT for 5G, a solar-cell capable of covering the entire solar spectrum while efficiently extracting photocarriers, and a red LED resistant to temperature quenching.

Refs. [1] T. Matsuoka *et al.*, *Inst. Phys. Conf. Ser.*, 106, 141 (1990). [2]T. Matsuoka *et al.*, *Appl. Phys. Lett.*, 81, 1246 (2002), [3] T. Matsuoka *et al.*, *14th Intern. Conf. Nitride Semicond. (ICNS)*, CH1-5 (Japan, Nov. 12-17, 2023); submitted into *Phys. Status Solidi B*.

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