AlGaN nanowire UV LEDs using graphene as substrate and transparent electrode

Speaker: **Prof. Helge Weman**

Norwegian University of Science and Technology, Trondheim + CrayoNano AS

Host: Alok Rudra

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Abstract: In 2012 we outlined a generic atomic model, which describes the epitaxial growth of semiconductors on graphene that is applicable to all conventional semiconductor materials. The epitaxial model was first verified by cross-sectional transmission electron microscopy studies of self-catalyzed GaAs nanowires that grew vertically on graphene by self-assembly.1

The epitaxial growth of semiconductors on graphene is very appealing for device applications since graphene can function not only as a replacement of the semiconductor substrate but in addition as a transparent and flexible electrode for e.g. solar cells and LEDs.2 For deep ultraviolet (UVC) AlGaN-based light emitting diodes (LEDs), in need for various disinfection and sterilization purposes, the concept offers a real advantage over present thin film-based technology. UVC LEDs are today very expensive and inefficient due to the lack of a good transparent electrode (ITO is absorbing in UVC), the high dislocation density in the active thin film layers, low light extraction efficiency, and the use of very expensive AlN substrates or AlN buffer layers on sapphire substrates.

Motivated by this potential we are at present focused on investigating the growth of self-assembled GaN nanowires on graphene using both MOVPE and MBE.3,4 A very high nucleation yield has been achieved on untreated CVD graphene using nanometer-sized AlGaN nucleation islands. As an attempt to achieve higher uniformity and position control we have also reported on selective area MOVPE growth of AlGaN nanopyramids on graphene using a SiO2 hole-mask.5 A first proof-of-principle flip-chip UV LED was recently demonstrated using double-layer graphene, where GaN/AlGaN nanowires were grown as the light-emitting structure using plasma-assisted MBE.6 The GaN/AlGaN nanowires are found to exhibit a high crystal quality with no observable defects or stacking faults.7 Room-temperature electroluminescence measurements show a GaN related near bandgap emission peak at 365 nm with no defect-related yellow emission.

Our spin-off company CrayoNano are now developing UVC LEDs emitting at 275 nm based on this technology as will be further discussed in my talk.

**References**

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Dr. Helge Weman is a professor of nano-electronics at the Norwegian University of Science and Technology (NTNU) in Trondheim, Norway. He received his PhD in semiconductor physics in 1988 from Linköping University, Sweden. During his career, he has held various positions at UCSB, NTT, EPFL and IBM Res. Lab Zurich. Since 2005 Weman is leading a research group at NTNU on III-V semiconductor nanowire/graphene hybrid devices for use in optoelectronic applications. Prof. Weman is a member of the Norwegian Academy of Technical Sciences (NTVA).

He is the founder and Chief Scientific Officer of CrayoNano AS who are developing deep UV LEDs using graphene as substrate and transparent electrode.