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AT THE FOREFRONT OF NANO SCIENCE

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NANOSCIENCE COLLOQUIUM

Wednesday
May 25, 2016
at 15:15,
K-space, Fysicum

MOCVD Routes to 2D Films

The spectrum of two-dimensional (2D) materials "beyond graphene" has been continually expanding driven by the compelling properties of monolayer films. The majority of studies have focused on materials such as MoS_2 and hexagonal BN that have layered crystal structures and can be cleaved or exfoliated to form flakes of monolayer or few layer thickness. Device applications, however, require the ability to deposit large area 2D films with controlled thickness and properties. Our studies have focused on the development of metalorganic chemical vapor deposition (MOCVD) processes for the direct growth of layered chalcogenide films including WSe_2, WS_2 and Bi_2Se_3 on sapphire and epitaxial graphene substrates. MOCVD provides flexibility in precursor selection and gas phase concentration and also enables growth at higher pressures which is advantageous for controlling native selenium and sulfur defect concentrations in the films. Recent results on the effects of growth conditions and precursor chemistry on 2D film properties will be discussed.
In addition to direct growth by MOCVD, we have also developed a novel graphene intercalation process to form "2D" films of GaN. In this process, gallium atoms are initially intercalated within the interfacial region of quasi-free standing epitaxial graphene formed on SiC and then nitridated in ammonia within an MOCVD growth environment to form stable ultrathin GaN films. The graphene capping layer provides thermodynamic stabilization of a unique structure of GaN as identified by aberration-corrected scanning transmission electron microscopy. Density functional theory predicts a bandgap energy in the range of 4.79-4.89 eV for this structure which correlates well with experimental results from UV-visible reflectance and absorption coefficient measurements (direct bandgap energy 4.90-4.98 eV). The graphene intercalation method provides an intriguing route to the synthesis of 2D forms of GaN and other III-V semiconductors that do not naturally exist as layered materials.

Host: Lars-Erik Wernersson (Electrical and information Technology)