Epitaxial growth of semiconductor nanostructures on graphene:
A solution for UV LEDs

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Abstract

We have recently developed a generic atomic model which describes the epitaxial growth of semiconductor nanostructures on graphene that is applicable to all conventional semiconductor materials [1, 2], as shown in Fig. 1. The model was first verified by cross-sectional transmission electron microscopy studies of GaAs nanowires that grow epitaxially and dislocation-free on graphene, in spite of a lattice mismatch of 6.3 % [1]. Recently we have also shown the vertical growth of dislocation-free GaN nanowires on graphene mediated by nanometer-sized AlGaN nucleation islands [3]. The epitaxial growth of semiconductor nanostructures 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.

For deep ultraviolet AlGaN based LEDs in huge need for various disinfection and sterilization purposes, the concept offers a real advantage over present thin film based technology. Such thin film UV LEDs are today very expensive and inefficient due to the lack of a good transparent electrode (ITO is absorbing in deep UV), the high dislocation density in the active thin film layers, low light extraction efficiency, and the use of very expensive semiconductor substrates (e.g. AlN). The spin-off company CrayoNano are now developing LEDs based on the selective-area growth of AlGaN nanostructures on mask-patterned graphene, which potentially can overcome all these problems, as will be further discussed in my talk.

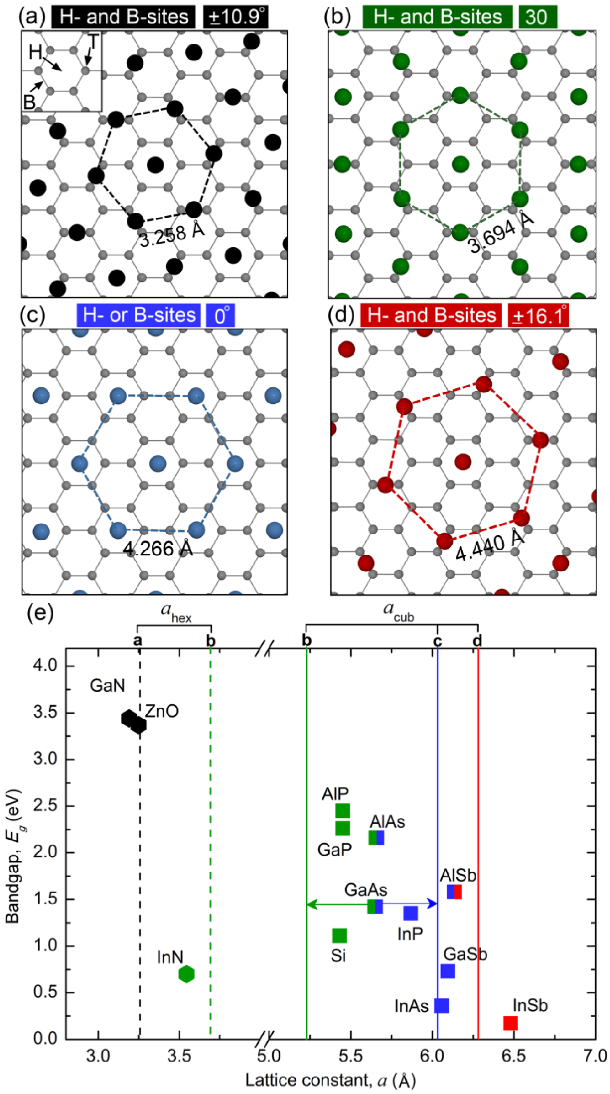

Fig. 1. (a-d) Relative orientation and arrangement when semiconductor atoms are adsorbed on H- and/or B-sites. (e) Generic model describing the semiconductor bandgaps vs. lattice constants together with lattice constants for the lattice-matched atom arrangements on graphene [1].

References

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2. A.M. Munshi and H. Weman, Phys. Status Solidi RRL **7**, 713 (2013).
3. M. Heilmann et al., Nano Letters **16**, 3524 (2016).