Modeling InAs/GaSb Type-II Superlattices for Mid-Wavelength Infrared Photodetectors with the nextnano++ Software

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Type-II superlattices (T2SLs) are characterized by: i) flexible tunability of the energy band gap by adjusting thicknesses of consisted layers without changing their content, ii) carrier separation suppressing nonradiative Auge recombination, and iii) high effective masses reducing band-to-band tunnelling current [1]. In contrast to type-I superlattices where effective mass approximation often is applied, modeling T2SL may cause additional difficulties originating in strong hybridization of S and P orbitals. Such conditions occur when T2SLs consist of thick layers resulting in small energy gap or even energies of some electron states lower than energy of first hole state, within the picture of effective mass approximation. As both electrons and holes are described in such cases by mutually overlapping wavefunctions, additional interaction is inevitable and hybridization effects must be considered. Eight-band k·p model can be applied for this purpose [2].

In this poster, I present a simple analysis of InAs/GaSb T2SL using the nextnano++ software [3-5]. The InAs/GaSb T2SLs are examples of promising heterostructures with potential to outperform currently state-of-the-art mercury cadmium telluride in applications for mid-wavelength infrared photodetectors [1]. I show how to effectively design these super lattices and how to obtain information about electronic band structures, relevant optical transitions, wavefunction envelopes, and hybridization effects. Presented approach can be easily applied and followed for basic analysis of any superlattices, that might come very helpful for groups focusing on optical spectroscopy or growth of numbers of such structures.

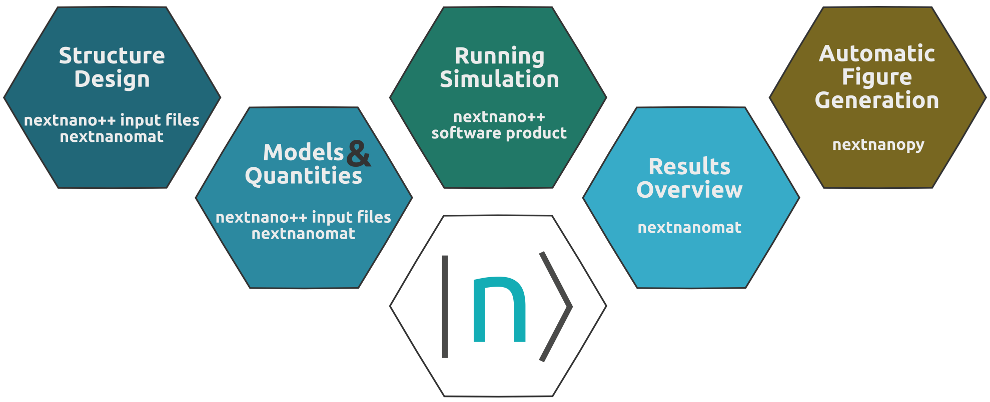

Figure 1: Basic design and analysis process of T2SL with the nextnano++ software

[1] D. O. Alshahrani, M. Kesaria, E. A. Anyebe, V. Srivastava and D. L. Huffaker, *Adv. Photonics Res.* **3**, 2100094 (2022).

[2] C. H. Grein, P. M. Young, M. E. Flatté and H. Ehrenreich, *J. Appl. Phys.* **78**, 12 (1995).

[3] A. Trellakis, T. Zibold, T. Andlauer, S. Birner, R. K. Smith, R. Morschl and P. Vogl, *J. Comput. Electron.* **5**, 285-289 (2006).

[4] https://www.nextnano.com

[5] https://github.com/nextnanopy