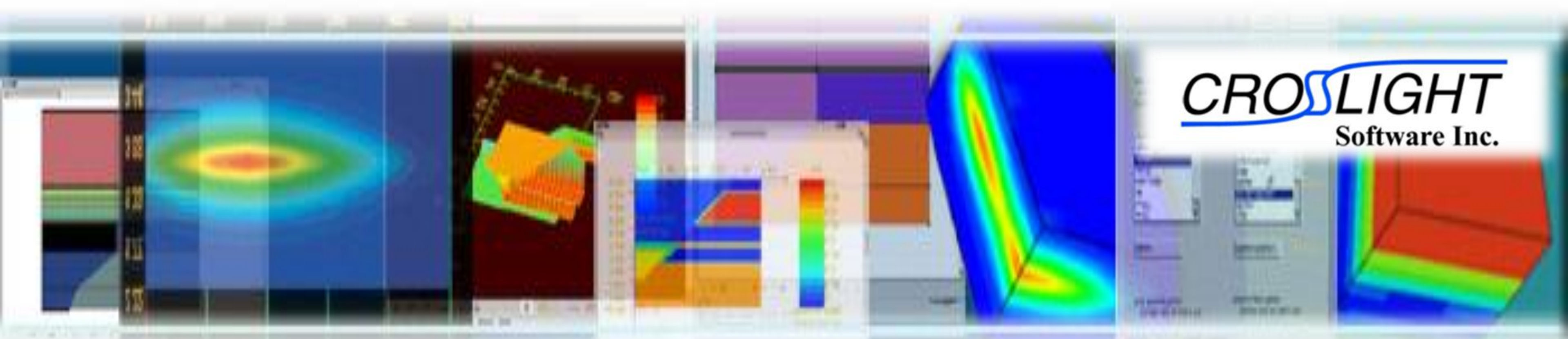


Lighting up the Semiconductor World…

3D Simulation of Nanowire / Nanotube Light Emitting Diode

Physical models

- Self-consistent calculation combining quantum mechanical solution with drift-diffusion simulation.

- Polarization charges may be used for polar or semi-polar interfaces.

- Thermal model.

- Very mature GaN-based material data base incorporating latest understanding of IQE droop due to EBL doping, band-offset and polarization charges.

- FDTD extraction calculation.

Numerical Approach

- Basic device structure of a cross-section constructed using the user-friendly GUI LayerBuilder.

- Cross-section converted to a 3D format compatible with the new 3D GUI SemiCrafter.

- Symmetric polygons structures are formed using the change_material operation.

- As a preliminary demo, 15K mesh points used for a single tube with single quantum well.

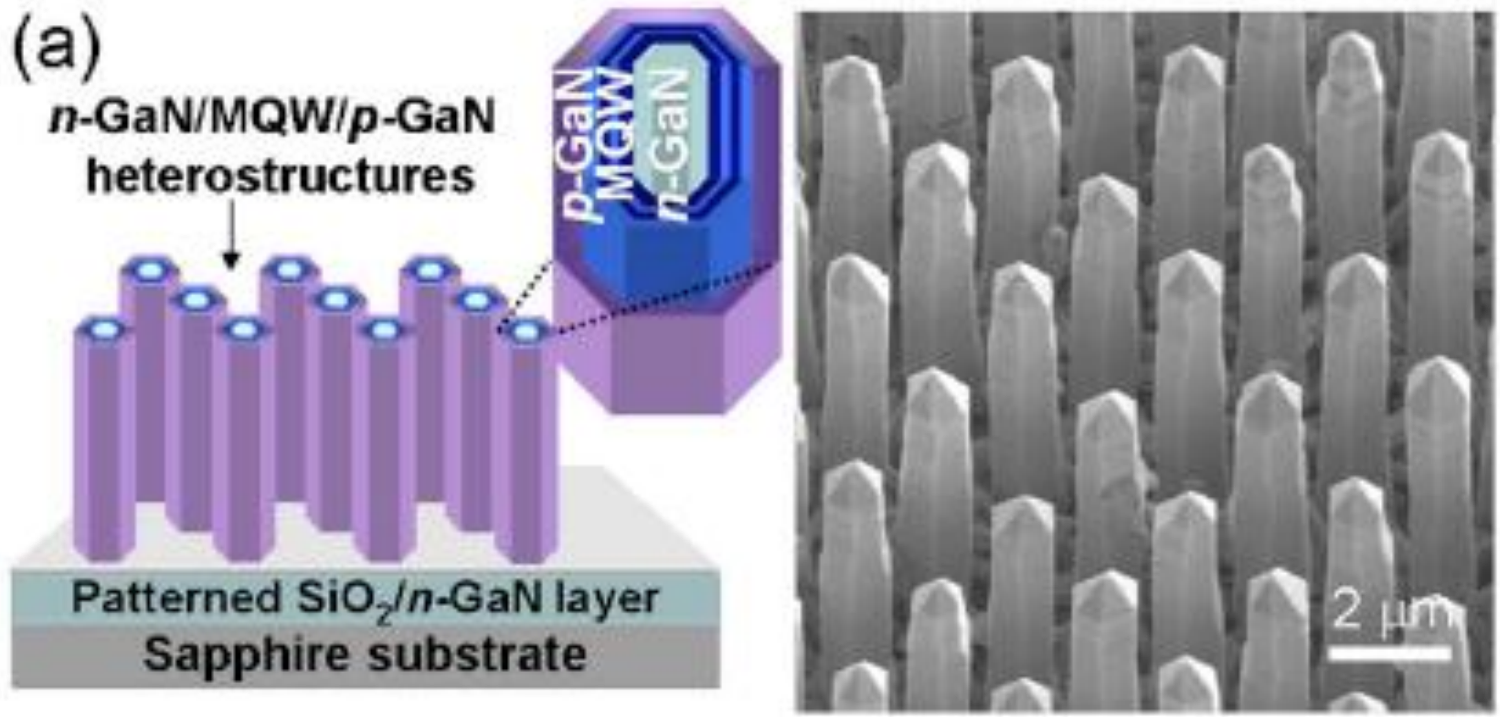
- A typical I-V scan costs about 20 minutes on an i5 laptop with Windows 7 OS.

Reference structure:

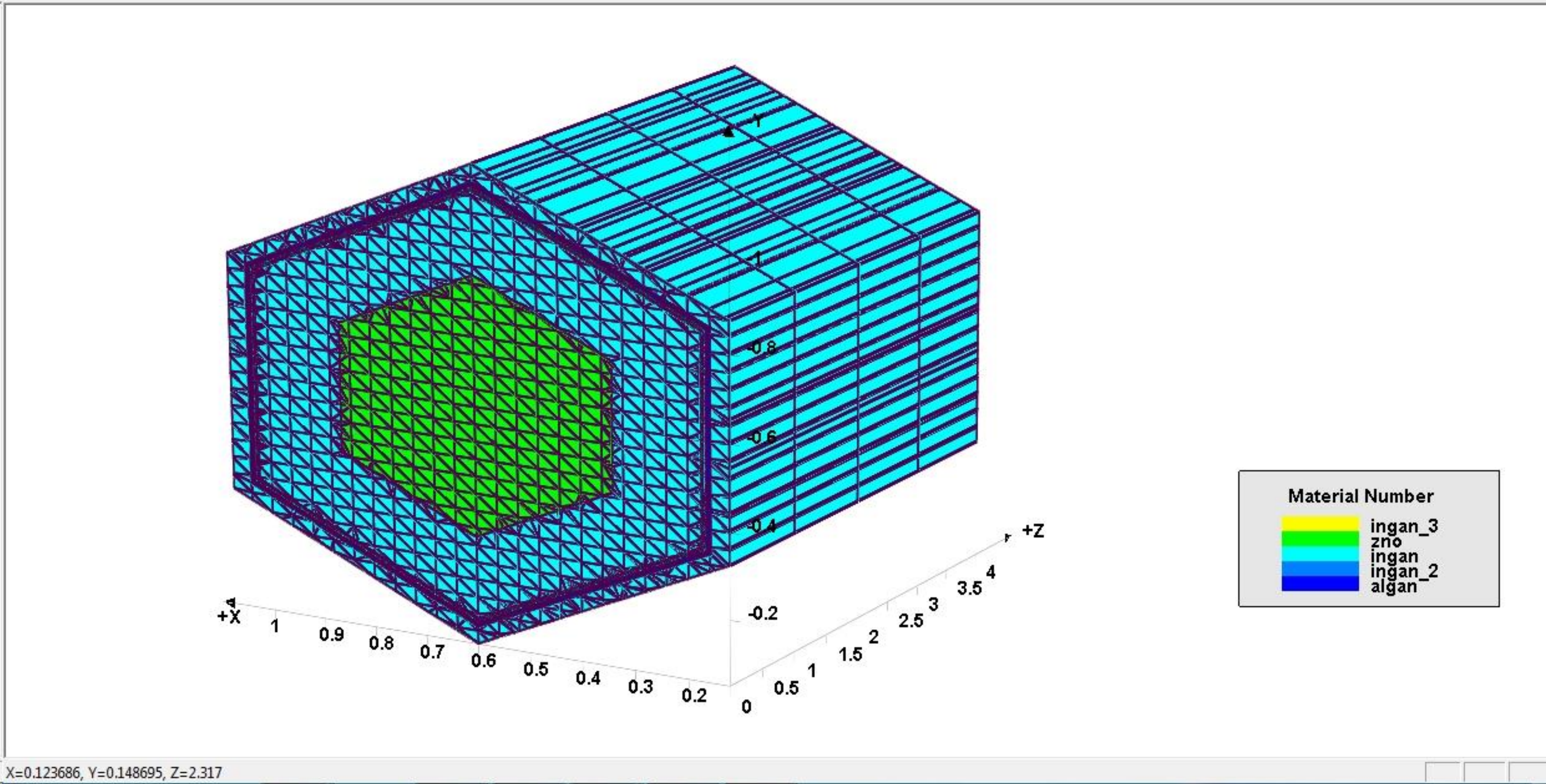
APPLIED PHYSICS LETTERS
94, 213101 2009

GaN/ In1−*xGaxN/GaN/ZnO nanoarchitecture light emitting diode microarrays*

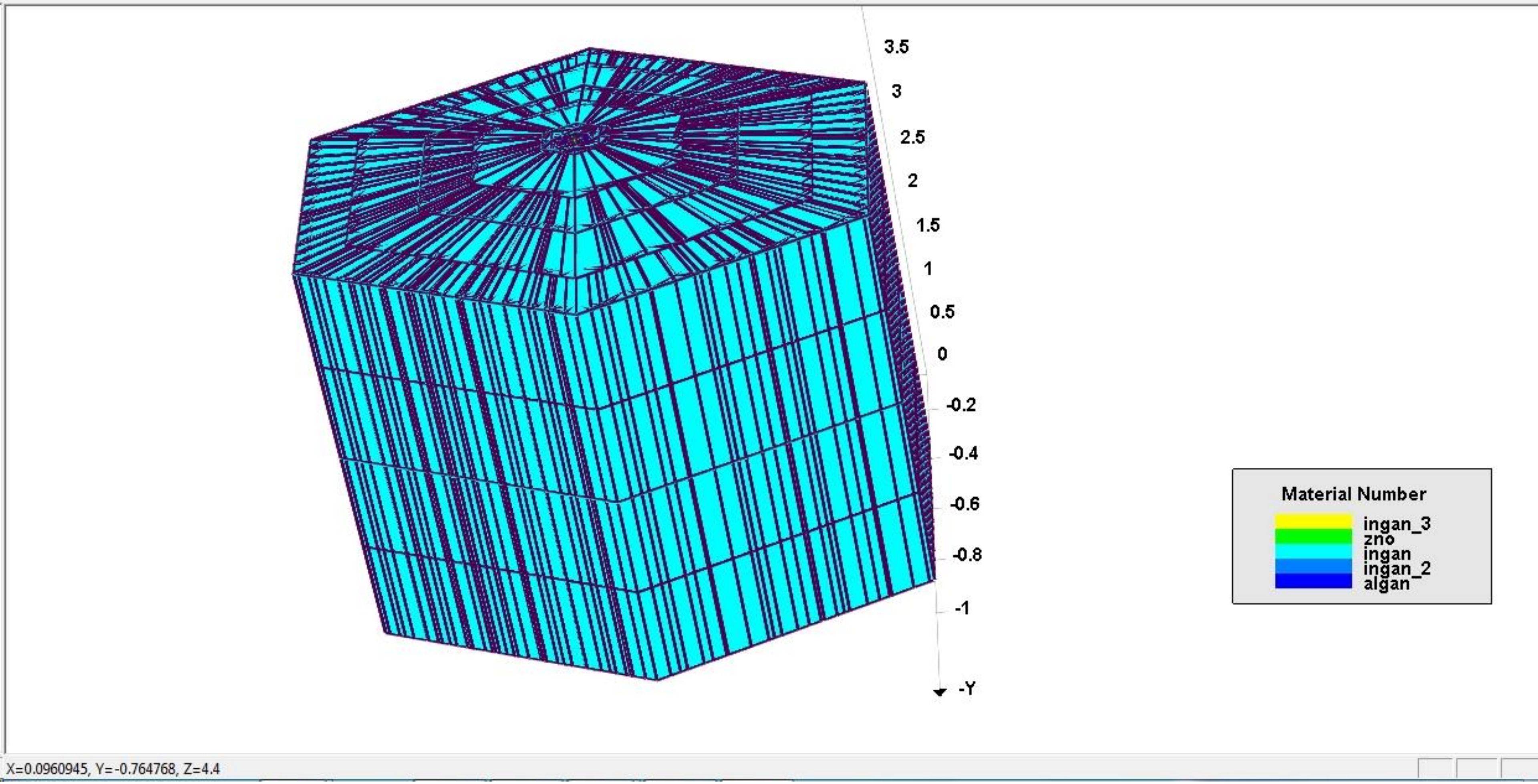
Chul-Ho Lee, Jinkyoung Yoo, Young Joon Hong, Jeonghui Cho, Yong-Jin Kim, Seong-Ran Jeon, Jong Hyeob Baek, and Gyu-Chul Yi



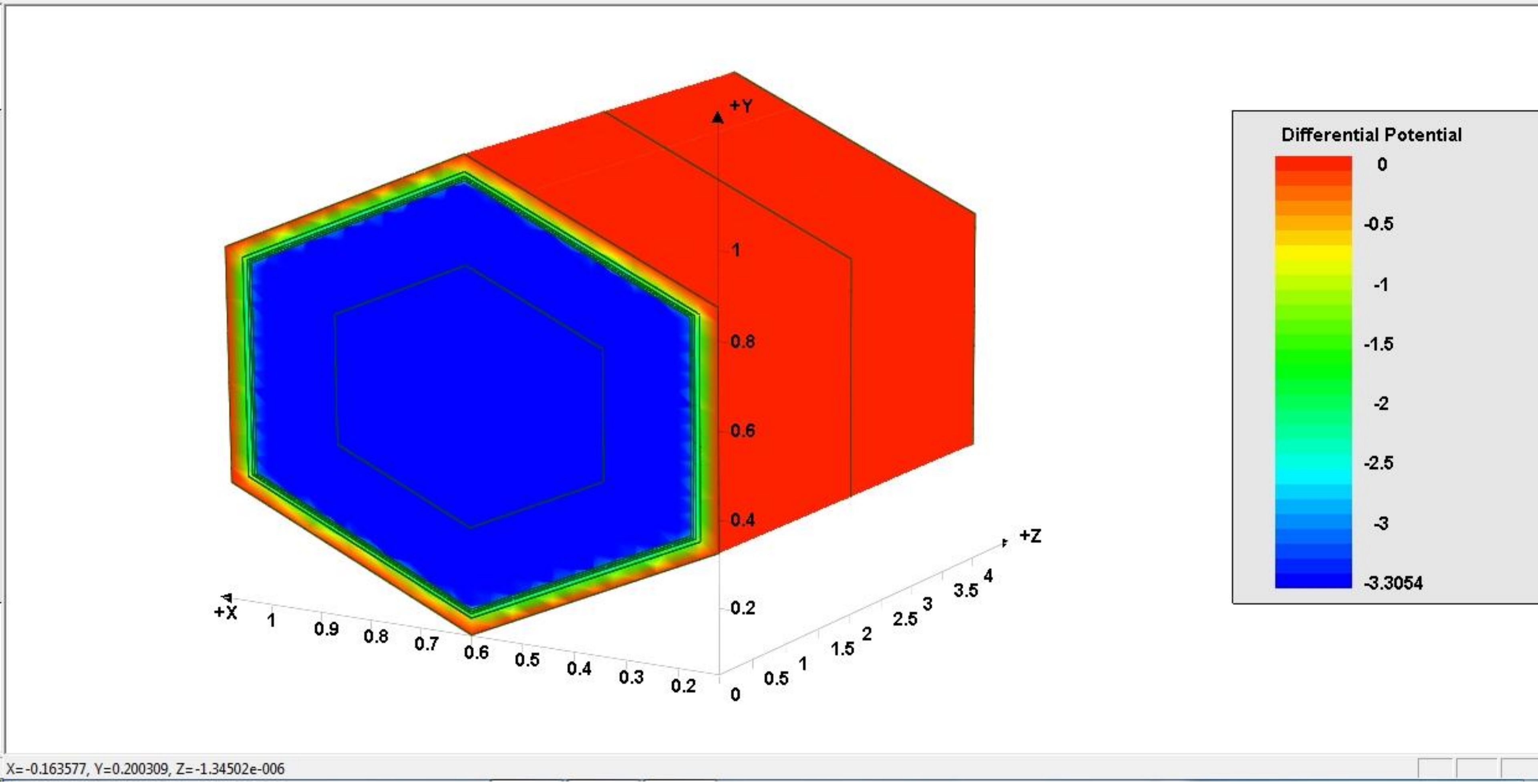
3D mesh; bottom view:



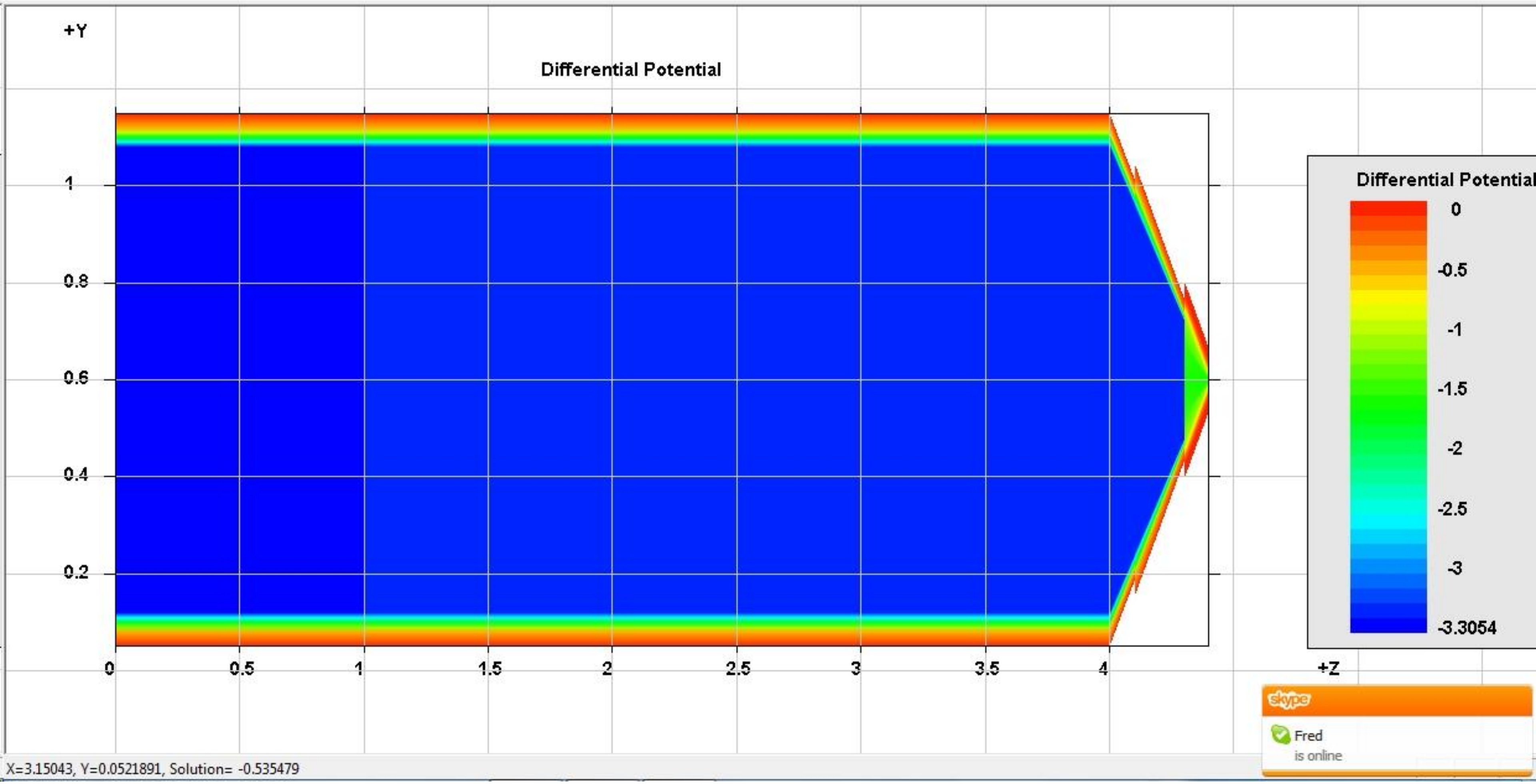
3D mesh; top view:



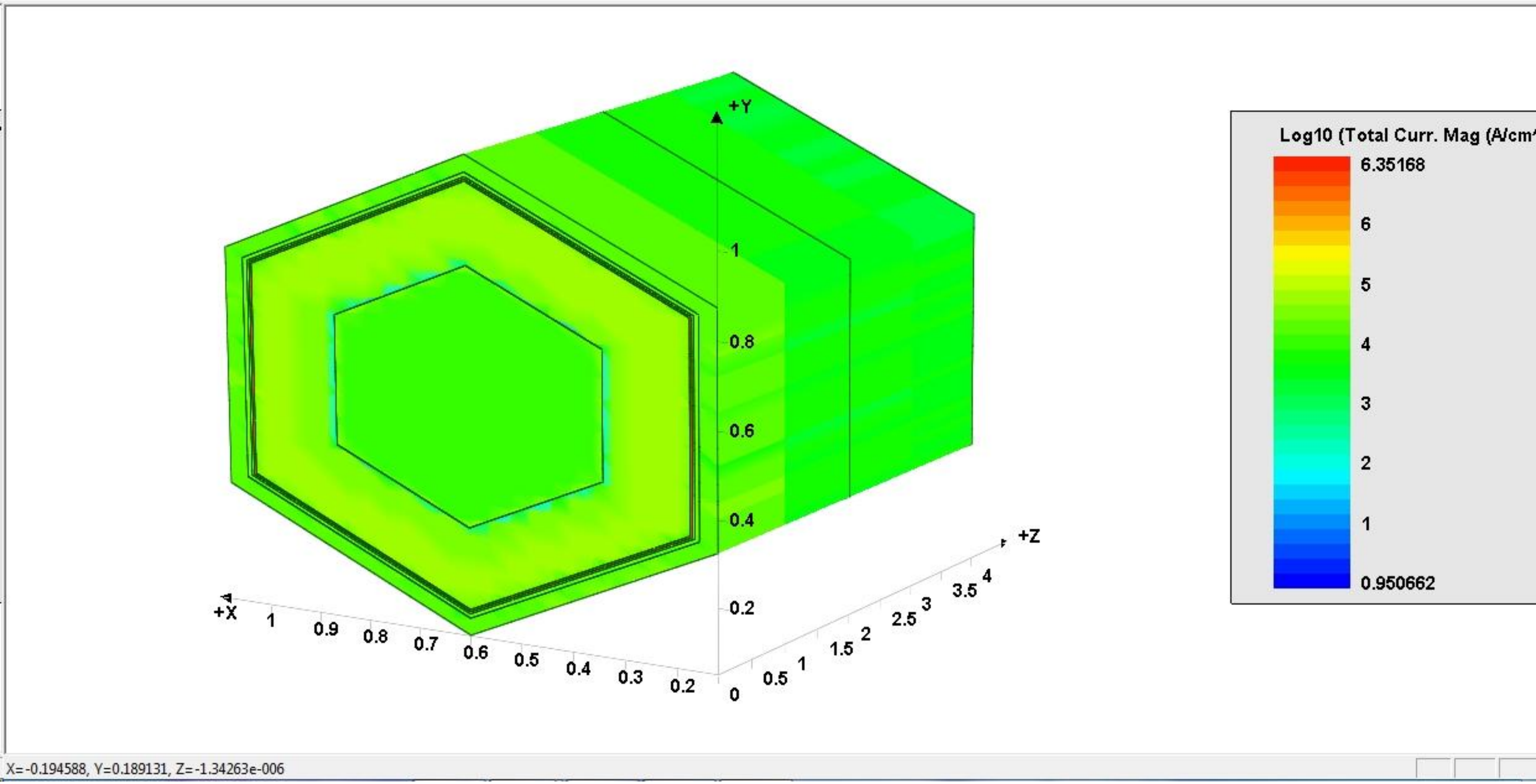
Nanowire /nanotube 3D potential distribution



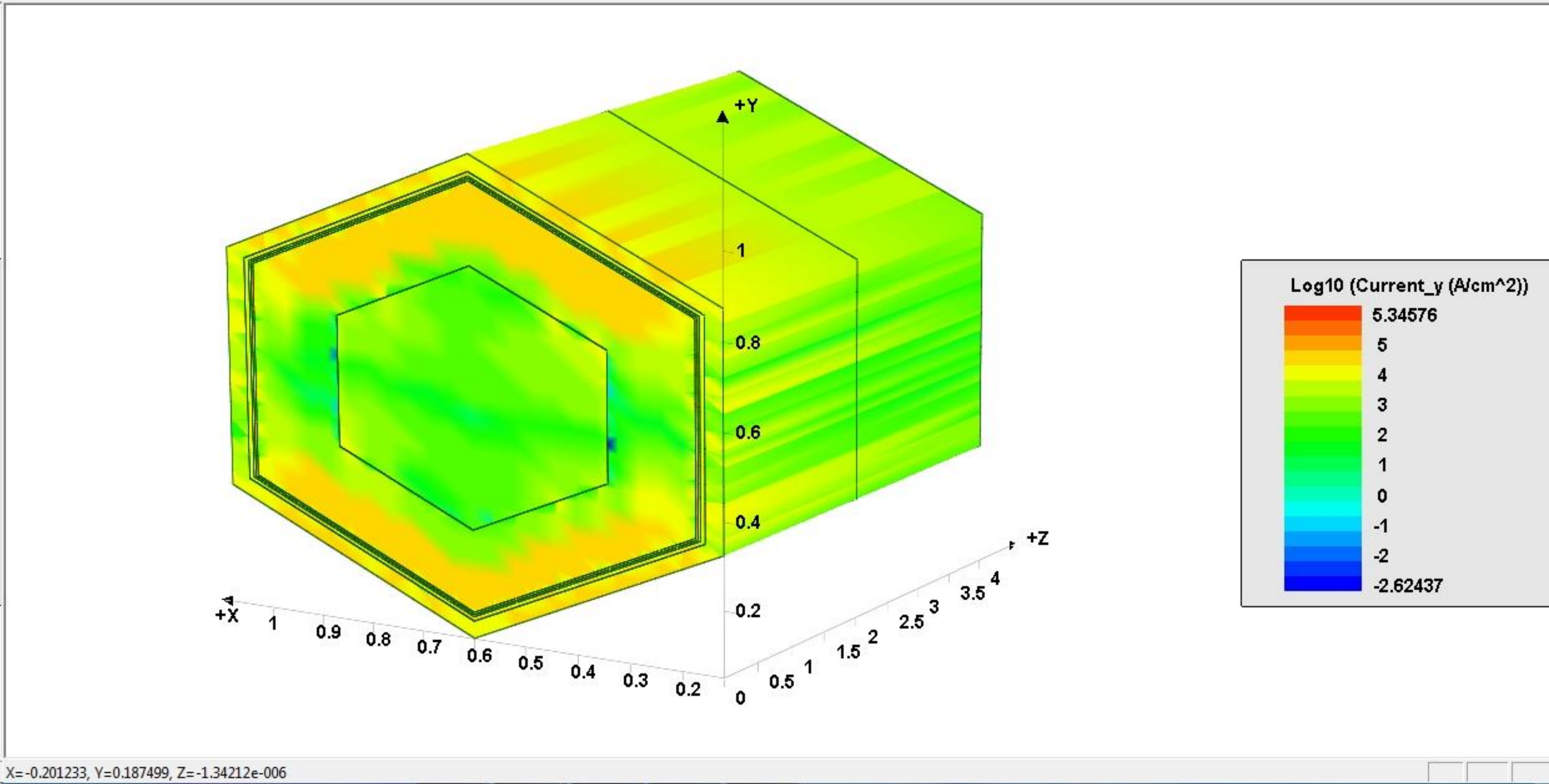
Potential distribution: y-z plane



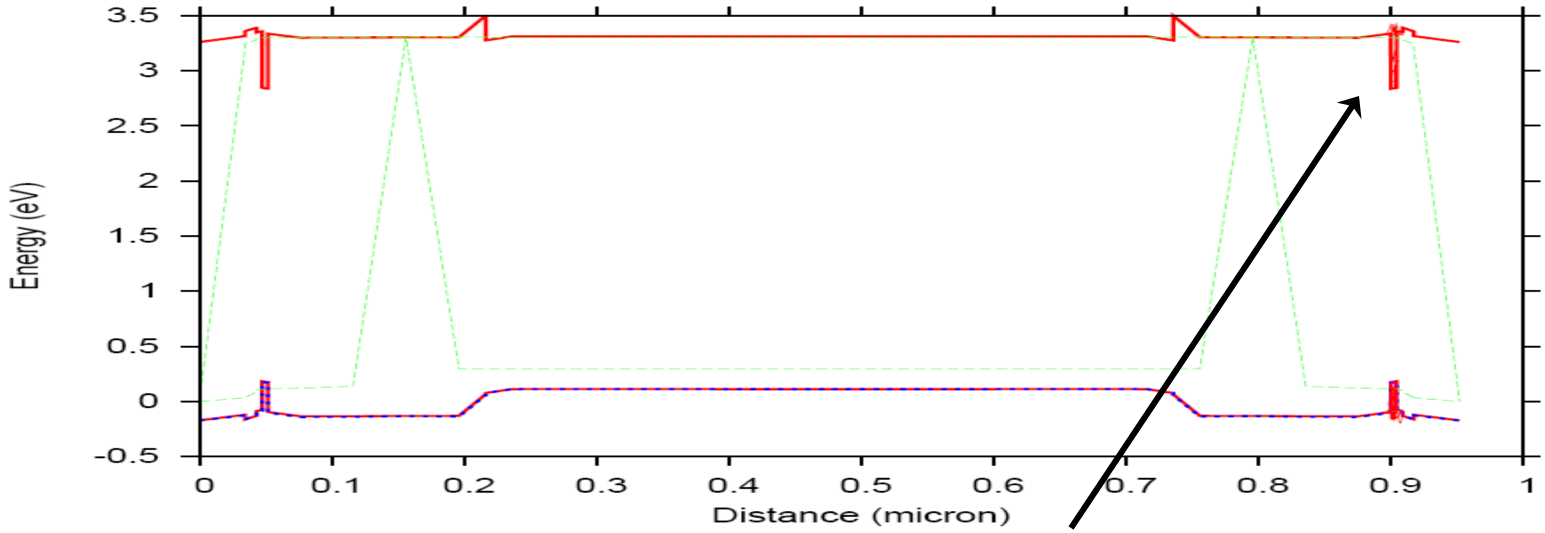
Nanowire current flow distribution



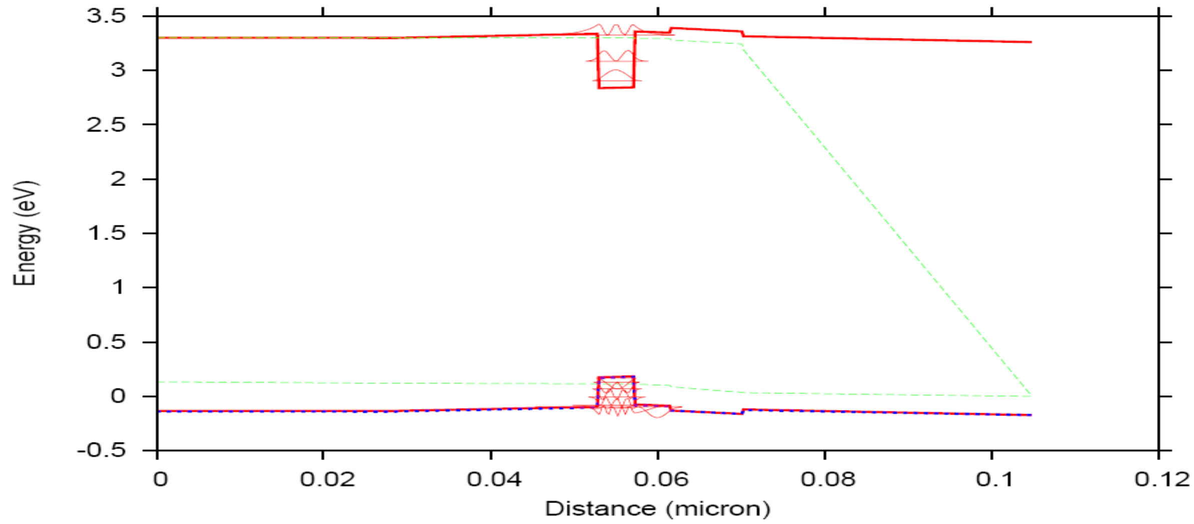
Nanotube current y-comp. distribution



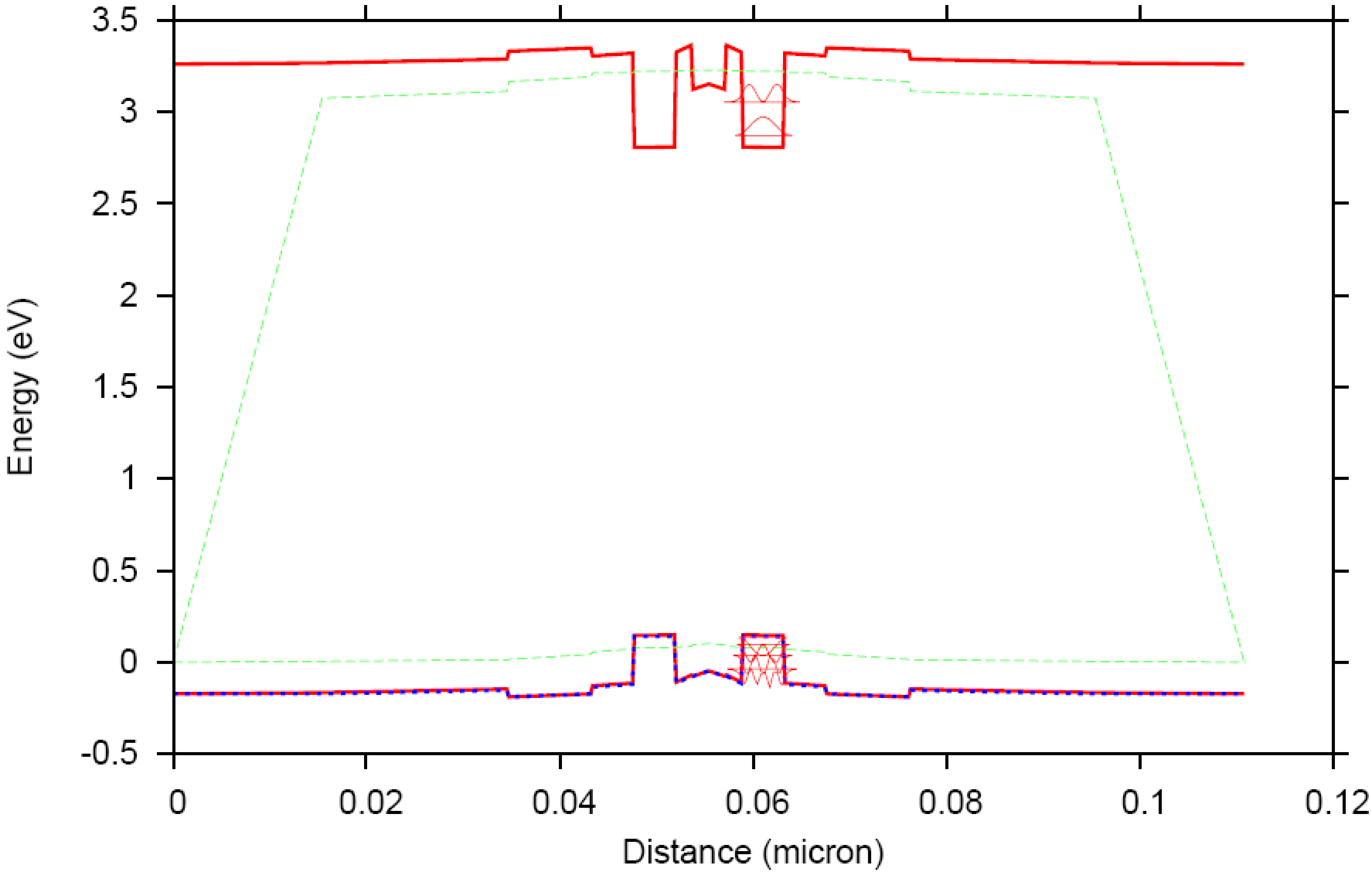
Nanotube band structure



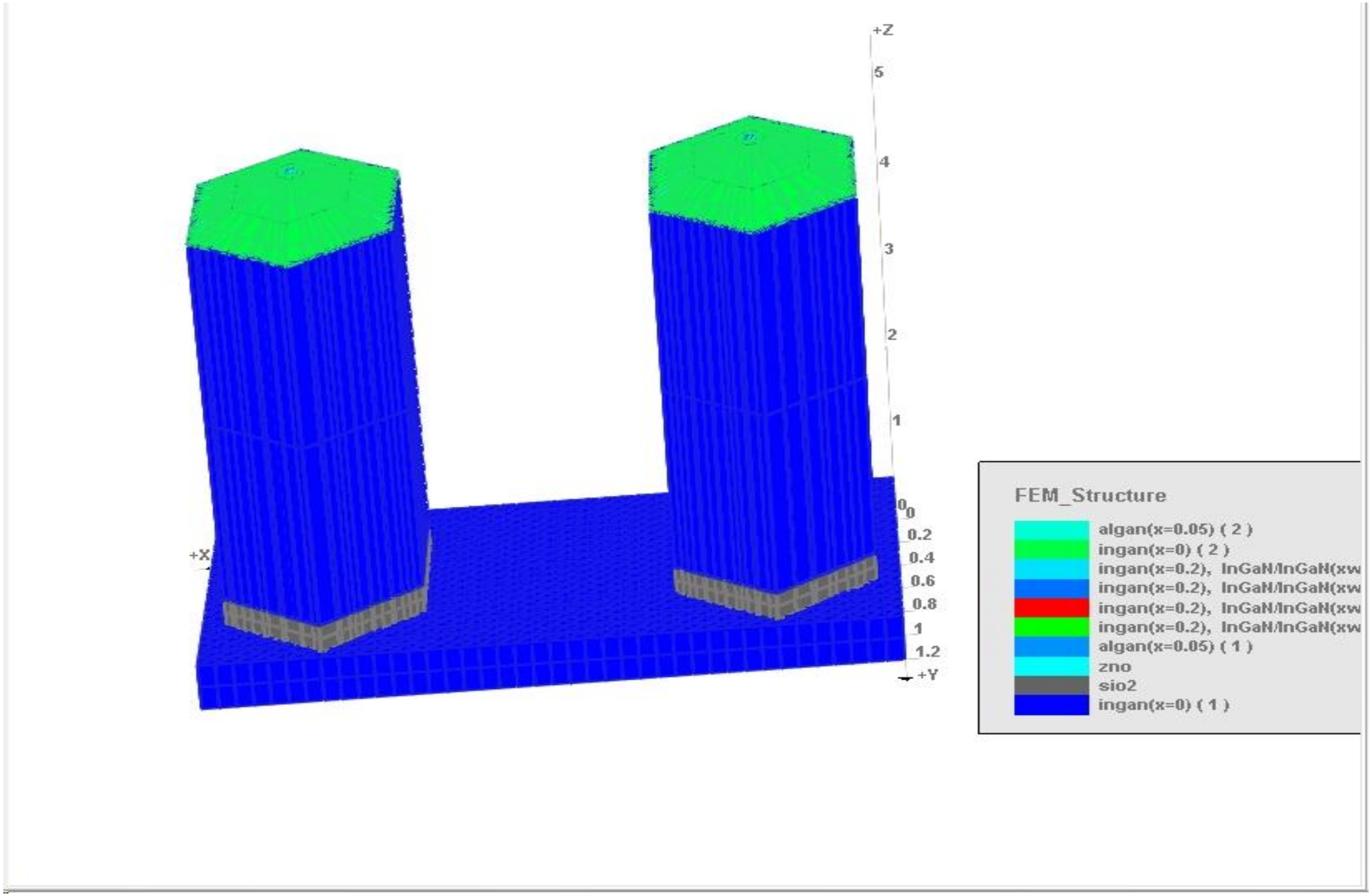
Cross-section made across the wire with single quantum well of InGaN/GaN



Nanowire band structure at the tip



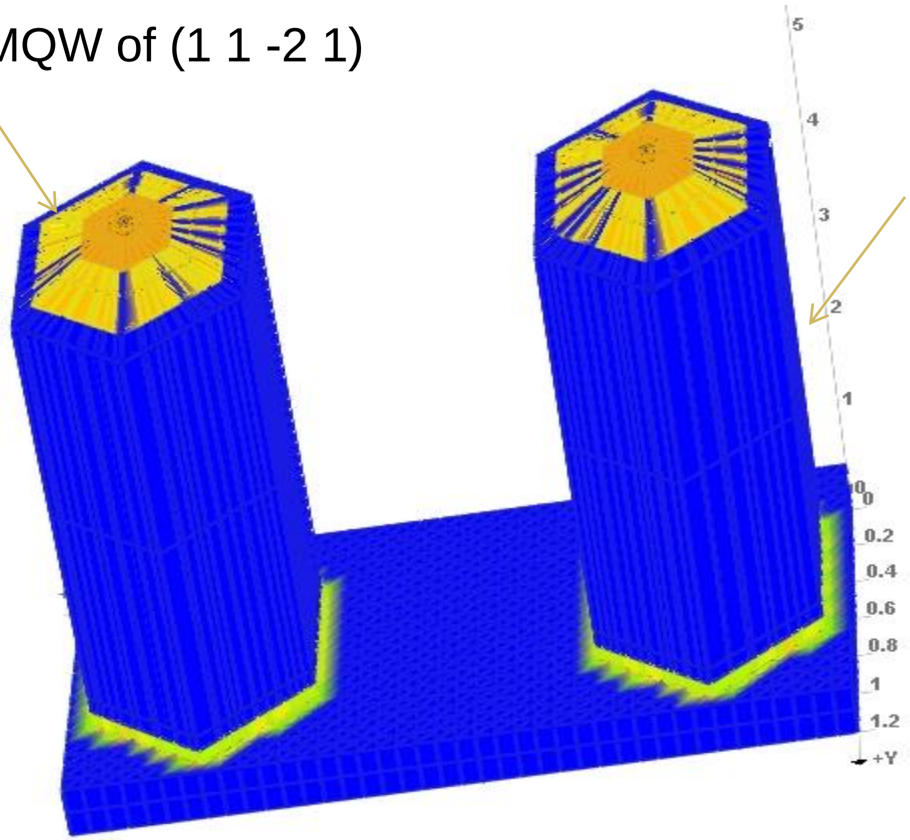
Multiple nanowires in same 3D simulation

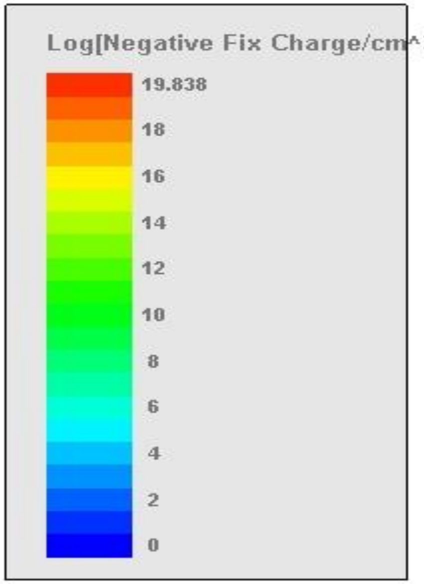


Nanotube crystal orientation models.

MQW of (1 1 -2 1)

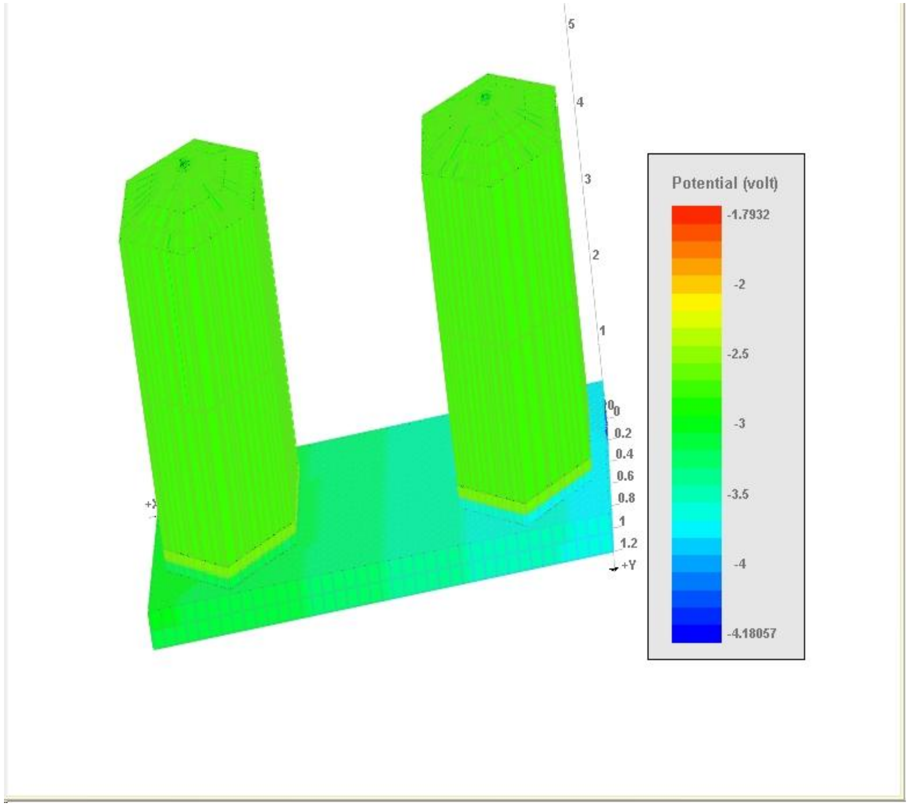
MQW of (1 0 -1 0) m-plane

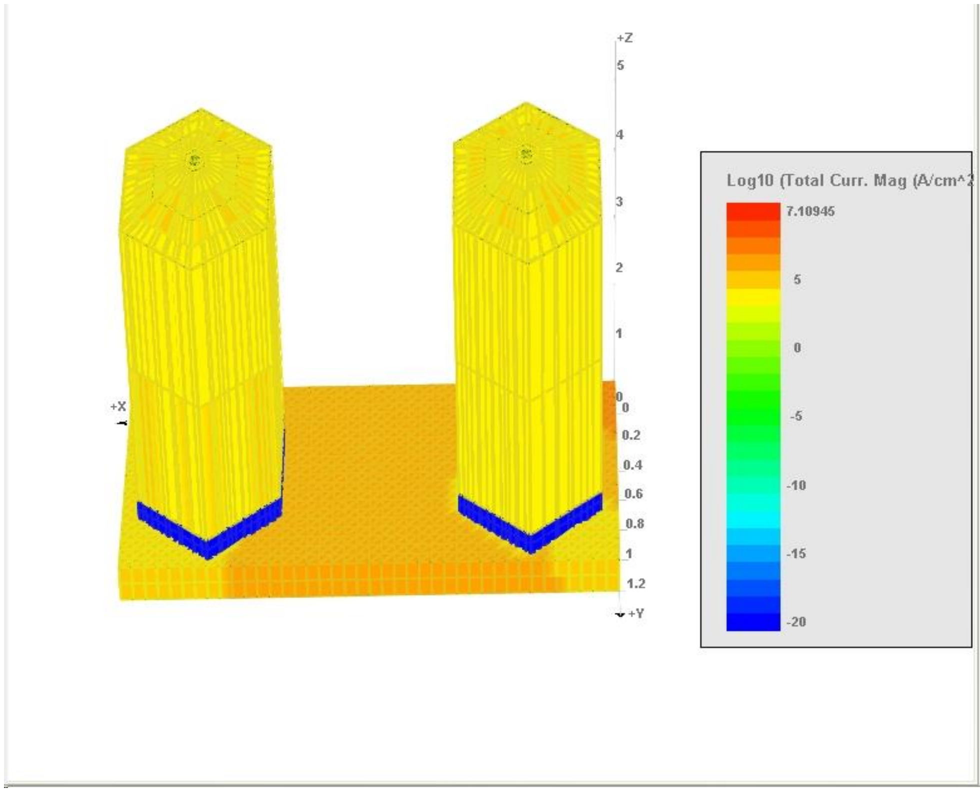




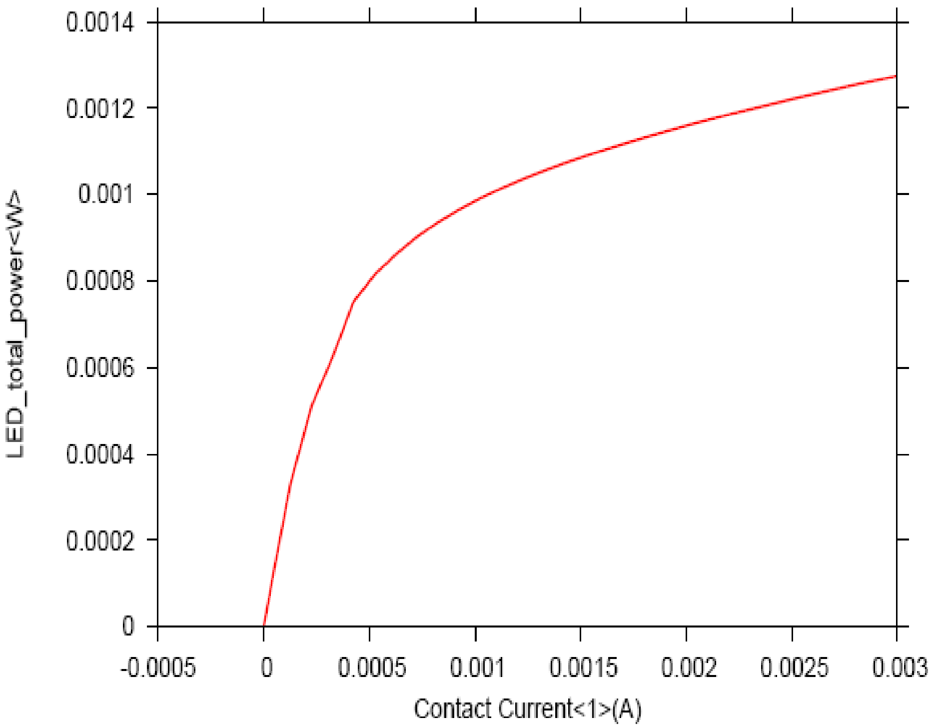
Polarization charge appears at bottom and on the tip of the nanowire

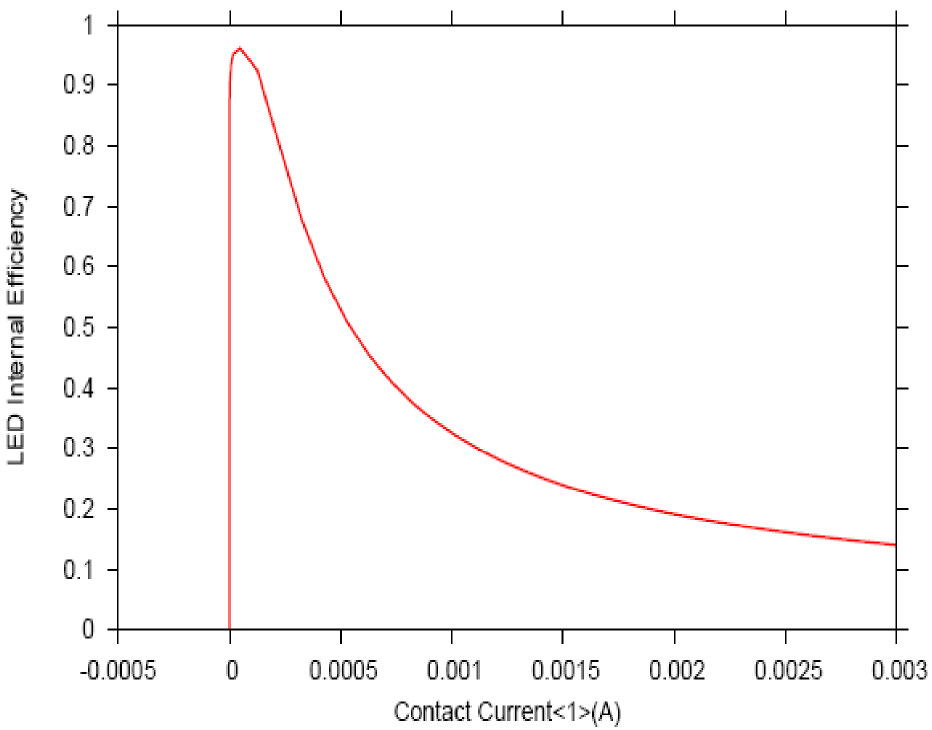
Potential and current flow



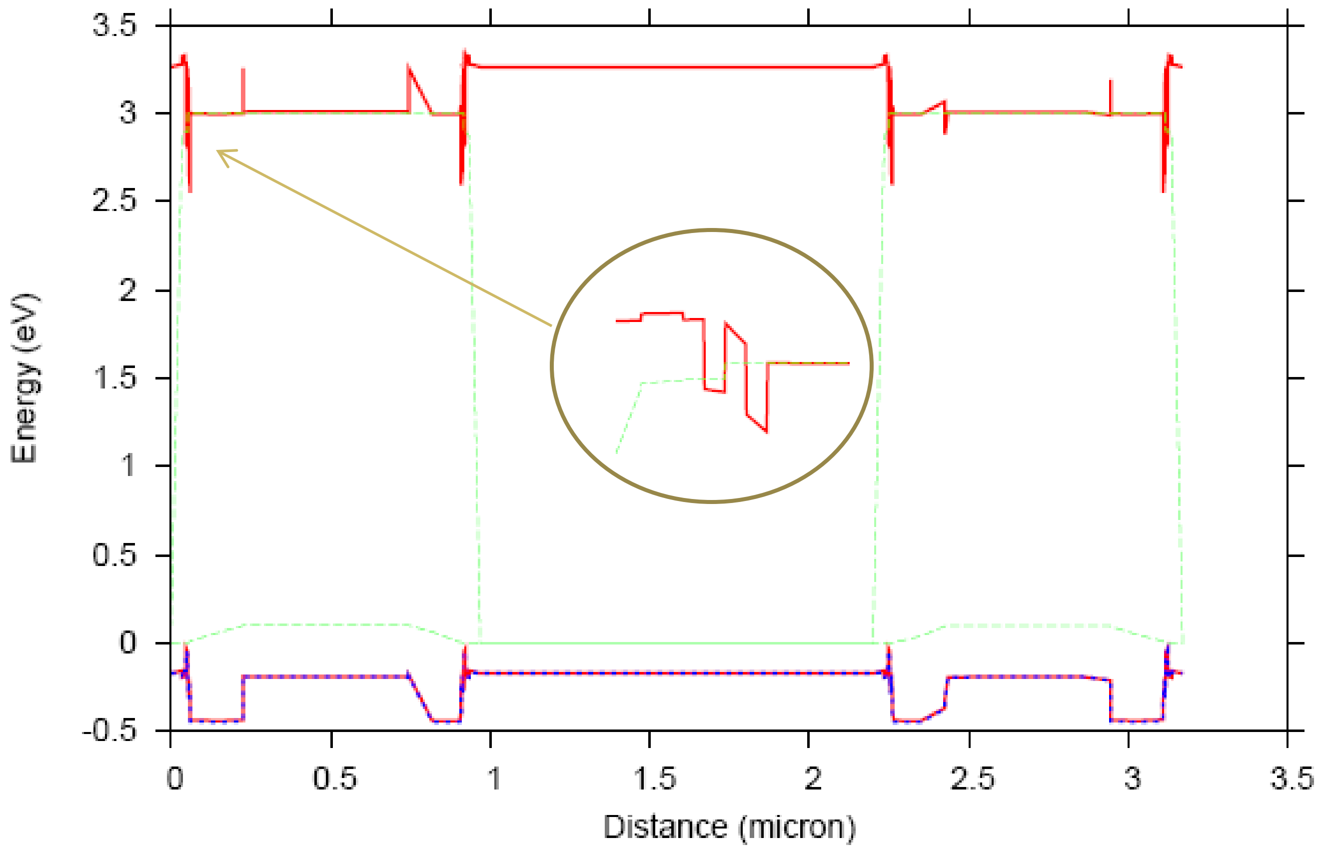


Nanowire LED power and IQE





Band diagram of MQW



Conclusions

- Efficient numerical simulation with advanced physical models established for GaN-based nanowire or nanotube LED.

- Initial simulation studies show promising results with much optimization needed ahead.

- Electron current overflow has been determined to be the main limitation in such devices.

A Glimpse

Crosslight Software

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