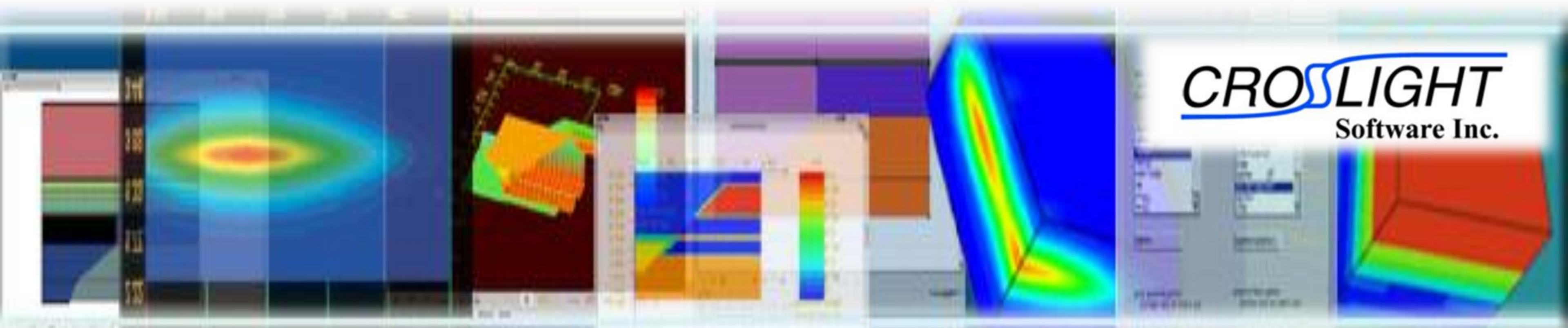


Lighting up the Semiconductor World…

Advanced physical models of

InP-based MQW Mach-Zehnder Modulators

Physical & numerical models

Crosslight Advantages

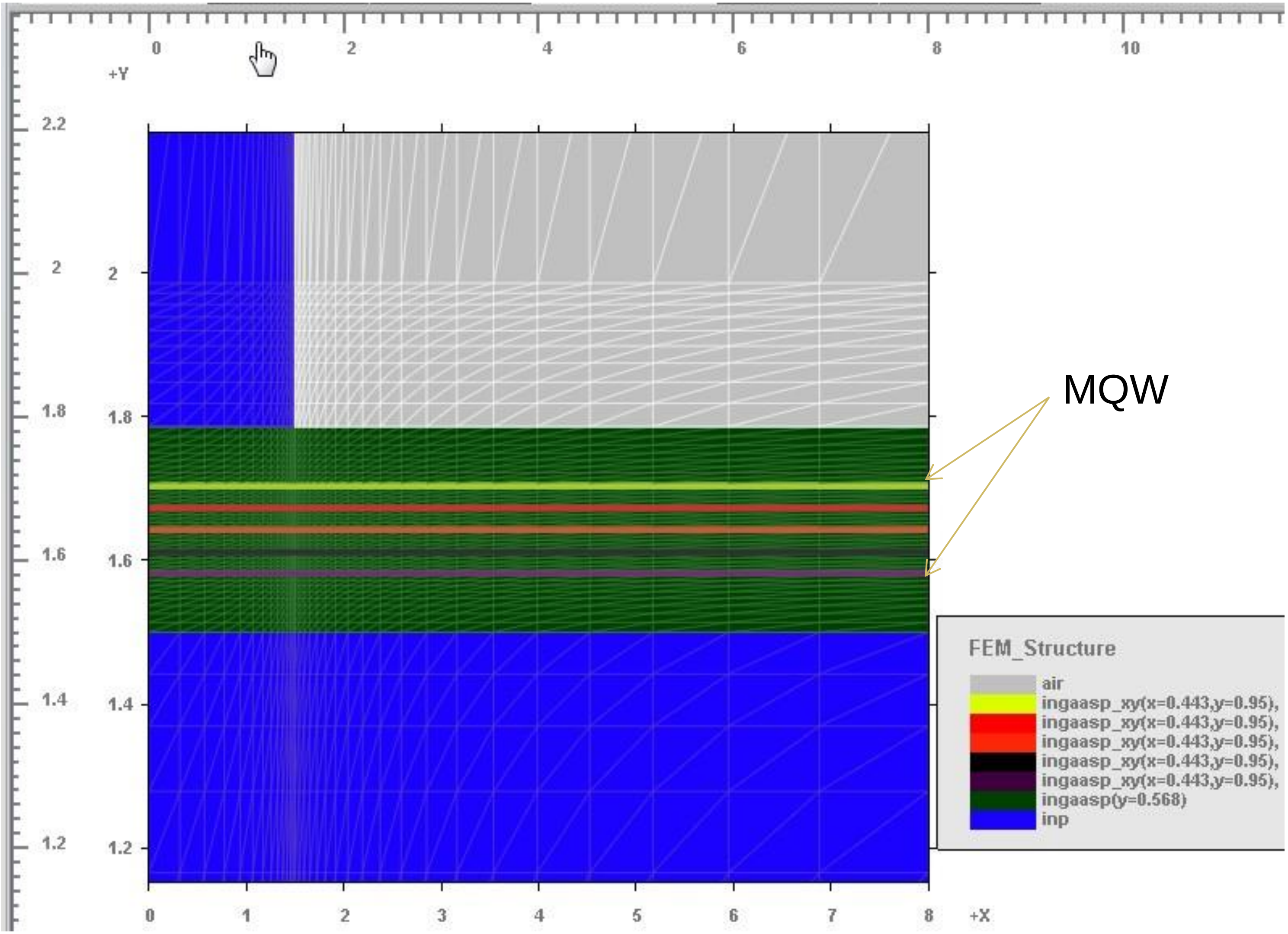
- *k.p band structure solved self-consistently for quantum confined stark effect (QCSE).*
- *Many-body optical gain/absorption method with slightly more computational cost.*
- *Field-dependent Pockels effect included.*
- *Sparse eigenmode solution coupled with the beam propagation method (BPM) offers both accuracy and efficiency in 2D/3D simulation.*
- *Modulators in other material systems (e.g. silicon) can be modeled using free-carrier absorption and index change models.*

Physical & numerical models – continued

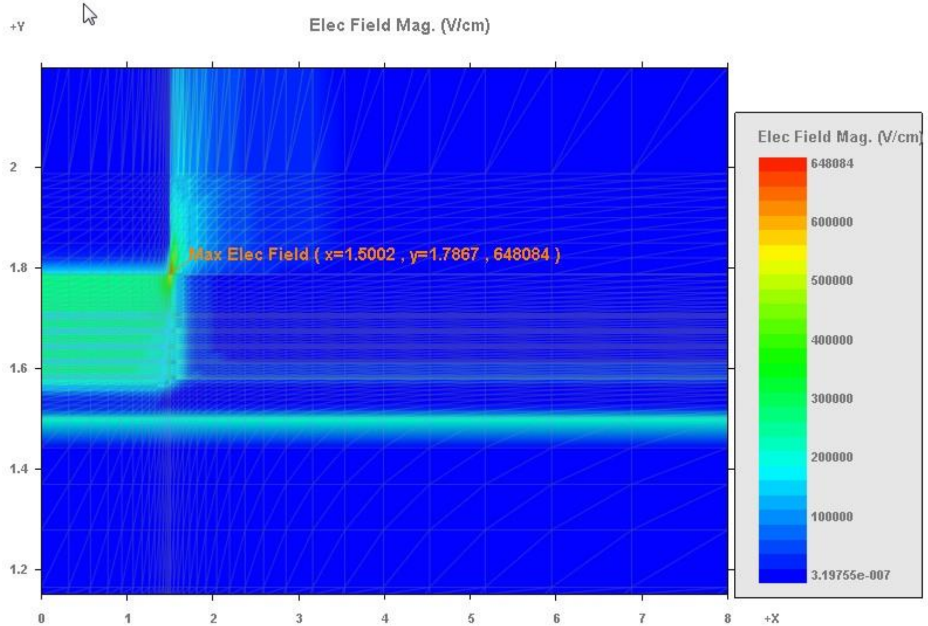
Crosslight Advantages

- *3D process simulation with CSUPREM enabling the use of GDSII layout tools and relating to realistic process details.*
- *Accurate 3D coupled electrical and optical solutions obtained with ease on laptop/desktop PC's.*
- *Full range of capabilities: a) Optical: BPM, FDTD and transfer matrix. b) Electrical: DC, AC/RF and mixed-mode simulation compatible with SPICE circuits.*

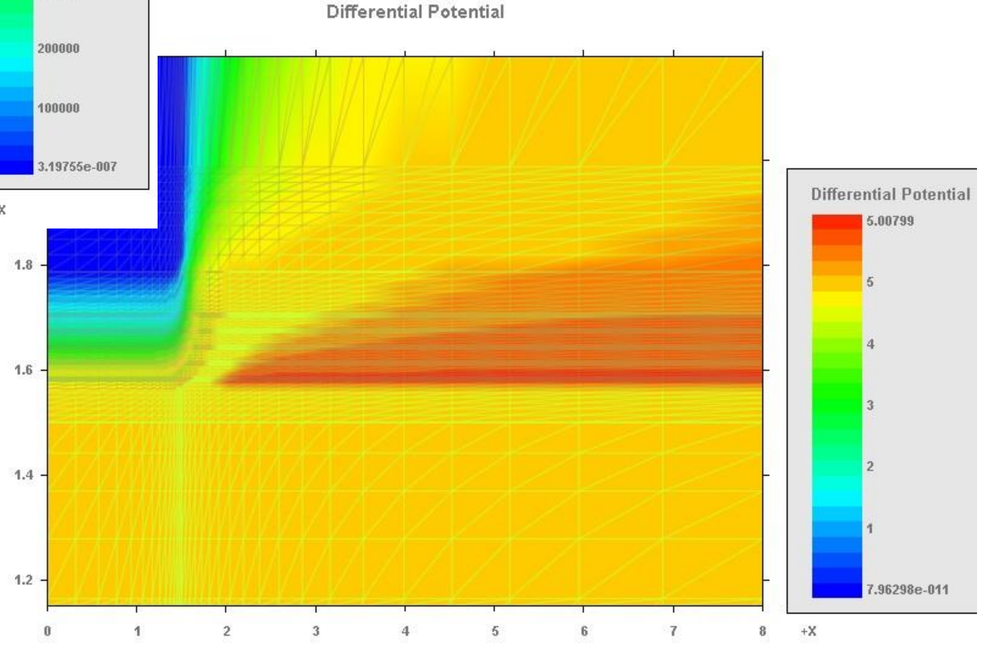
InP based MQW for 1.55 application



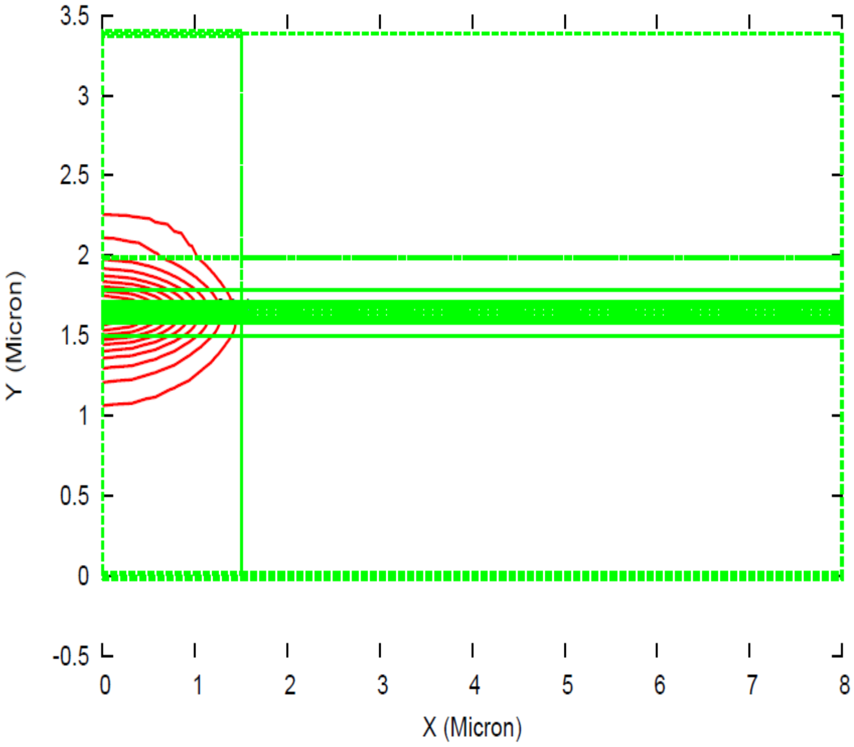
2D-differential potential & field

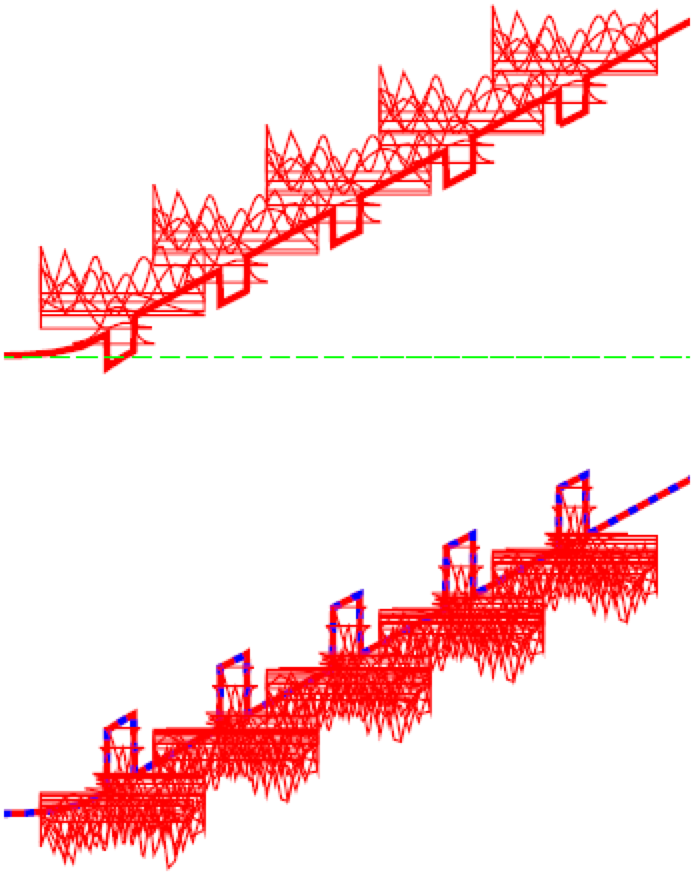


Bias=5V

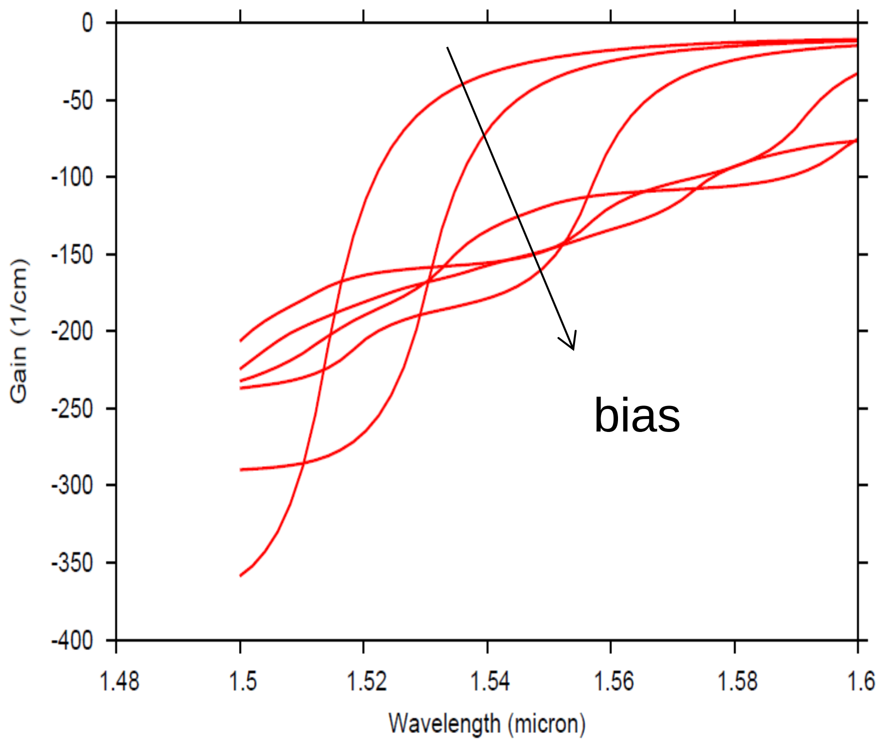


Optical mode and quantum confined states

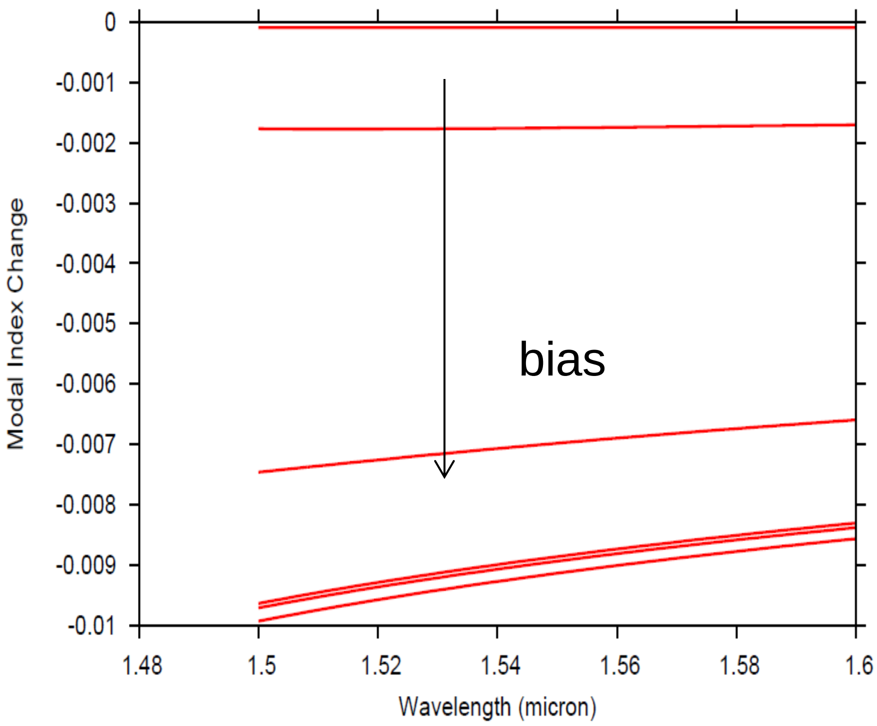




Absorption and index change from quick 2D analysis

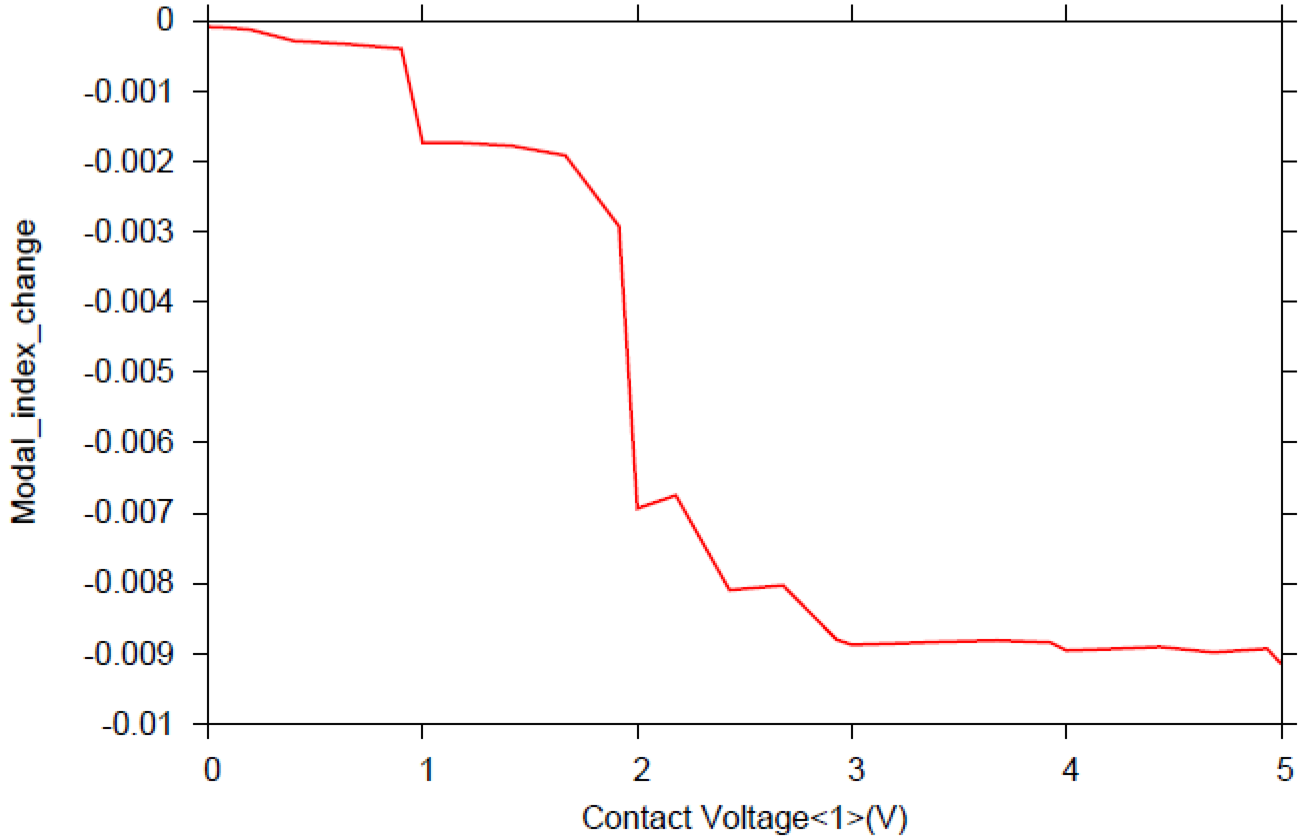


Absorption (-gain) at 0 to 6 volt biases (step=1 volt).



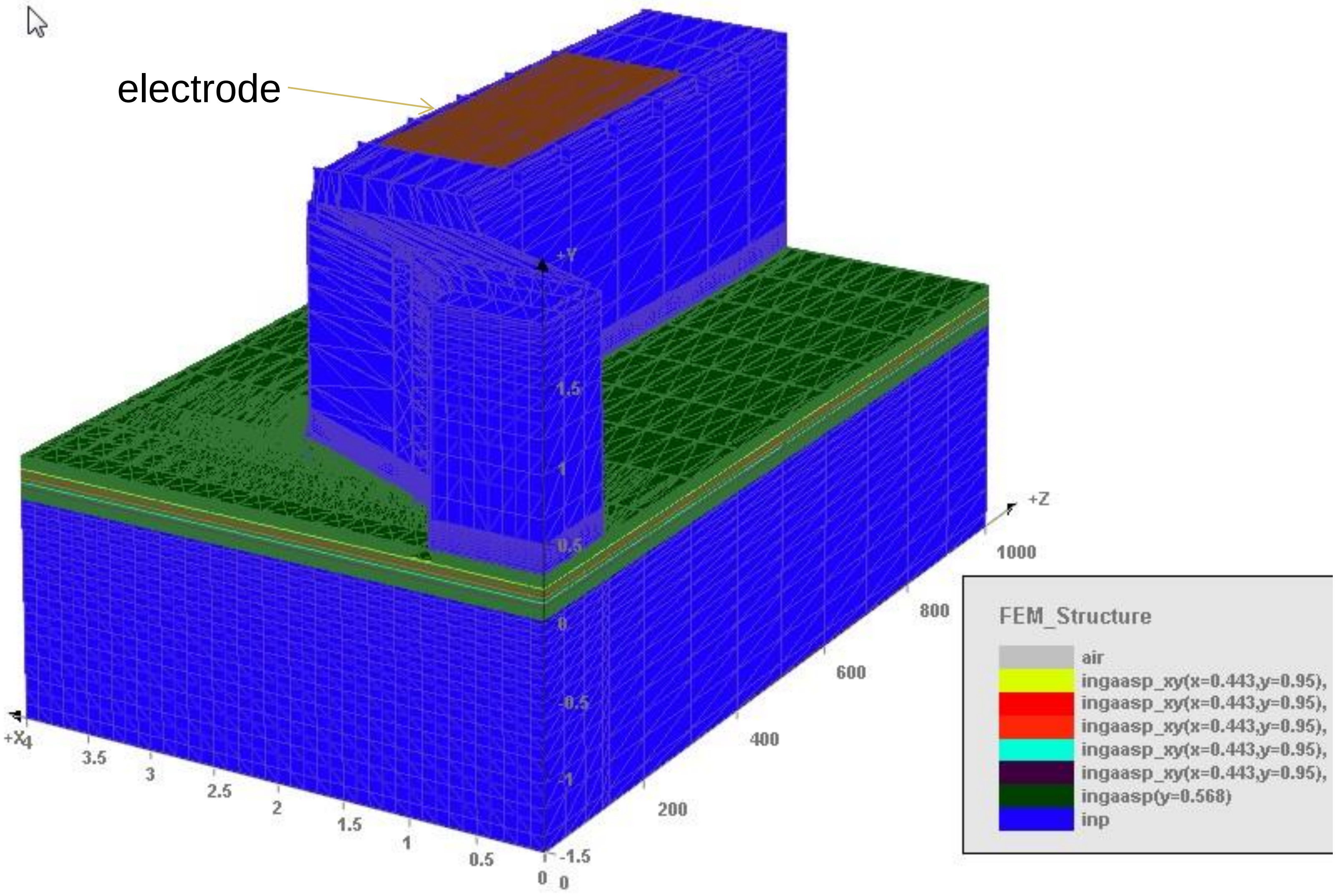
Modal index change at 0 to 6 volt biases (step=1 volt)

Key result of 2D analysis: modal index change vs. bias

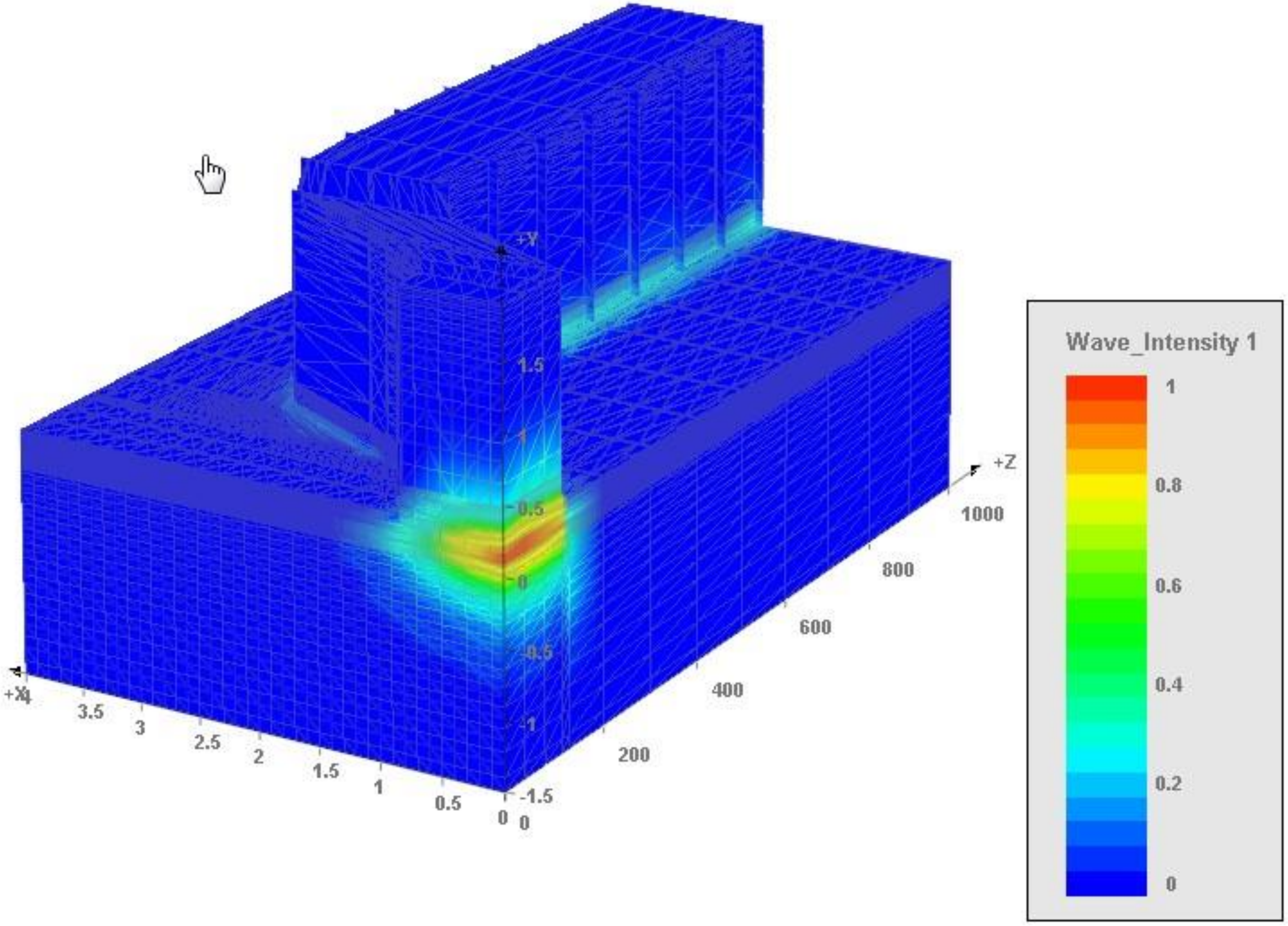


The apparent steps are due to disappearance of un-broadened confined states.

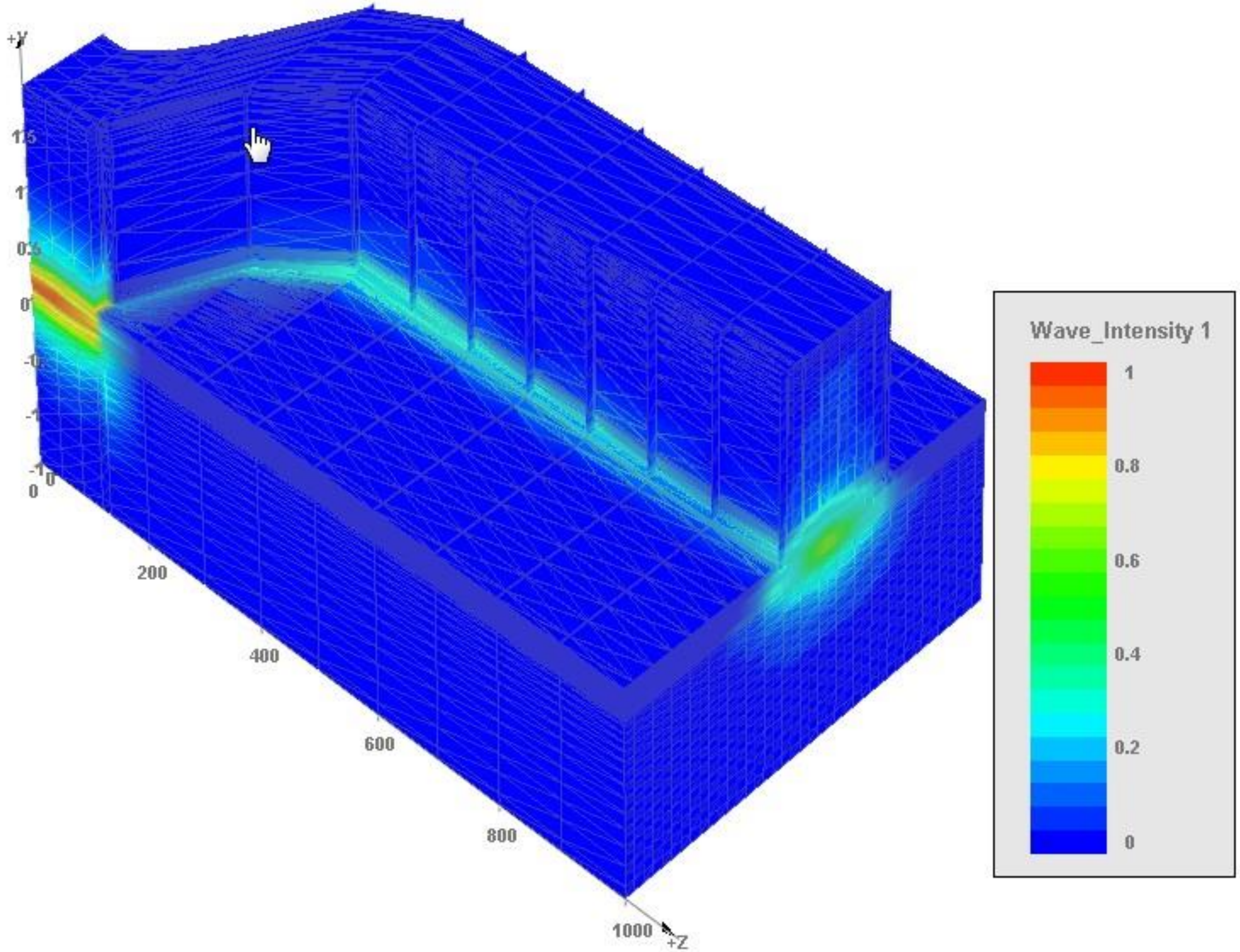
3D mesh setup by CSUPREM



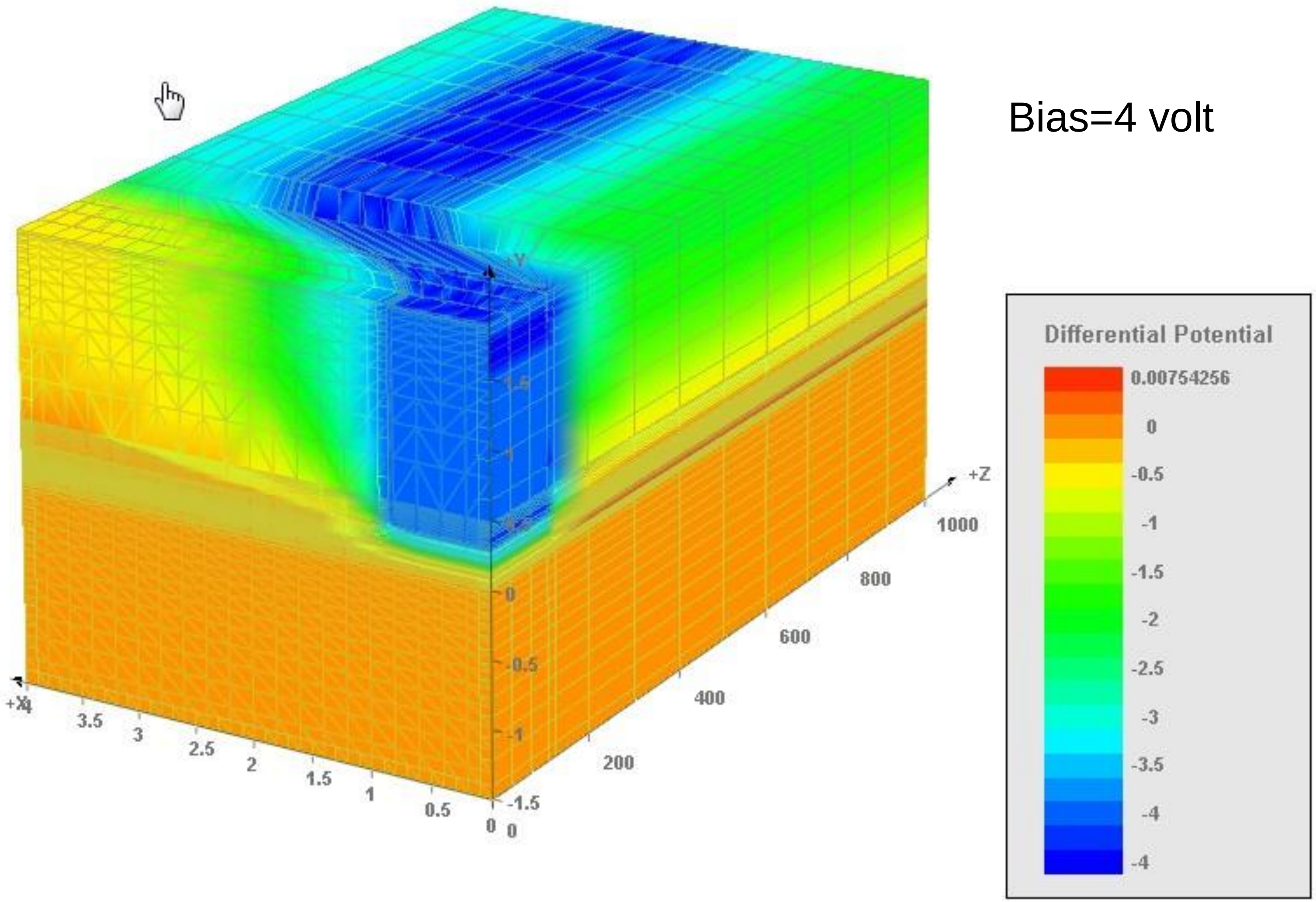
BPM wave intensity



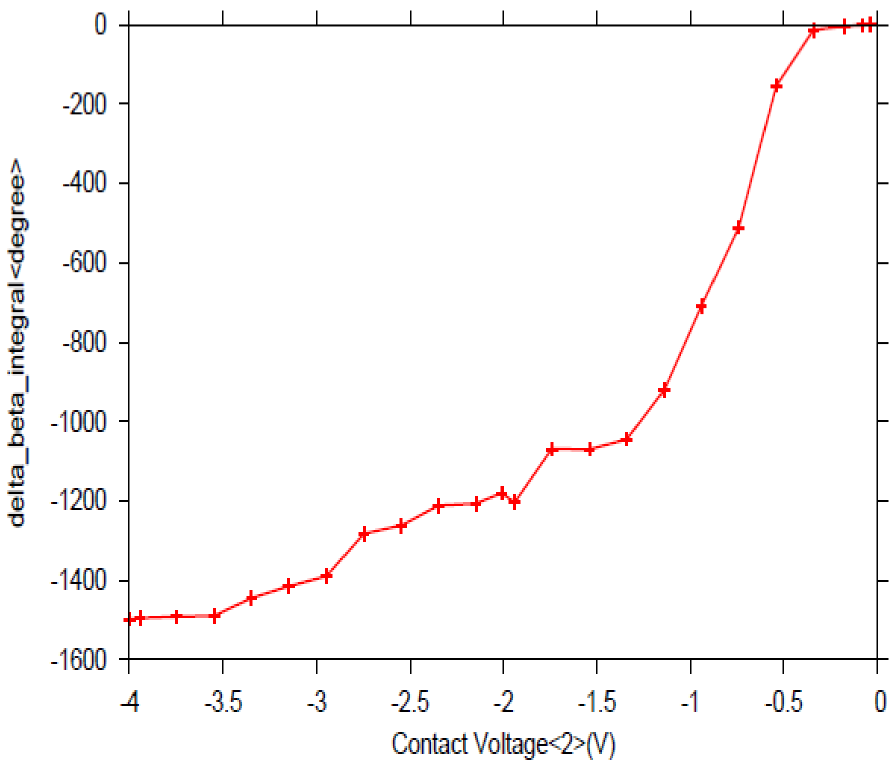
BPM wave intensity-II



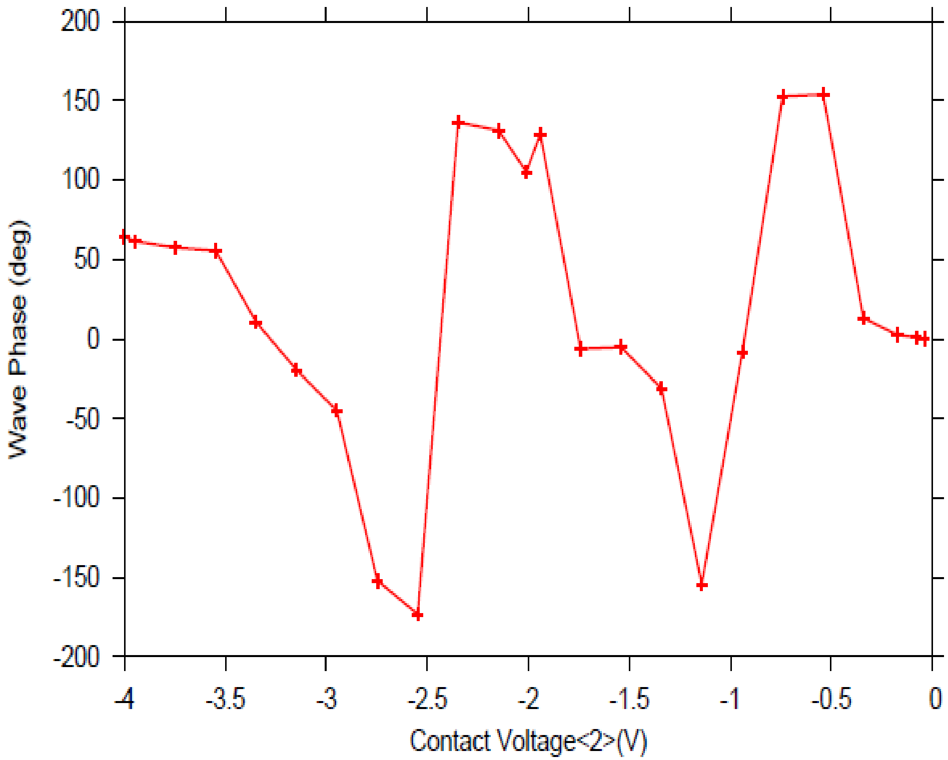
3D differential potential



Key results of 3D simulation



Index change induced propagation constant change integrated over trip path.



Wave phase at output versus bias. Results show that for InP MQW ZMZ, it may take less than a volt to achieve pi phase change.

Conclusions

- *MQW Mach-Zehnder modulator (MZM) requires models ranging from microscopic quantum well models to waveguide and system related circuit models.*

- *Crosslight offers a well integrated state-of-the-art solution for designers of MZM.*

- *Software modules: APSYS for 2D MQW analysis only, PICS3D for full self-consistent treatment in 3D.*