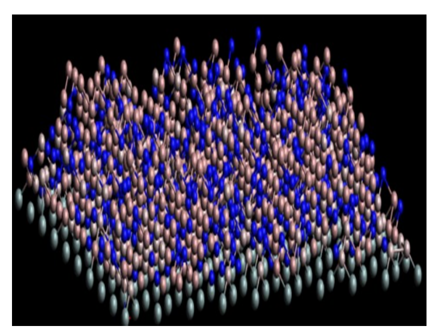
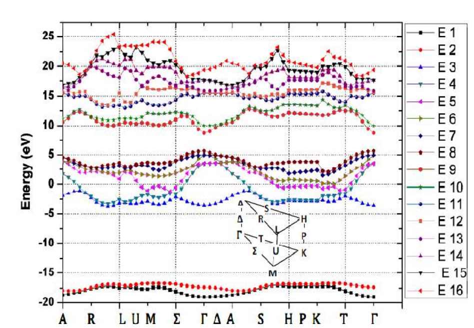
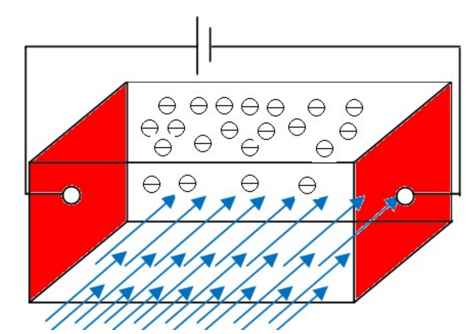
Atomistic Solution

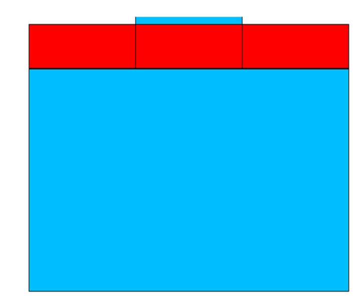
Carrier Field Mobility Characterization

Technology of Next Level
driven through innovation



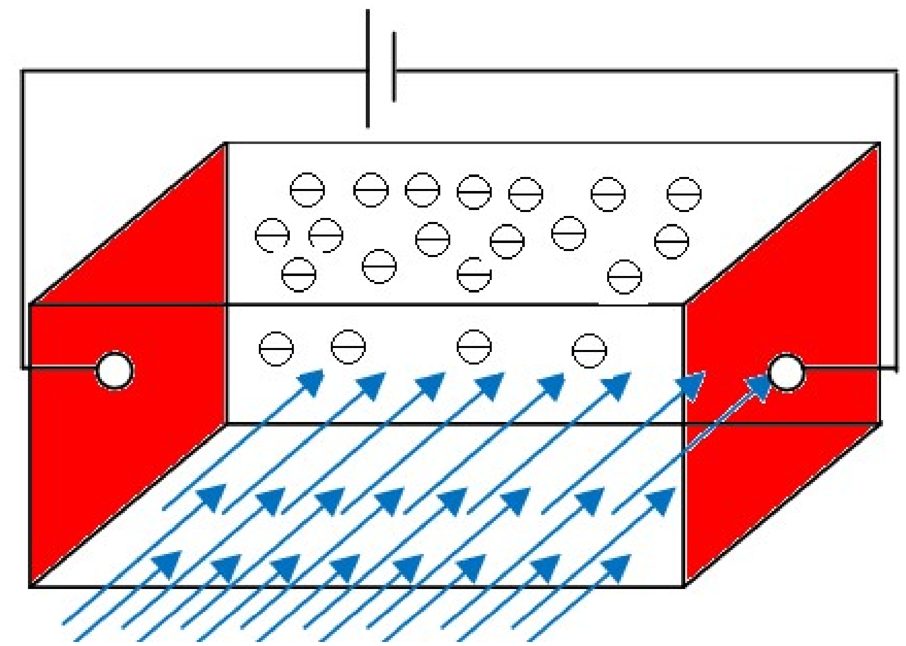






Field Mobility Characterization

- **Challenges with conventional commercial TCAD**
- Mobility modeling divided into: (i) low-field behavior, (ii) high field behavior, (iii) bulk semiconductor regions and (iv) inversion layers
- **Calculate equilibrium conditions mobility**
- **Using some fitting parameters**
- **Lot of Hits & Trials require**
- **Continuum Model's proposed by others**



In reality, carriers accelerated by electric fields, lose momentum as a result of various scattering processes. These scattering mechanisms include lattice vibrations (phonons), impurity ions, other carriers, surfaces, and other material imperfections. Since the effects of all of these microscopic phenomena are lumped into the macroscopic mobilities introduced by the BTE equation these and are functions of the local electric field, lattice temperature, doping concentration, and so on.

TNL-EM SIMULATOR

Features

- ❑ Graphical User Interface (GUI) based
- ❑ Windows based application
- ❑ Boltzmann transport equation solution
- ❑ Ensemble Monte Carlo Technique
- ❑ Include standard scattering mechanisms
- ❑ Fermi Golden Rule for momentum & energy conservation
- ❑ Modeled beyond the effective-mass approximation on the full electronic band structure obtained from FullBand Simulator
- ❑ The electron-phonon, electron-impurity, and electron-electron scattering rates included in a way consistent with the full band structure of the solid
- ❑The carrier transport on the full energy band under influence of electromagnetic forces is traceable for each single carrier.
- ❑ Accurate up to a particle level

TNL-EM SIMULATOR

- The equation is given as

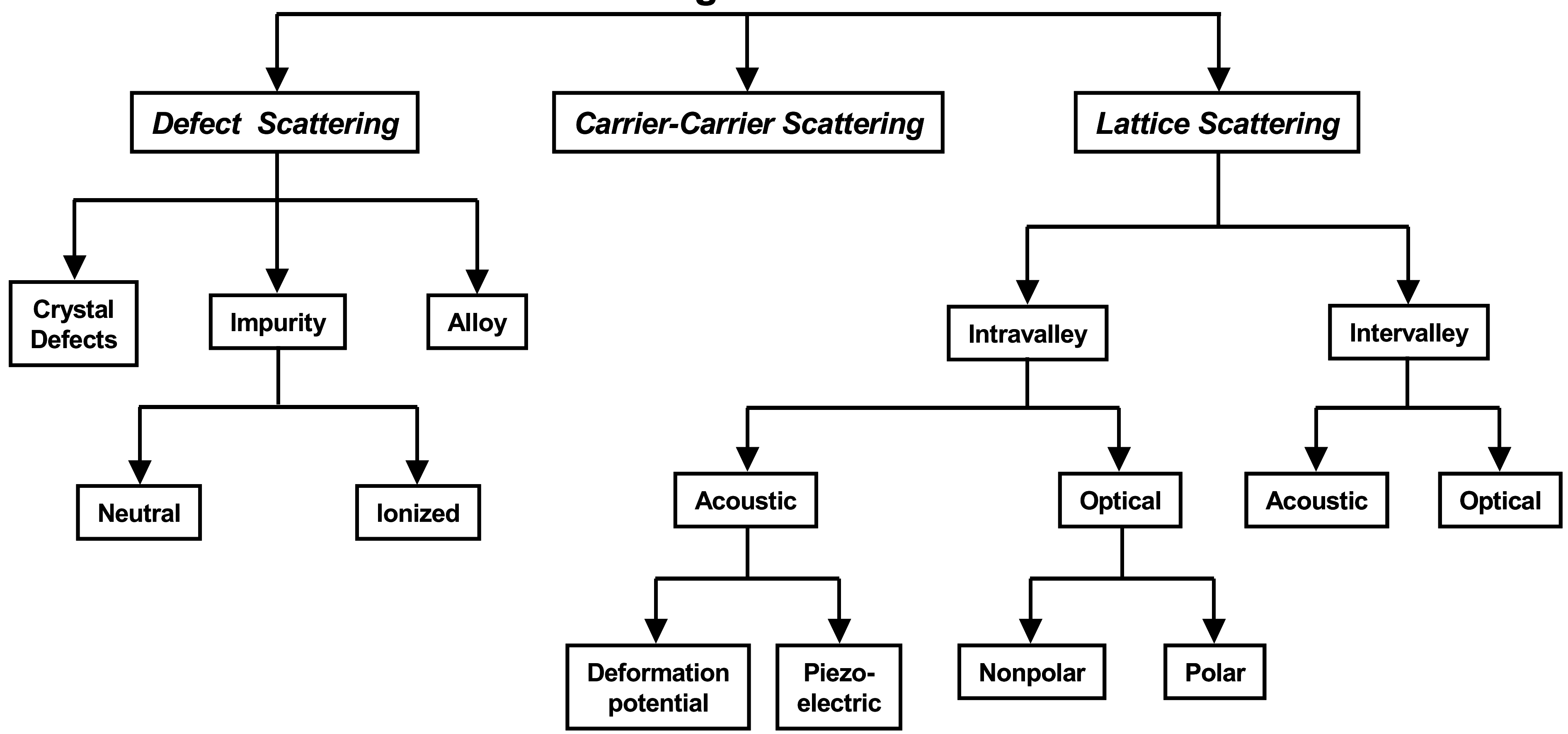
$$\frac{df}{dt} + \nabla_k E(k).\nabla_r f + F.\nabla_p f = \left|\frac{df}{dt}\right|_{scattering} + GR$$

Here f is the distribution function, E is the electric field, F is the external electromagnetic force.

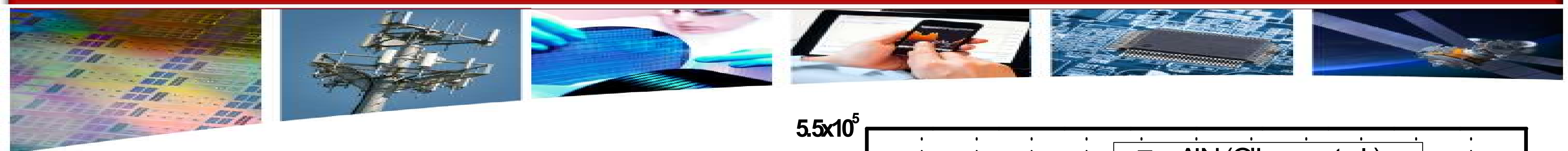
- **Solution of 6+1 dimensional is possible through:**
- **A spherical harmonic expansion (SHE) method with initial approximations**
  - accuracy of simulation results **??**
- **The ensemble Monte Carlo (EMC) technique (stochastic), to simulate non-equilibrium transport in semiconductor.**
- **In Monte Carlo (MC) method, physics is more straightforward and provides flexibility in exploring physical mechanisms and carrier transport.**

TNL-EM SIMULATOR

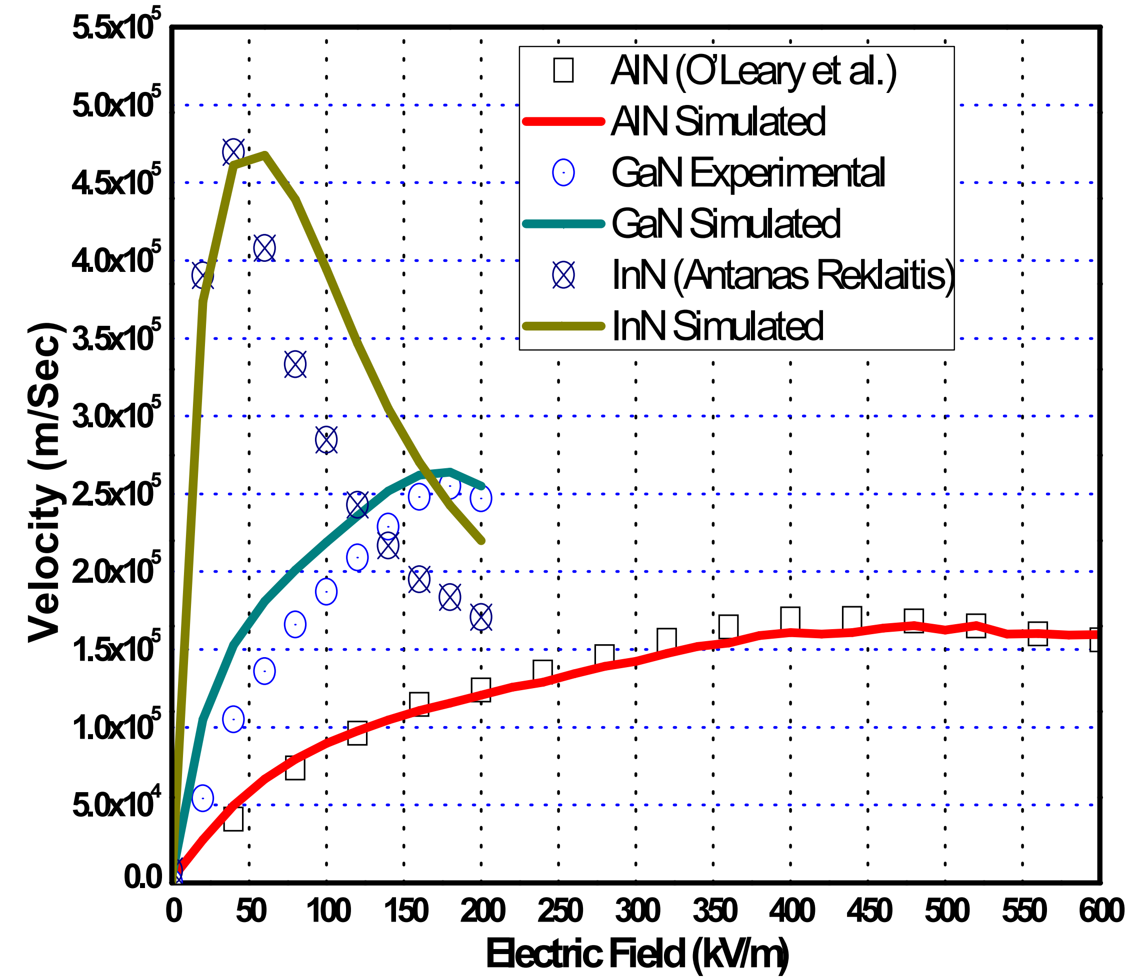
Scattering Mechanisms



GROUP-III NITRIDES



Comparison of simulated carrier drift velocity as a function of applied electric field with the Experimental Date.
solid lines represents – *TNL-EM Simulator*
experimental results open circles, squares and triangles for AlN, GaN and InN respectively.



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❖ Marini, J., Bell, L. D. & Shahedipour-Sandvik, F. Monte Carlo simulation of III-nitride photocathodes. *J. Appl. Phys* 123, 124502(1-9) (2018).
❖ Reklaitis, A. Nonequilibrium optical phonon effect on high-field electron transport in InN, *J. Appl. Phys.* 112, 093706(1-6) (2012)

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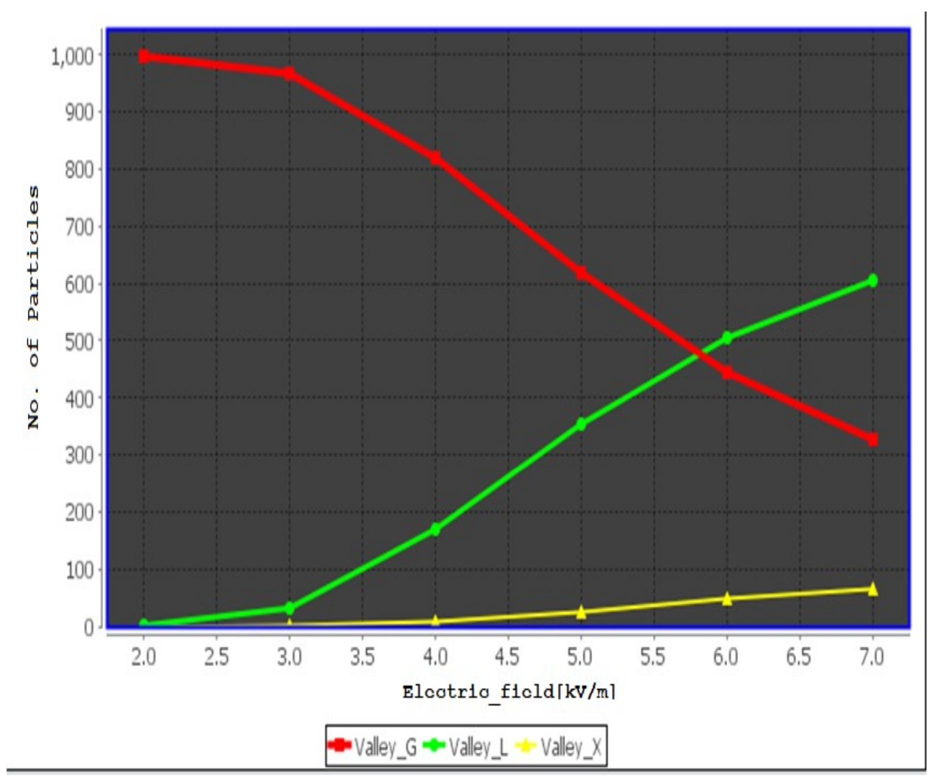
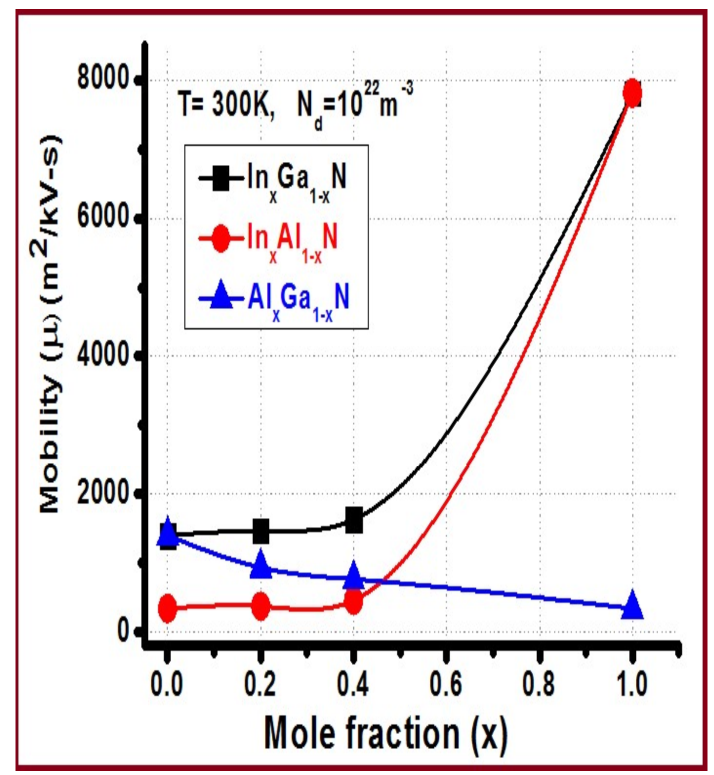
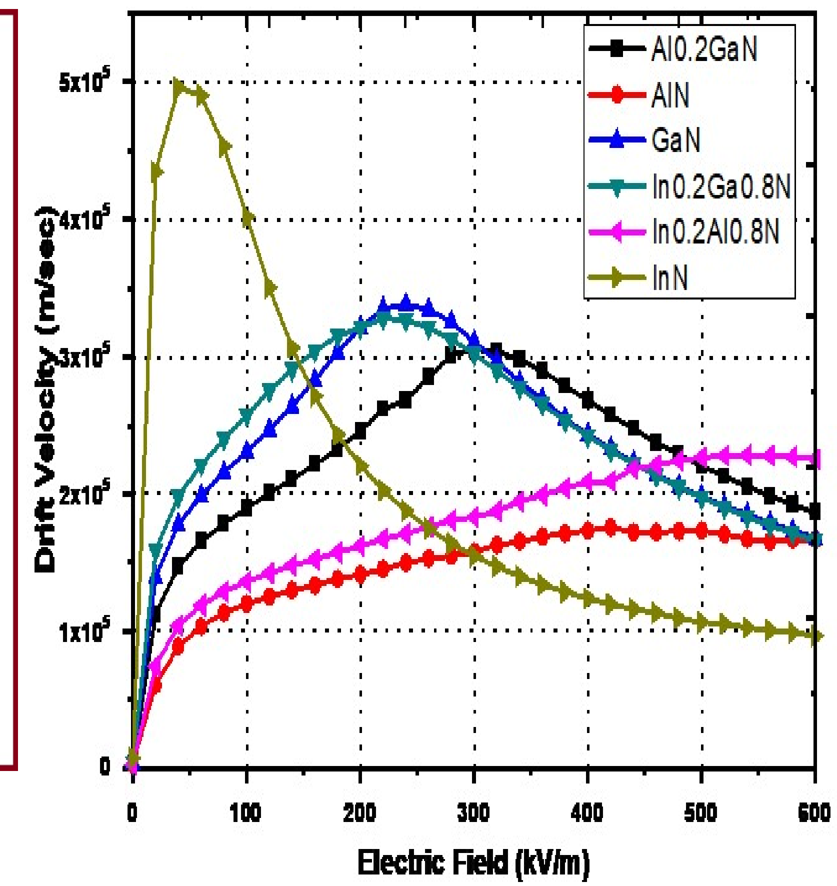
OCCUPATION



No. of Particles
Electric_field[kV/m]
Valley_G
Valley_L
Valley_X



T= 300K, $N_d=10^{22}m^{-3}$
$In_xGa_{1-x}N$
$In_xAl_{1-x}N$
$Al_xGa_{1-x}N$
Mobility (μ) (m^2/kV-s)
Mole fraction (x)



Al0.2GaN
AlN
GaN
In0.2Ga0.8N
In0.2Al0.8N
InN
Drift Velocity (m/sec)
Electric Field (kV/m)

Advance Licensing & Price Value

TNL's tools support advanced and unique licensing models tailoring based on customer needs.

➢ ADVANCED LICENSING OPTIONS:

- Term-Based
- Perpetual
- TCAD Academic Suite
- 24x7 Technical Support for **Academic Institutions**

Publications

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Thank You

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