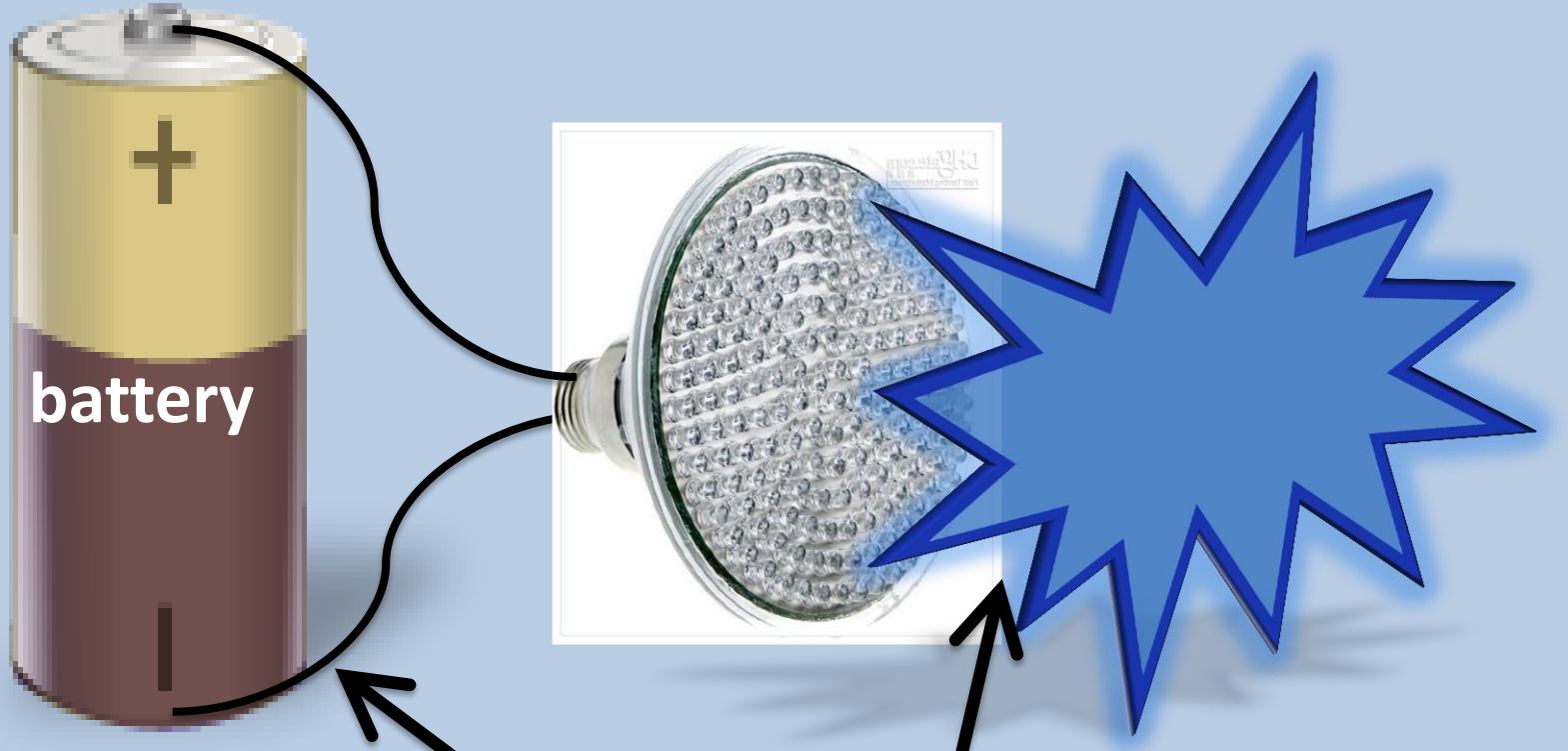
Understanding LED function and mechanisms of energy loss

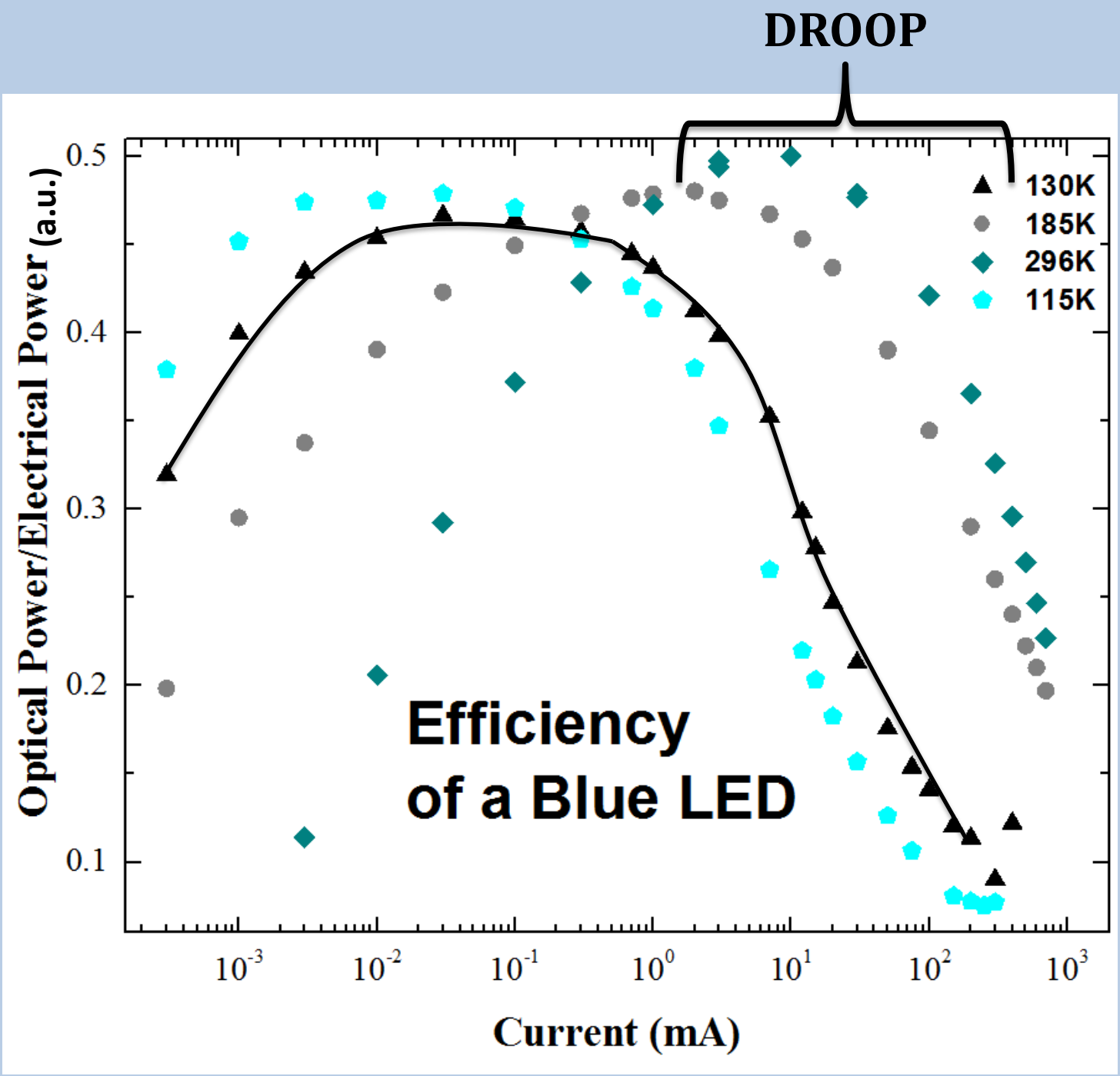
Grace Watt and Tim Gfroerer, Davidson College
Yong Zhang, UNC Charlotte

Davidson College Academic Dean's Office

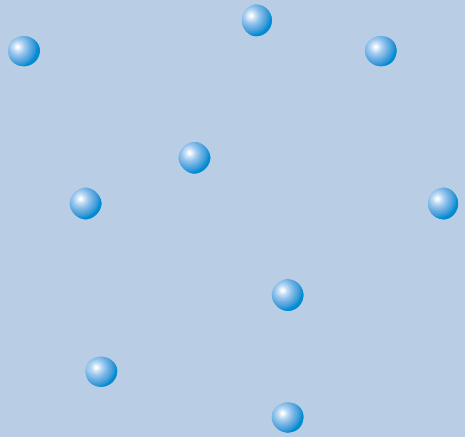
Motivation

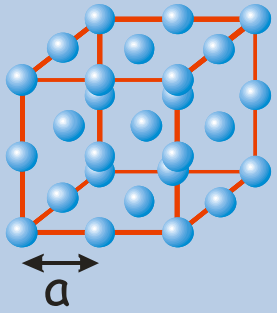


$$efficiency = \frac{optical\ power}{electrical\ power}$$


DROOP
Optical Power/Electrical Power (a.u.)
0.5
0.4
0.3
0.2
0.1
130K
185K
296K
115K
Efficiency
of a Blue LED
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
Current (mA)

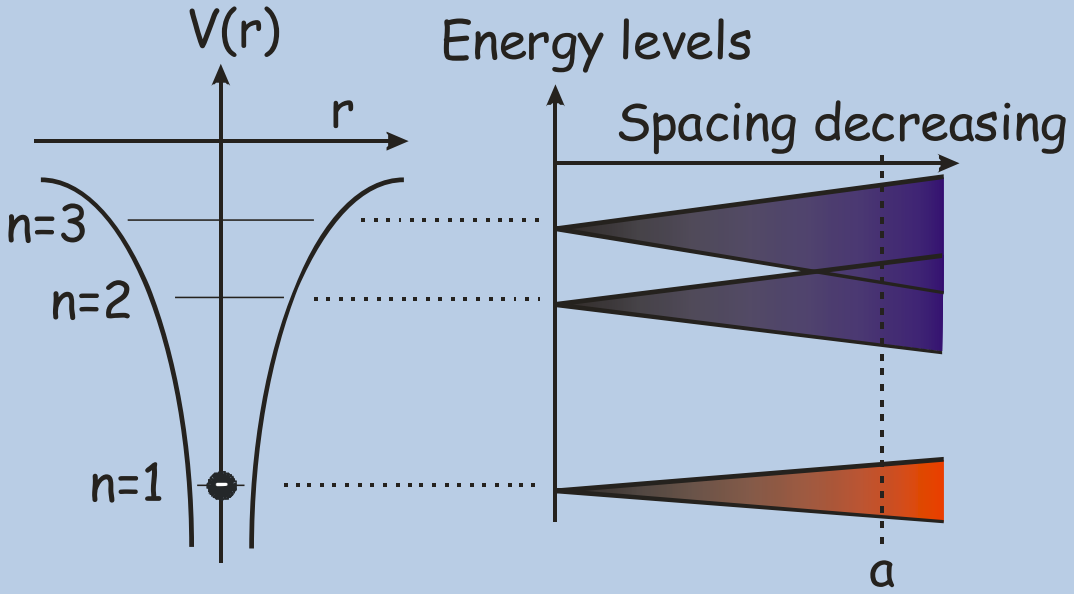
Semiconductor theory



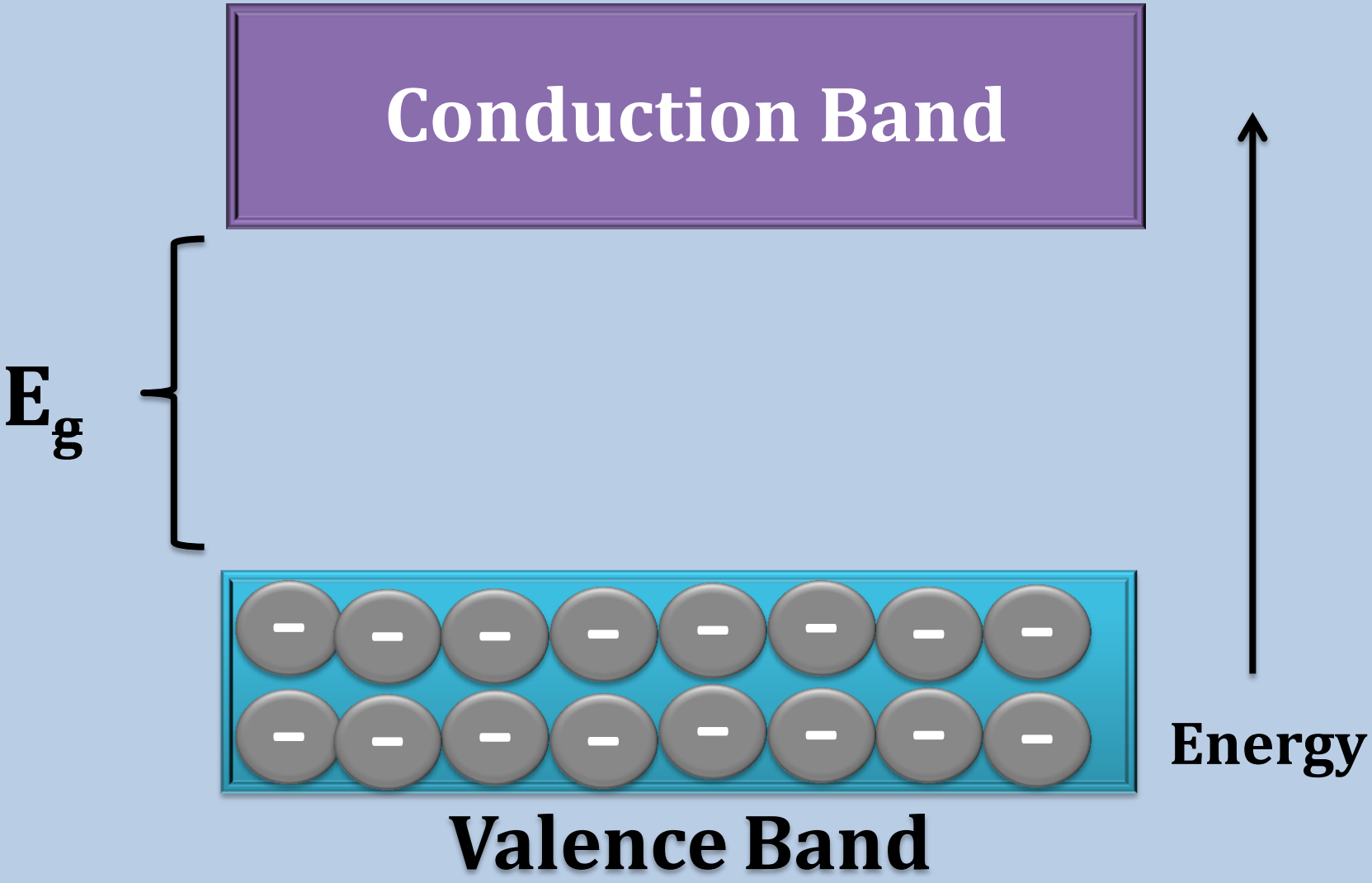


free atoms

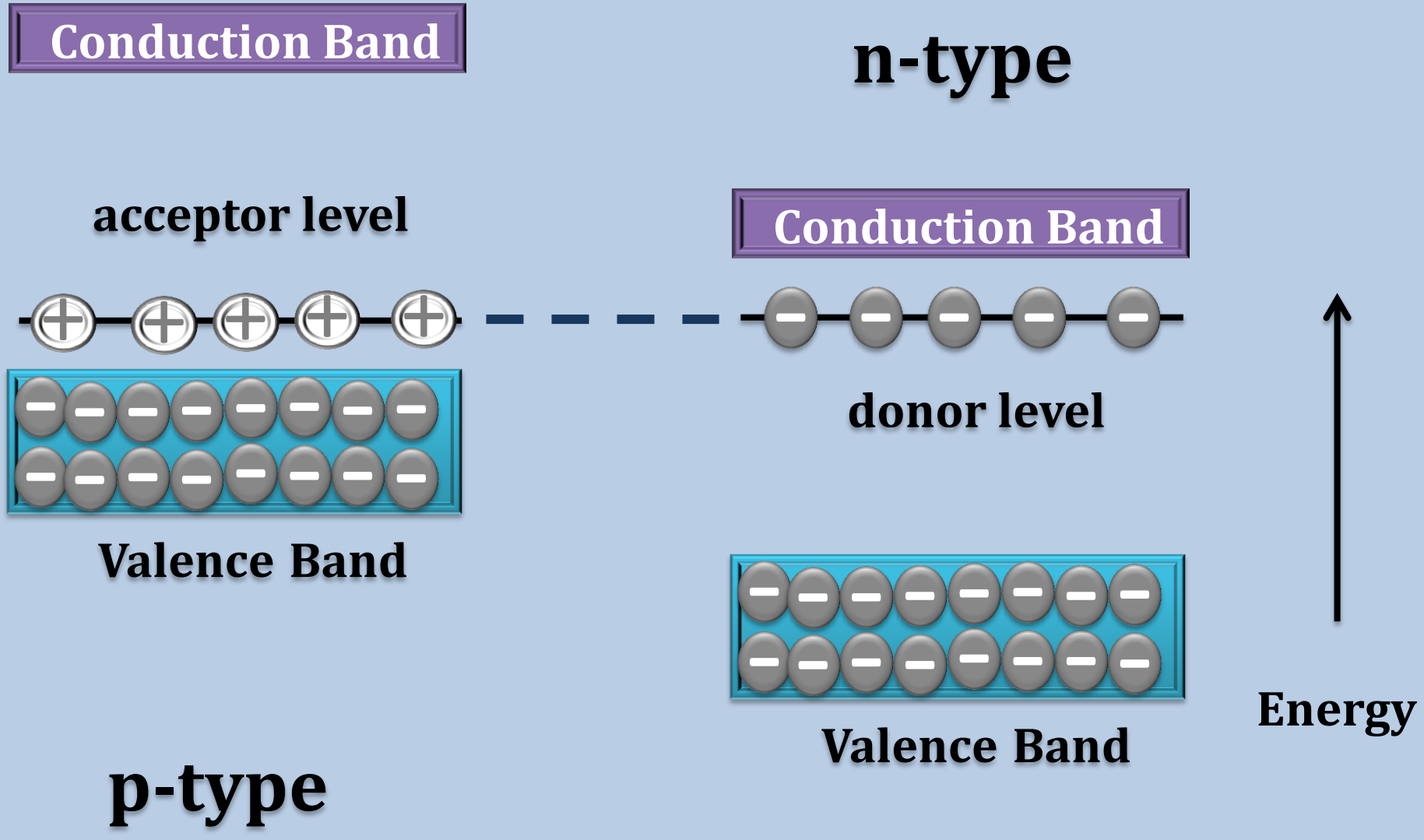
atomic crystal



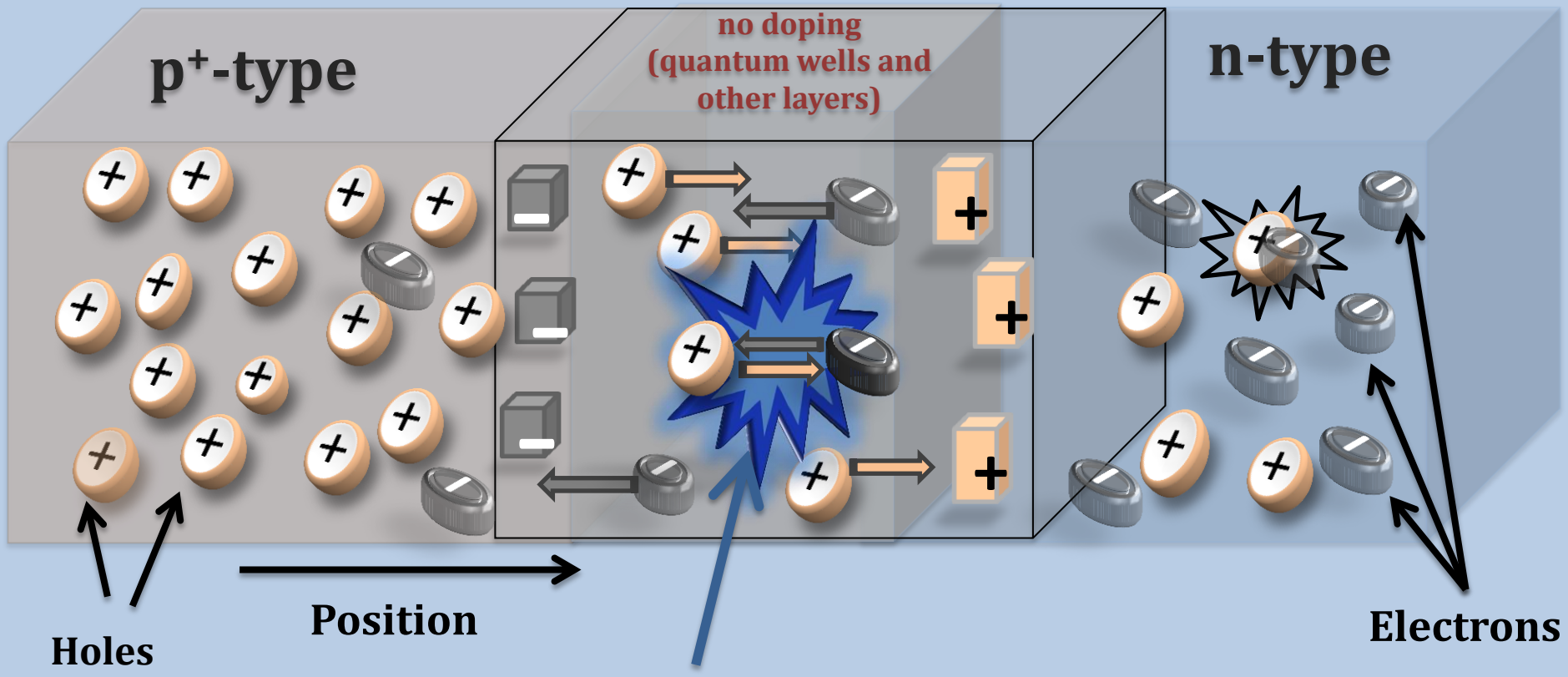
Semiconductor theory



Doped semiconductors

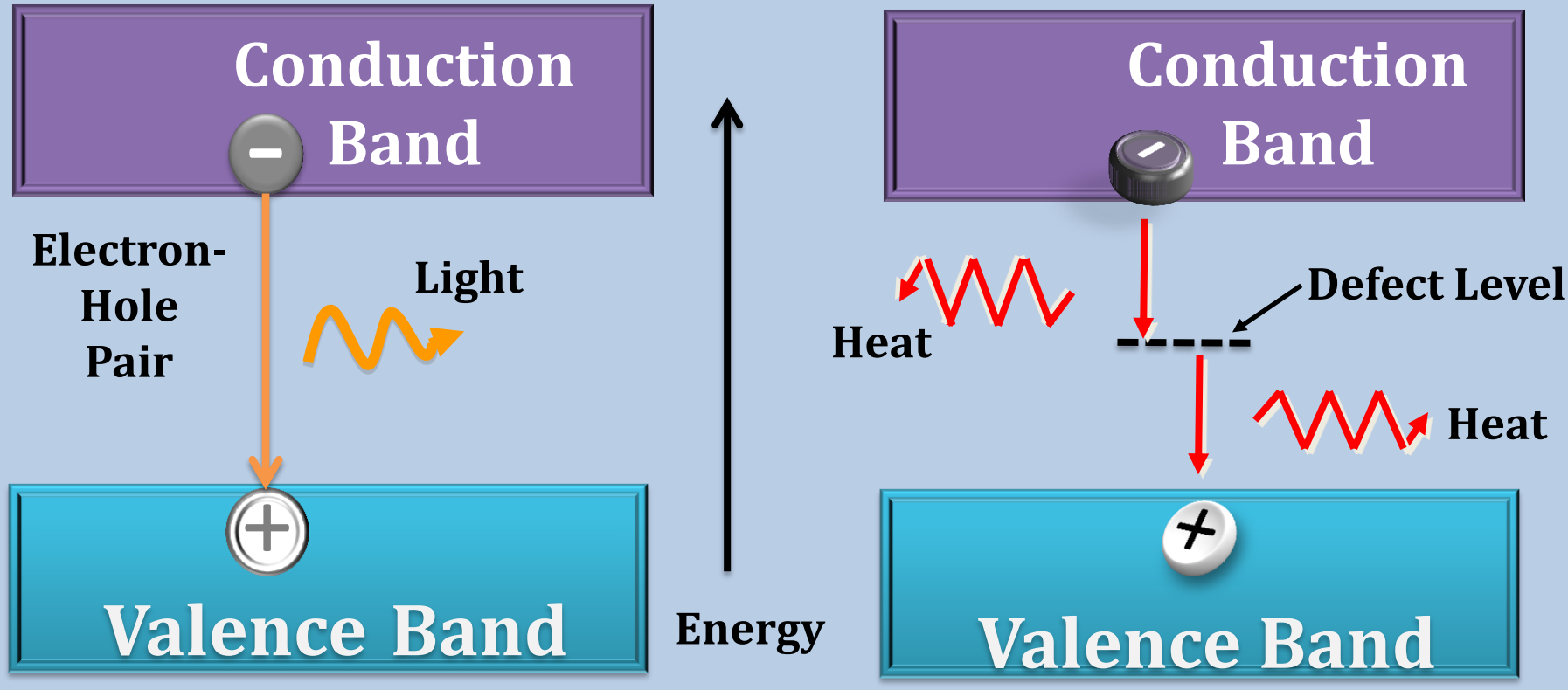


LED Function and Design: Physical Space



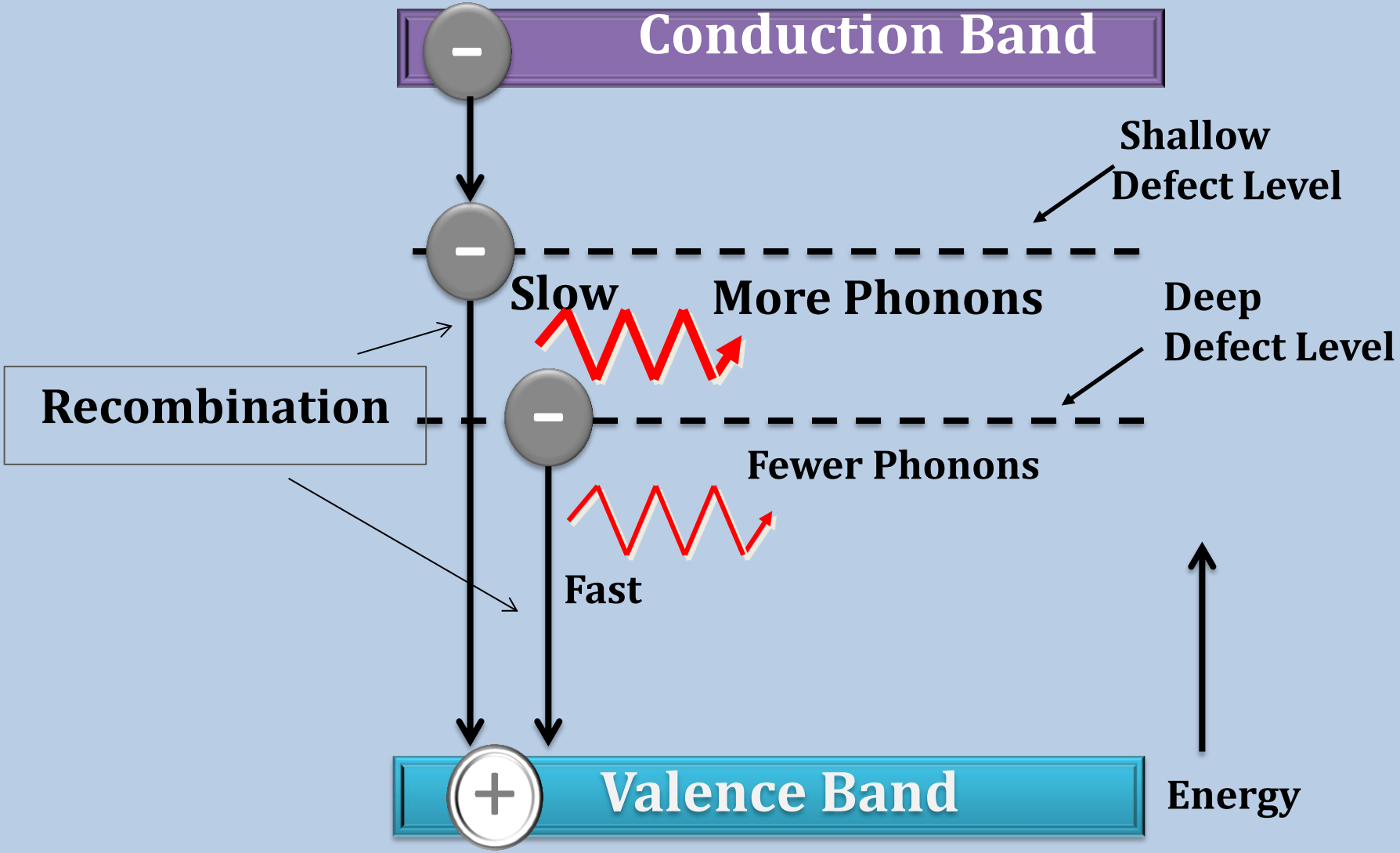
Optical Recombination

LED Function and Design: Energy Space

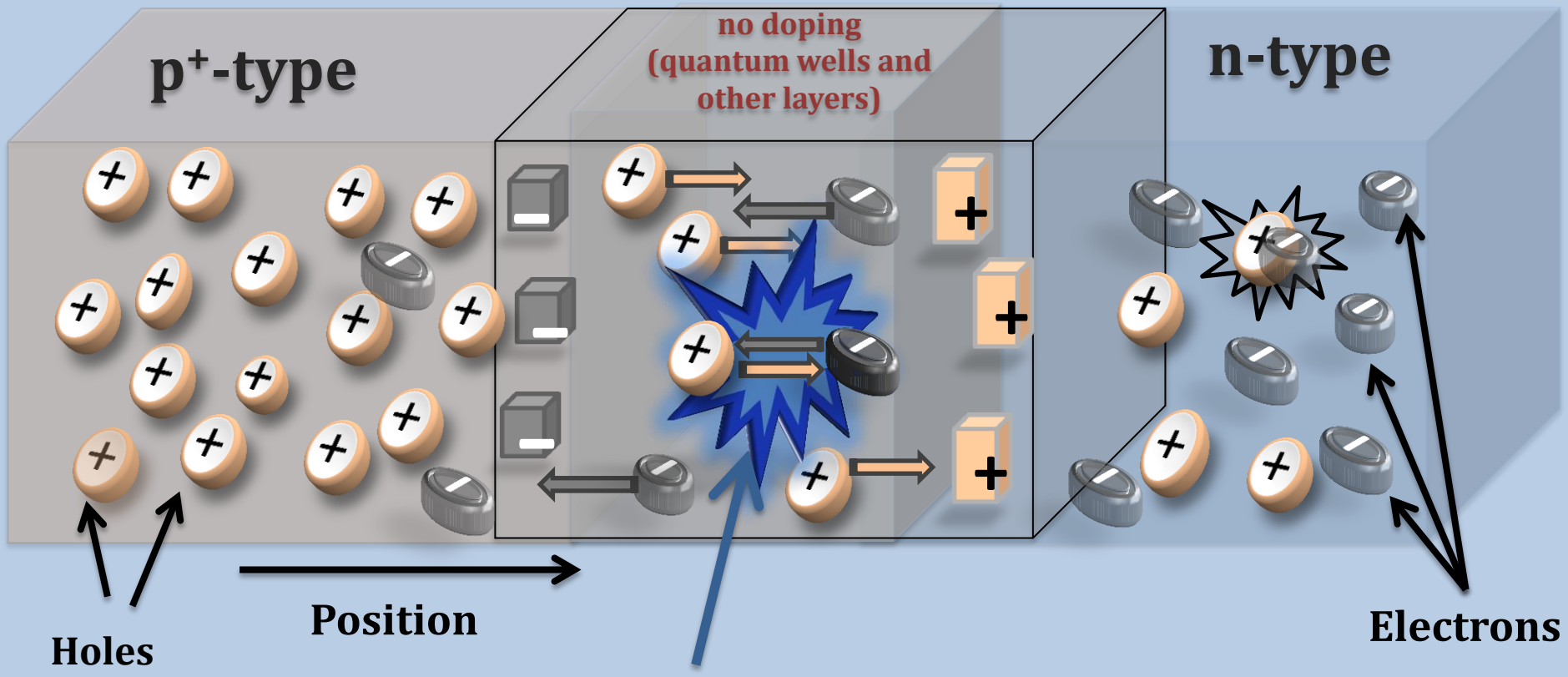


Electrical Energy → Charge carriers transition between bands → Wavelength of light depends on transition energy

Recombination

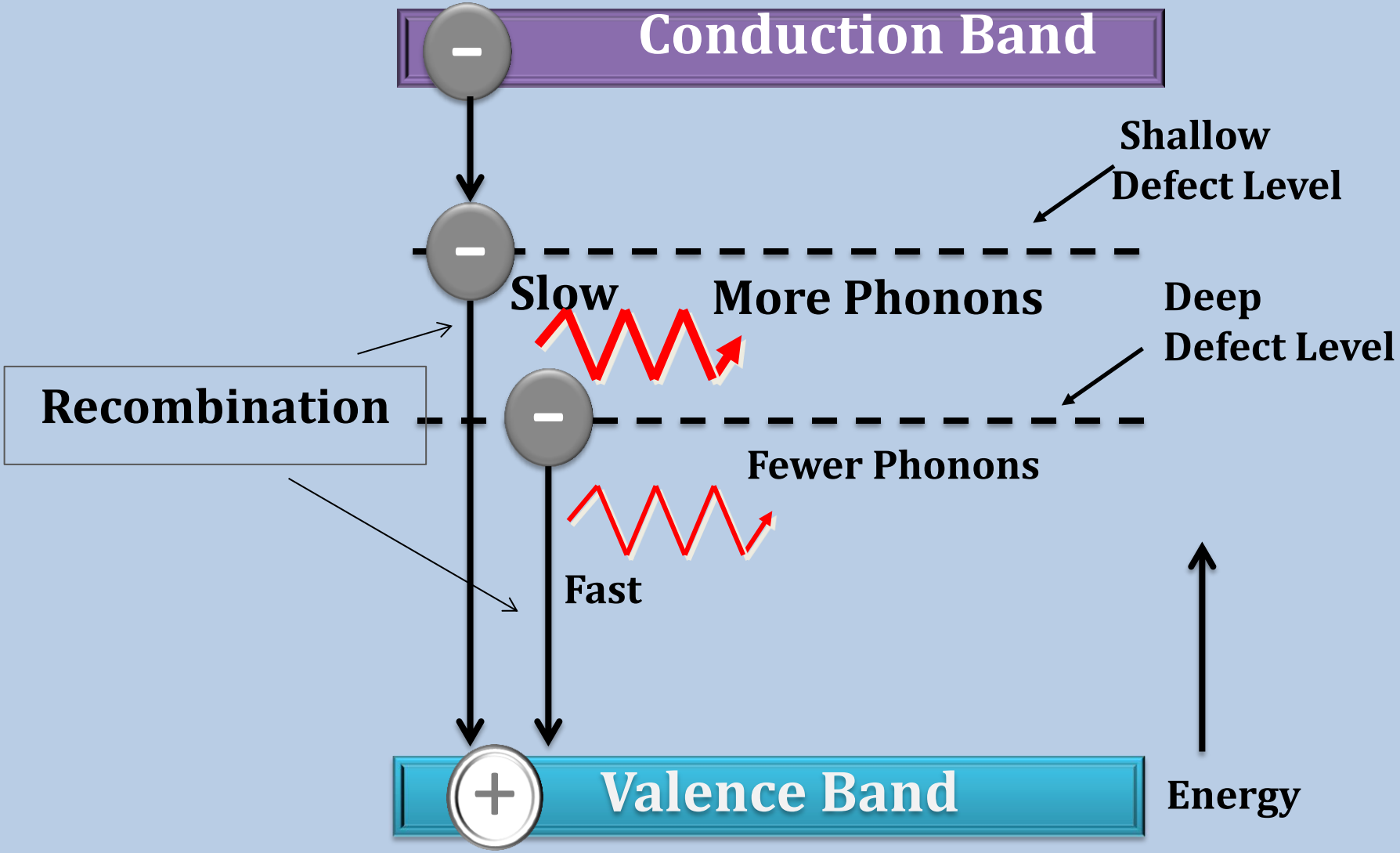


LED Function and Design: Physical Space

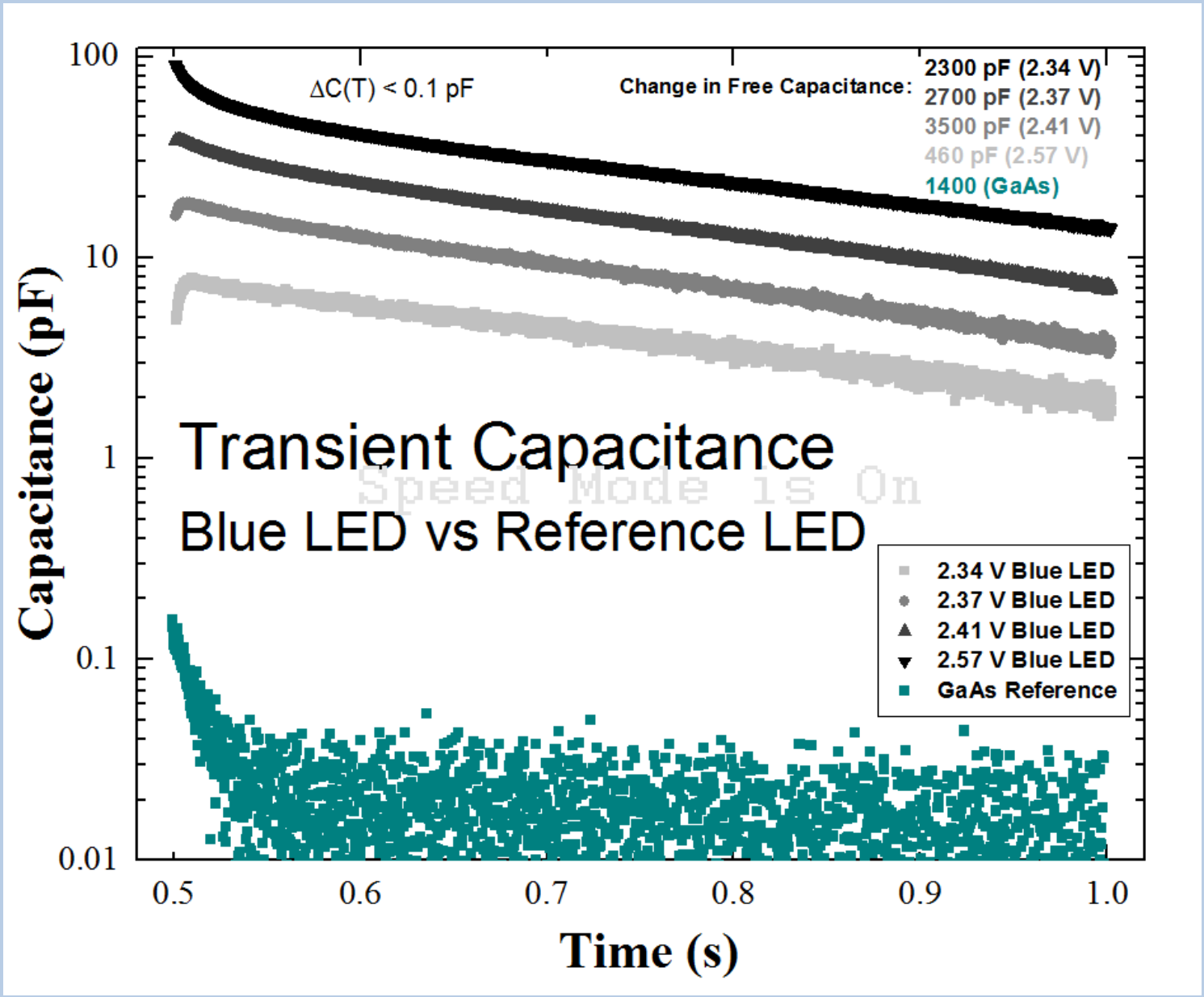


Optical Recombination

Recombination



Capacitance Transient



Conclusions

- Prior work suggests that droop is associated with localization of charge in shallow traps.
- Our transient capacitance measurements are consistent with that model.
    - Slow transients are most prominent at high current
    - Both slow and fast transients are present at low current

Future Work

- Laser excitation of diode (instead of current) to distinguish between the contributions of transport and recombination to droop

Works Consulted

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- Monemar, B., Fundamental energy gap of GaN from photoluminescence excitation spectra, *Phys. Rev. B 10 (1974) 676*.
- Streetman, Ben G, and Sanjay Kumar Banerjee, "Figure 3.4," *Solid State Electronic Devices,* ed. 6. Upper Saddle River: Pearson Education. 2006. p 58. Web.

- Streetman, "Figure 3-7," 62.

- We would like to thank Yong Zhang and collaborators for sharing the InGaN LEDs. We also thank the Davidson College Academic Dean's Office for fellowship support.