Making Time for Collaborative Active Learning

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ABSTRACT

Engineering is about understanding how things work, and exploring the ways to engineer them for the benefit of society. A solid foundation of STEM knowledge can open a student endless opportunities in various fields. An instructor must train students for defining, understanding, and solving problems with an organized critical way of thinking. The major challenge of teaching of engineering subject is motivating the less motivated students, while rewarding, encouraging as well as challenging high achievers. To overcome these challenges, teaching methodologies essential to adjust from traditional teaching methods to collaborative active learning methods such as Think-pair-share, Group assignments, Peer Instruction and Problem Based Learning and interactive simulations. Here, I will discuss how to implement above-mentioned collaborative teaching methods in Semiconductor devices course.

MOTIVATION & BACKGROUND

Traditional teaching methods typically rely on students learning class material passively, which encompasses listening to lectures and taking notes. However, many studies show that the collaborative active learning leads to increase the students' performance in the classroom.

Collaborative learning is the educational approach of using students' groups to enhance learning through working together. Some methods are,

- Think-pair-share
- Group assignments
- Peer Instruction
- Problem Based Learning
- Interactive simulations

Here, I discuss my experiences in implementing a collaborative active learning classroom model in a Semiconductor devices course.
This poster also presents the course design and pedagogical methods with selected examples from the most recent offering of the course (Fall 2021).

CONTEXT

PHY 380-Semiconductor Devices is a 3-credit hour course for all undergraduate electrical and computer engineering majors . It is an overview of the operation of basic semiconductor devices, device characterization, modeling and device design. The main topics are;

Semiconductor Physics	Semiconductor Devices
Crystal structure	pn junction & Diode
Semiconductor in equilibrium	Transistors
Carrier Transport	Bipolar Junction Transistors (BJT)
Band structures	Field effect transistor (FET) & MOSFET

Learning Outcomes :

By the end of the semester, the student will demonstrate the ability to:

- Describe the fundamental semiconductor properties.
- Model and analyze the energy band diagram for semiconductor materials.
- Describe the principle and analyze the operation of pn-junction diode.
- Describe the principle and analyze the operation of Metal-Oxide-Semiconductor field Effect Transistor and the Bipolar Junction Transistor.

Acknowledgments

- Semiconductor Device Fundamentals 2nd Edition by Robert Pierret ISBN 10: 0131784595 ISBN 13: 9780131784598 Publisher: Pearson, 2003
- Center for Teaching and Leaning, Marian University Indianapolis
- Department of Chemistry and Physical Sciences, Marian University Indianapolis
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ACTIVE LEARNING APPROACHES

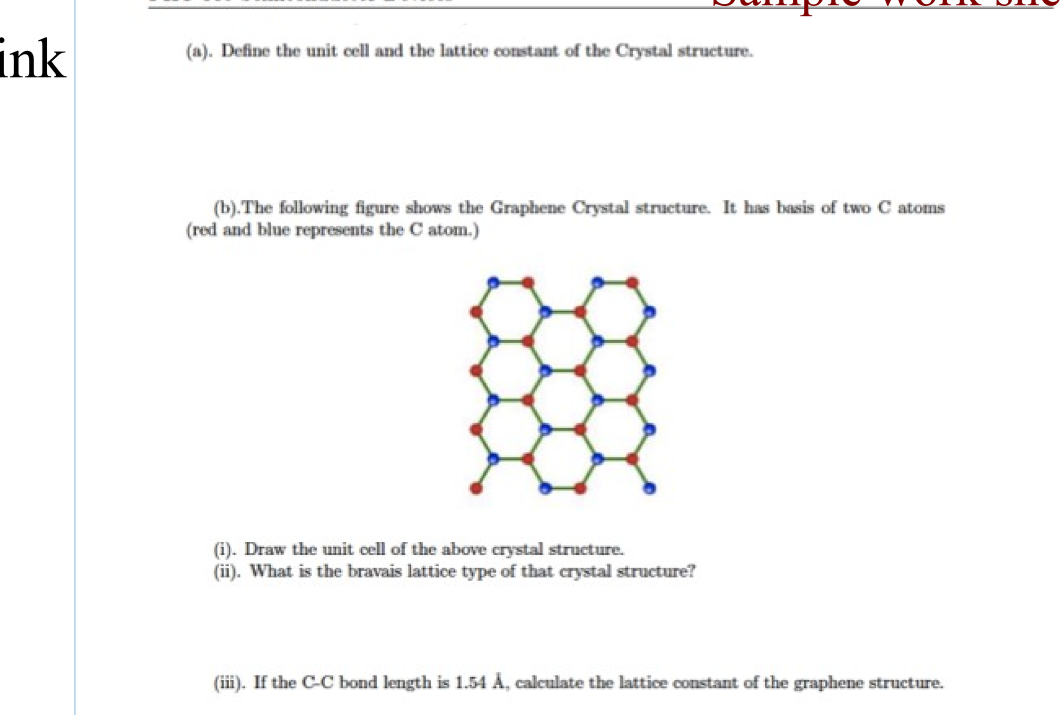
Many studies show that student attention span during a lecture is roughly 15 minutes. To keep the healthy learning environment throughout the lecture period I use different collaborative active learning methods. These activities help students to refresh their minds and actively engage in the learning process.

Think-Pair-Share

- ✓ In-class worksheet problems -poses a problem and the students think about it individually for a short time.
- ✓ Form pairs and share their solutions.
- ✓ In class homework discussion.
- ✓ A student discuss a problem/solution to the class.

Pros: Total engagement
Share their ideas
Understand the mistakes
Cons: Sometimes hard to assist all the students
Time consuming

Sample work sheet


PHY 380 Semiconductor Devices

(a). Define the unit cell and the lattice constant of the Crystal structure.

(b).The following figure shows the Graphene Crystal structure. It has basis of two C atoms (red and blue represents the C atom.)

(i). Draw the unit cell of the above crystal structure.
(ii). What is the bravais lattice type of that crystal structure?

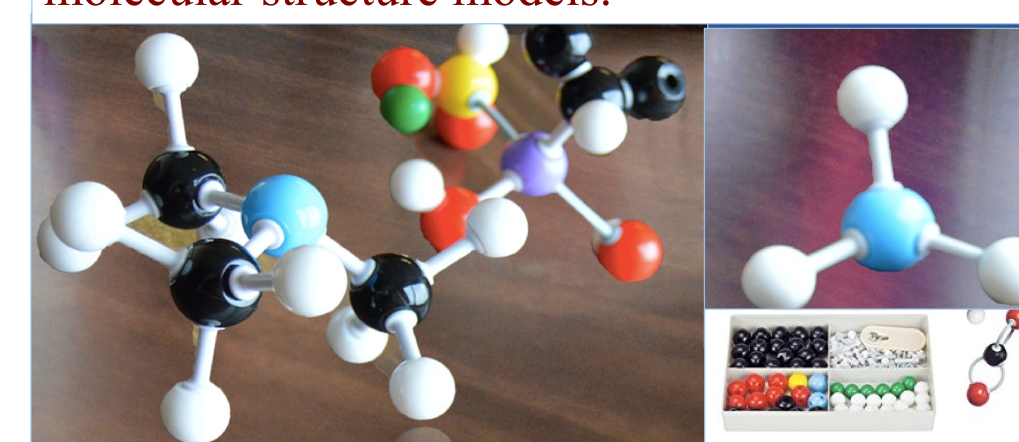
(iii). If the C-C bond length is 1.54 Å, calculate the lattice constant of the graphene structure.

Small group activities

- ✓ Intercommunication among a small number of students to achieve a shared goal using in class demonstrations.

Pros: Can ask for help when they're struggling
Help, teach and learn from each other
Creativity
Cons: Conflicts among each other
Time consuming

Understanding the crystal structure using the molecular structure models.

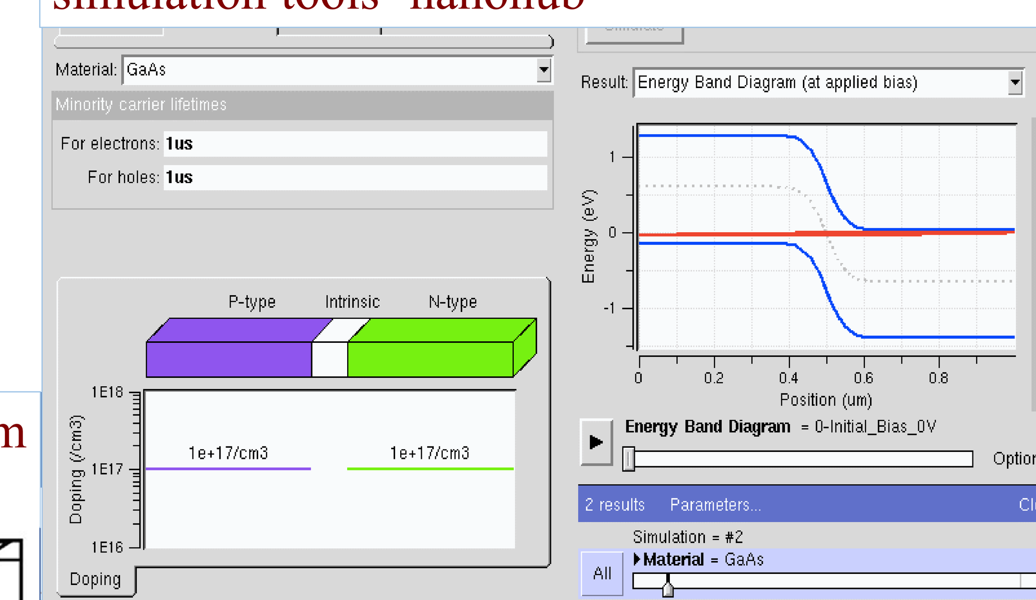


Interactive simulations

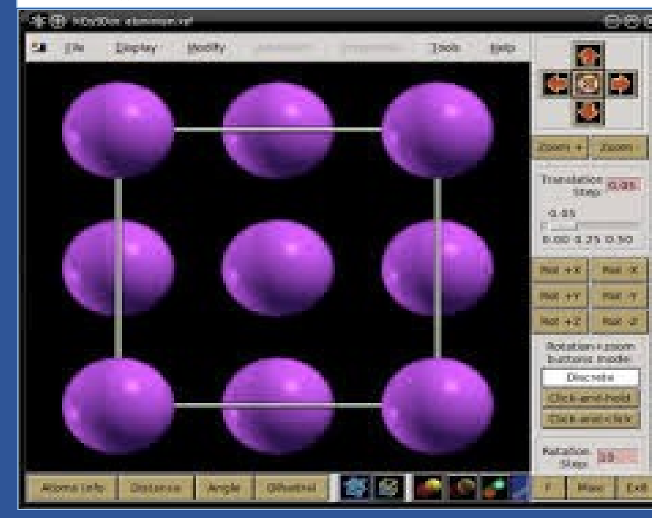
- ✓ Use different types of simulation tools to understand the concepts of semiconductor devices.

Pros: Hands-on experience
Total engagement
Develop visualization skills
Cons: Technology barrier

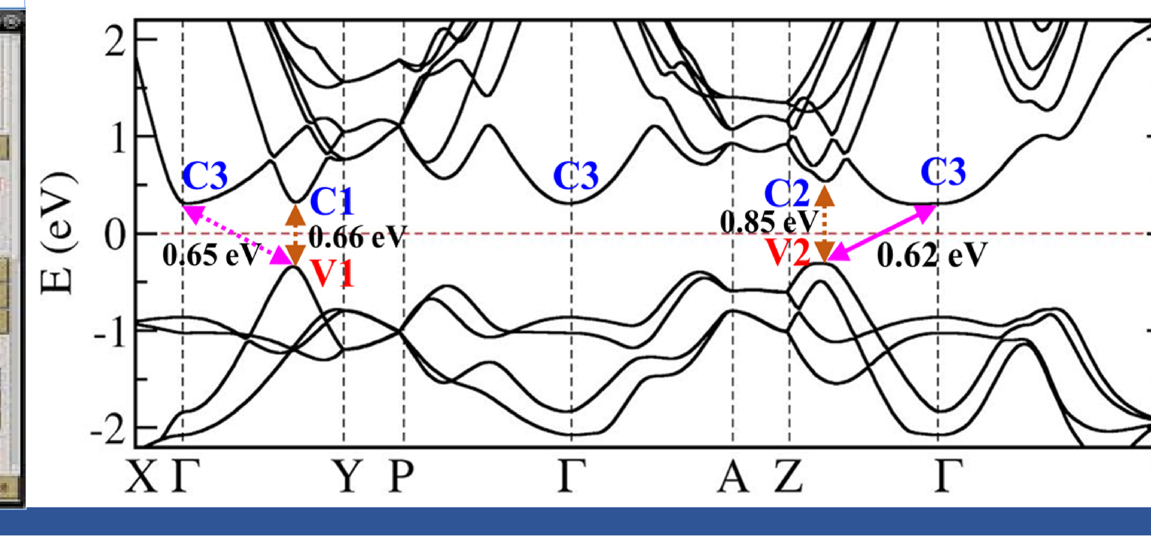
Understanding pn-junction devices using simulation tools -nanohub



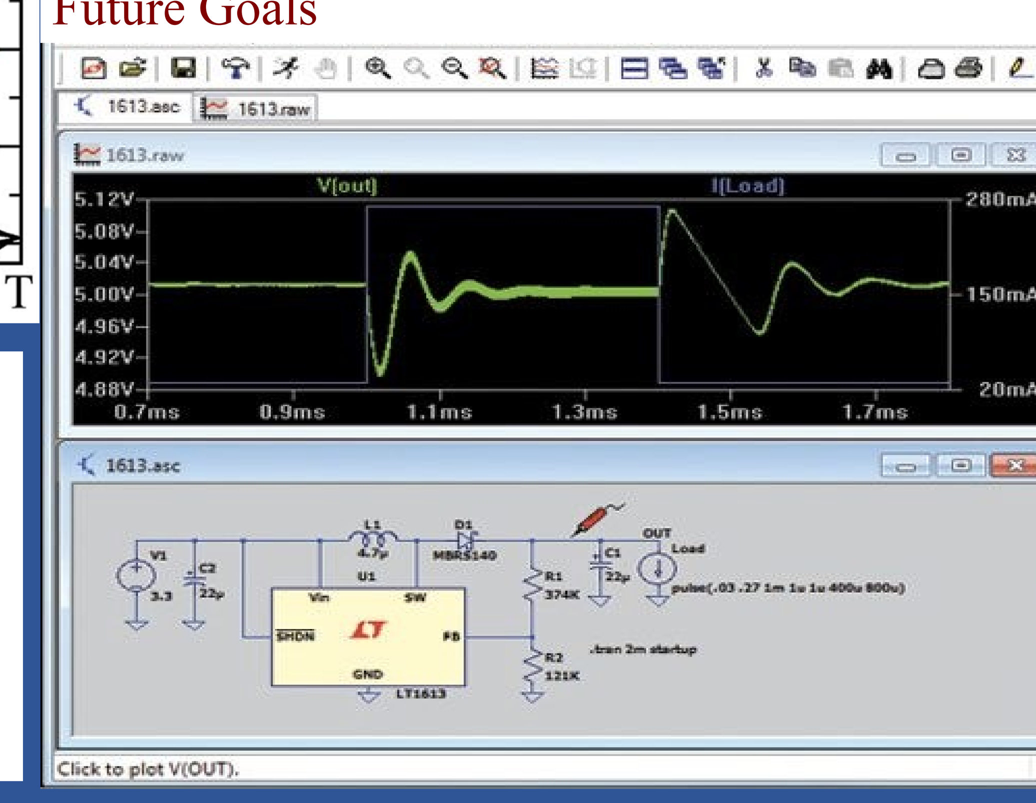
Crystal structure modeling using Xcrysden software



Engineering of electronic band structure using quantum espresso- Future Goals



LTspice simulations for semiconductor devices – Future Goals



Peer Review

- ✓ Having students review each others work is a great way to make sure each student benefits from individual feedback and attention.

-Used canvas Discussion feature to review their works
-At the end of class, it is often a good idea to have students explain key ideas in their own words