

**Southwest Center for Microsystems Education (SCME)
University of New Mexico**

MEMS Fabrication Topic

**Crystallography Overview for MEMS
Learning Module**

This booklet contains six (6) units
Knowledge Probe (KP)
Primary Knowledge (PK)
Growing Crystals – Hot Ice Activity
The Miller Index Activity
Breaking Wafers Activity
An Origami Crystal Activity
Final Assessment

The purpose of this learning module is to introduce the science of crystallography and its importance to microtechnology. Activities provide for additional exploration into crystallography and its applications.

Target audiences: High School, Community College, University

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Website: www.scme-nm.org

Crystallography Overview for MEMS

Knowledge Probe (pre-test)

Participant Guide

Introduction

The *purpose of this learning module* is to introduce the science of crystallography and its importance to microtechnology. Activities provide additional exploration into crystallography and its applications.

This knowledge probe helps to determine your current understanding of crystallography, silicon crystal structure, and Miller Indices as it relates to microsystems technology and fabrication. This pre-quiz should be completed prior to starting the Crystallography Overview for MEMS Learning Module.

There are 15 questions. Answer each question to the best of your knowledge.

1. Which of the following BEST defines Crystallography? The science of ...
 - a. developing arrangements for atoms in solid matter.
 - b. determining the arrangement of atoms in solid matter.
 - c. studying the properties of atoms in solid crystal.
 - d. developing new crystals using atomic structures.
2. Matter without a regular arrangement of atoms is called...
 - a. Amorphous
 - b. Chaotic
 - c. Polycrystalline
 - d. Crystalline
3. In a crystal, the simplest repeating section of atoms is called the
 - a. Single crystal
 - b. Poly crystal
 - c. Unit cell
 - d. Crystal seed
4. Polycrystalline solids consist of small crystals called _____ that are separated by _____.
 - a. Unit cells, cell boundaries
 - b. Amorphous solids, amorphous boundaries
 - c. Single crystals, crystal boundaries
 - d. Grains, grain boundaries

5. What type of solid is peanut brittle?
 - a. Amorphous
 - b. Chaotic
 - c. Polycrystalline
 - d. Crystalline

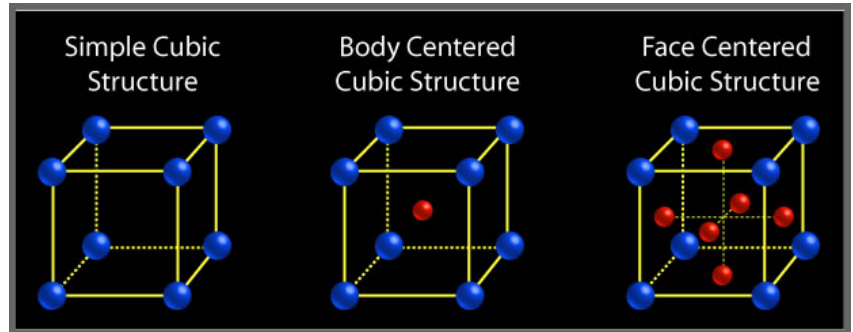
6. Which of the following is NOT a characteristic of monocrystalline silicon?
 - a. Longer range order compared to polycrystalline silicon
 - b. Well-ordered silicon atoms arranged in a lattice structure
 - c. Many single crystalline solids held together by ionic bonds

7. The material properties of a silicon wafer are determined by surface atoms and the _____ of the silicon wafer.
 - a. crystal orientation
 - b. doping concentration
 - c. long range order
 - d. bandgap

8. What is the roadmap or compass called for identifying the crystal planes of single crystals?
 - a. X-ray diffraction
 - b. Crystallography
 - c. Miller Index
 - d. Cartography

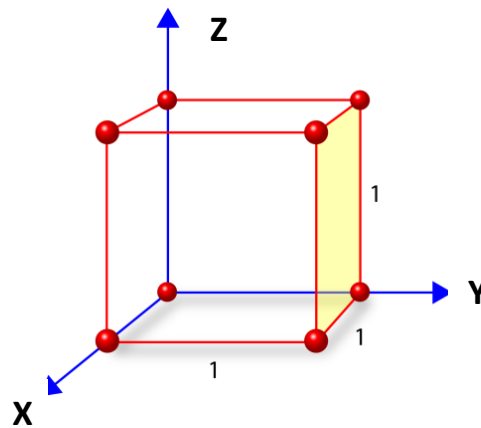
9. Which of the following BEST describes why crystalline silicon is used for microsystems fabrication?
 - a. Readily abundant and can be easily formed into polycrystalline ingots and cut into wafers
 - b. Its relatively short range order, strength, and unique ability to be etched along grain boundaries
 - c. Its semiconductor properties that allow it to act as an insulator or a conductor depending on design
 - d. Its unique electrical and mechanical properties that make it possible to form specific well-defined structures

10. There are different configurations for unit cells with each configuration having different number of atoms. A face centered cubic structure has how many atoms?
- 1
 - 4
 - 7
 - 15



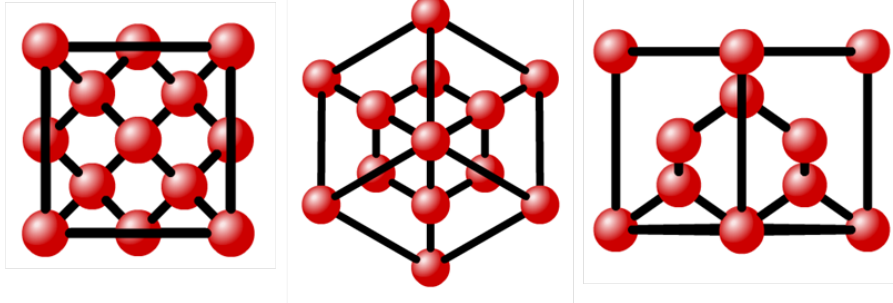
11. A silicon atom has _____ valence electrons that are shared with _____ other silicon atoms when forming a crystal.
- 8,8
 - 6,2
 - 4,4
 - 2,6

12. What is the Miller Index notation for the yellow plane in this diagram?
- (100)
 - (010)
 - (001)
 - (110)
 - (111)



13. The following diagram represents different _____ in the same crystal structure.

- a. Grains
- b. Unit cells
- c. Growth structures
- d. Crystal planes



14. In the manufacture of silicon wafers, the crystal orientation of the wafers is determined by the...

- a. purity of the silicon
- b. orientation of the seed crystal
- c. type of seed crystal
- d. pull rate of the ingot

15. The bulk modulus of a microsystems structure is determined by the _____ properties of the material in which they are constructed.

- a. dimensional
- b. electrical
- c. mechanical
- d. optical

Support for this work was provided by the National Science Foundation's Advanced Technological Education (ATE) Program through Grants. For more learning modules related to microtechnology, visit the SCME website (<http://scme-nm.org>).