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

A Learning Module Map has been provided as a suggested outline on how to use this learning module.

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

Learning Module Map for Crystallography Overview

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.

Learning Module units (6):

- Knowledge Probe (Pre-test)
- Crystallography Overview PK
- Growing Crystals – Hot Ice Activity
- The Miller Index Activity
- Breaking Wafers Activity*
- An Origami Crystal Activity*
- Crystallography LM Assessment

*These activities are supported by a SCME kit that can be ordered through the SCME website (http://scme-nm.org) until supply last and the center is funded.

Following is a <u>suggested map</u> on the implementation of this learning module.

IMPORTANT STEPS	KEY POINTS	REASONS
Knowledge Probe (KP)	Have the participants take the knowledge probe to determine their current knowledge of crystallography and its importance to microtechnology.	The KP can be compared with the Final Assessment to determine the participants' level of learning and areas that may need a better understanding.
Inquiry Activity – The first part of the "Breaking Wafers Activity"	Have the participants break one 100 and one 111 wafer from the Crystallography Kit by breaking ONCE in the middle of the wafer using a nail and hammer. Do NOT break more than once.	Participants should notice that the two wafers break differently. Ask them "WHY?" This LM will explain WHY. You only want to break each wafer ONCE so that you can have the participants break them again later when they better understand the concept of crystal planes.

Types of Solids – Another inquiry activity	Gather various types of solids for the participants to study. The solids should be amorphous, polycrystalline and crystalline. You should be able to find several examples at rock and mineral stores. Ask questions: How do they differ? How would they conduct light? How would they conduct electricity?	This activity helps the participants better understand the three (3) types of solid materials – amorphous, polycrystalline and crystalline.
Present the Crystallography Overview PK	Participants should read the PK. A PowerPoint presentation can be downloaded by the instructor from scme-nm.org and presented to all participants.	An introduction into crystallography is needed to help participants better understand the two activities.
Start the activity "Growing Crystals – Hot Ice"	This activity takes about an hour; therefore, it can be started and completed along with another activity. This activity does require a hot plate and several supplies not provided for in the SCME kit.	This activity allows the participants to actually "see" the crystallization process that occurs around a "seed crystal". It also teaches other concepts such as exothermic and endothermic reactions.
Complete the activity "The Miller Index"	Participants model several "crystal planes" relative to the x-y-z axes and relative to a unit cell using Miller Index notation.	Participants need a thorough understanding of the Miller Index and crystal plane notation to better understand the following activities.
Complete the activity "Breaking Wafer".	Participants need to be able to identify which wafer is 111 and which is 100 and explain the properties (physical, chemical, mechanical) of each.	Different orientations have different material properties. The type of MEMS devices determine the orientation required based on its properties.
Complete the activity "An Origami Crystal"	Participants can watch an animation on how to construct the crystal origami or they can just dive in and figure it out for themselves. The animation can be downloaded from scme-nm.org by the instructor.	Participants become more familiar with the many planes of a crystal structure and the notation used to represent each plane.

Crystallography Assessment	Give the participants the Crystallography Overview assessment.	Participants are evaluated on what they have learned about crystals, silicon crystals, crystal planes, and application of this knowledge in MEMS fabrication.

Adapted from Graupp, P. & Wrona, R. (2006) The TWI Workbook: Essential Skills for Supervisors. New York, NY. Productivity Press.

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