Microcantilevers Terminology and Research Activity
Instructor Guide

Notes to Instructor

This activity provides the participants an opportunity to demonstrate their understanding of the terminology associated with Microcantilevers. This activity should be given after at least two PKs and the Microcantilevers Model Activity are completed.

The Microcantilevers Learning Module consists of the following:
- *Book 1*
- Learning Module Map for Instructors
- Microcantilever Knowledge Probe
- Microcantilever Applications Overview (PK)
- Chemical Sensor Arrays (PK)
- Atomic Force Microscopes (PK)
- *Book 2*
- How Does a Cantilever Work? (PK)
- Microcantilever Model Activity: Resonant Frequency vs. Mass (SCME Kit Available)
- **Microcantilevers Terminology and Research Activity**
- Final Assessment

Description and Estimated Time to Complete

In this activity you demonstrate your understanding of microcantilevers terminology and how microcantilevers work in MEMS (microelectromechanical systems). This activity consists of two parts:
- A **crossword puzzle** that tests your knowledge of the terminology and acronyms associated with microcantilevers and MEMS that use microcantilevers, and
- **Post-activity questions** that ask you to demonstrate a better understanding of microcantilevers and their applications.

If you have not reviewed the reading materials in the Microcantilevers Learning Module, you should do so before completing this activity.

Estimated Time to Complete
Allow at least 1 to 1.5 hours to complete this activity.

Introduction

A cantilever is a type beam which is supported and constrained at only one end. Based on this description the wings of most aircrafts, balconies of buildings and certain types bridges are cantilevers. Free standing radio towers, anchored to the ground, suspended upwards without cables are also cantilevers. Of course the most familiar cantilever is a diving board.

Cantilevers come in all sizes. The previous examples range in length from a few meters to hundreds of meters. In contrast, microcantilevers can be as thin as a few nanometers with lengths that range from a few microns to several hundred microns. Microcantilevers are used in micro transducers, sensors, switches, actuators, resonators, and probes. As transducers, microcantilevers are operated in the static and the dynamic modes.

The microcantilever is one of the cornerstone components of MEMS. It is used in a wide variety of MEMS applications including micro-chemical sensor arrays, atomic force microscopes, microswitches, needles and atomic force probes.

Activity Objective

Activity Objectives

- Identify the correct terms used for several definitions or statements related to microcantilevers.
- Research and discuss the operation of a specific MEMS application that incorporates a microcantilever or microcantilever array.

Resources

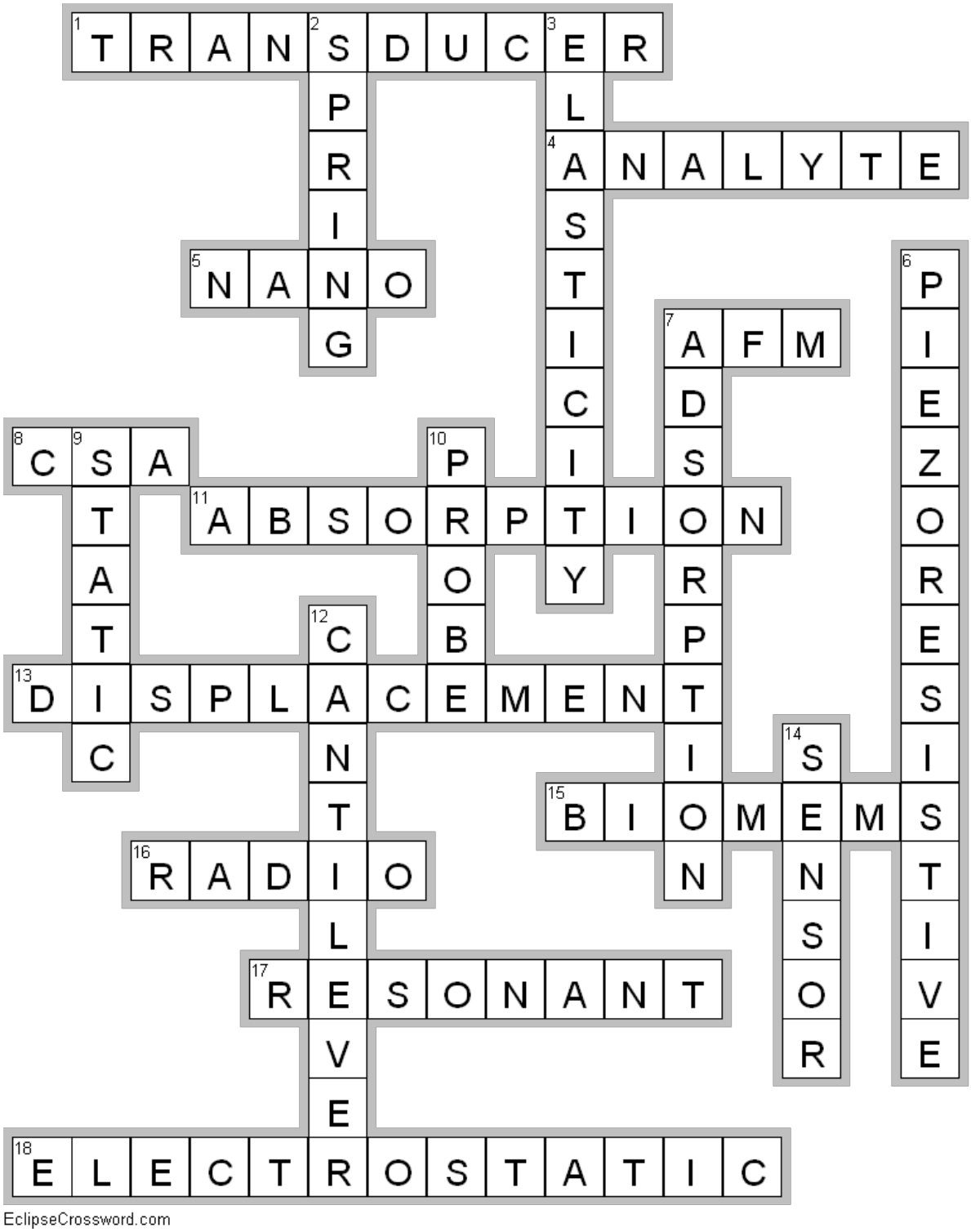
SCME's Microcantilevers Learning Module.

Documentation

1. Completed Crossword Puzzle
2. Questions and Answers to the Post-Activity Questions

Activity: Microcantilevers Terminology / Answers to Crossword Puzzle

Procedure:
Complete the crossword puzzle using the clues on the following page.



Across

1. A system which transforms one form of energy (mechanical) to another (electrical) or vice versa, is called a _____
4. A substance or chemical constituent that is undergoing analysis or being measured.
5. One one-thousands of a micron (micrometer) is a _____ meter
7. Abbreviation for the type of microscope which can measure down to the atomic forces.
8. Chemical Sensor Array - abbr.
11. The incorporation of a substance in one state into another of a different state (e.g., gas molecules entering into a liquid, or liquid into a solid).
13. A cantilever based sensor system used in static mode measures the bend or flex by detecting a change in the angular _____ of a light beam, for example.
15. Microsystems applications in the biological and medical fields are also referred to as _____
16. Cantilevers are used in RF application. The "R" stands for _____
17. The frequency at which an object vibrates naturally is also called the _____ frequency. It is the frequency at which a system oscillates when struck.
18. The type of actuation used in many MEMS devices, including the cantilever. Hint: Of or related to electric charges at rest or static charges

Down

2. For an object that obeys Hooke's Law, the _____ constant is defined as the force needed to stretch a structure per unit extension (N/m)
3. Young's modulus of _____
6. When stress is applied to these materials, the resistance changes. This is called a _____ material or effect.
7. _____ is the adhesion of molecules to a surface.
9. A cantilever can vibrate or just bend. When we measure the change in the frequency, we are using the cantilever system in dynamic mode. When we measure the amount that a cantilever bends, we are measuring the change in _____ mode.
10. Cantilever _____ coating on which the target molecules or particles stick.
12. A suspended beam fixed at one end.
14. A device or system which measures an environmental factor such as pressure, pH, amount of a certain gas in the air, microphone, chem lab on a chip, etc.

Post-Activity Questions / Answers

1. List at least three MEMS applications of microcantilevers.

   Answer: chemical sensor arrays, transducers, sensors – detect biomolecular analytes in blood samples, detect specific gases in the atmosphere, test water samples, support and transport probes for memory devices and analytical tools, needles and probes, switches

2. Briefly describe the two methods of transduction measurement used in static mode microcantilevers (how is the bend measured?)

   Answer:

   - *Change in Angular Deflection (Δ angular deflection) – Reflective material is embedded as a layer onto the surface of the cantilever. A laser beam is directed to and reflected from the cantilever's surface creating a reference angle of deflection (see figure). As the cantilever bends the change in the angular deflection is measured. The measuring device is normally a position sensitive light detector.*
   - *Change in resistance (ΔR) - Piezoresistive material is embedded as a structured layer within the cantilever. The piezoresistive layer is normally a doped silicon layer. As the cantilever bends, a change in resistance is measured in the piezoresistive layer. The change in resistance is proportional to the amount of bend (or stress).*

3. Research a specific MEMS that incorporates a microcantilever component which is used as a transducer or sensor. Describe the application, function, and limitations of this device. Your write-up should include, but is not limited to the following criteria.
   a. Application – What does it do, what is it use for, and who uses it?
   b. Operation – Physical description (i.e., size, components) and how does it work?
   c. Limitations and Versatility – What is its specificity (if any)? How versatile is it? (i.e., Is it adaptable for other fields than the one described?) What are its limitations (e.g., sample size, sample type)?

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