History of MEMS Activity
Instructor Guide

Note to Instructor

History of MEMS Activity is an activity for the *History of MEMS Learning Module*. This activity is a crossword puzzle for terminology and timeline, and a research project to delve more into the history of MEMS. This activity should be completed after the reading material – History of MEMS.

The *History of MEMS Learning Module* consists of the following:
- Pre-test or Knowledge Probe
- History of MEMS Primary Knowledge
- **History of MEMS Activity**
- New Innovations in MEMS Activity
- History of MEMS Final Assessment

This companion Instructor Guide (IG) contains all of the information in the PG as well as answers to the Post-Activity questions.

Description and Estimated Time to Complete

This Activity provides
- A crossword puzzle which tests your knowledge of MEMS history
- Research activity questions that allow you to delve deeper into the history of MEMS

Allow at least 15 minutes to complete the crossword puzzle.
Allow up to 3 hours to complete the research activity questions.

Introduction

There are many events and milestones which occurred in the development of microsystems technology. This activity will exercise your knowledge of many of these historical events.

Activity Objectives and Outcomes

Activity Objectives

- Exercise your knowledge of MEMS history by completing a crossword puzzle
- Exercise your knowledge of MEMS history by answering the research activity questions

Activity Outcomes

After the completion of this activity, you will have strengthened your knowledge of the milestones which have occurred in MEMS history.

Dependencies

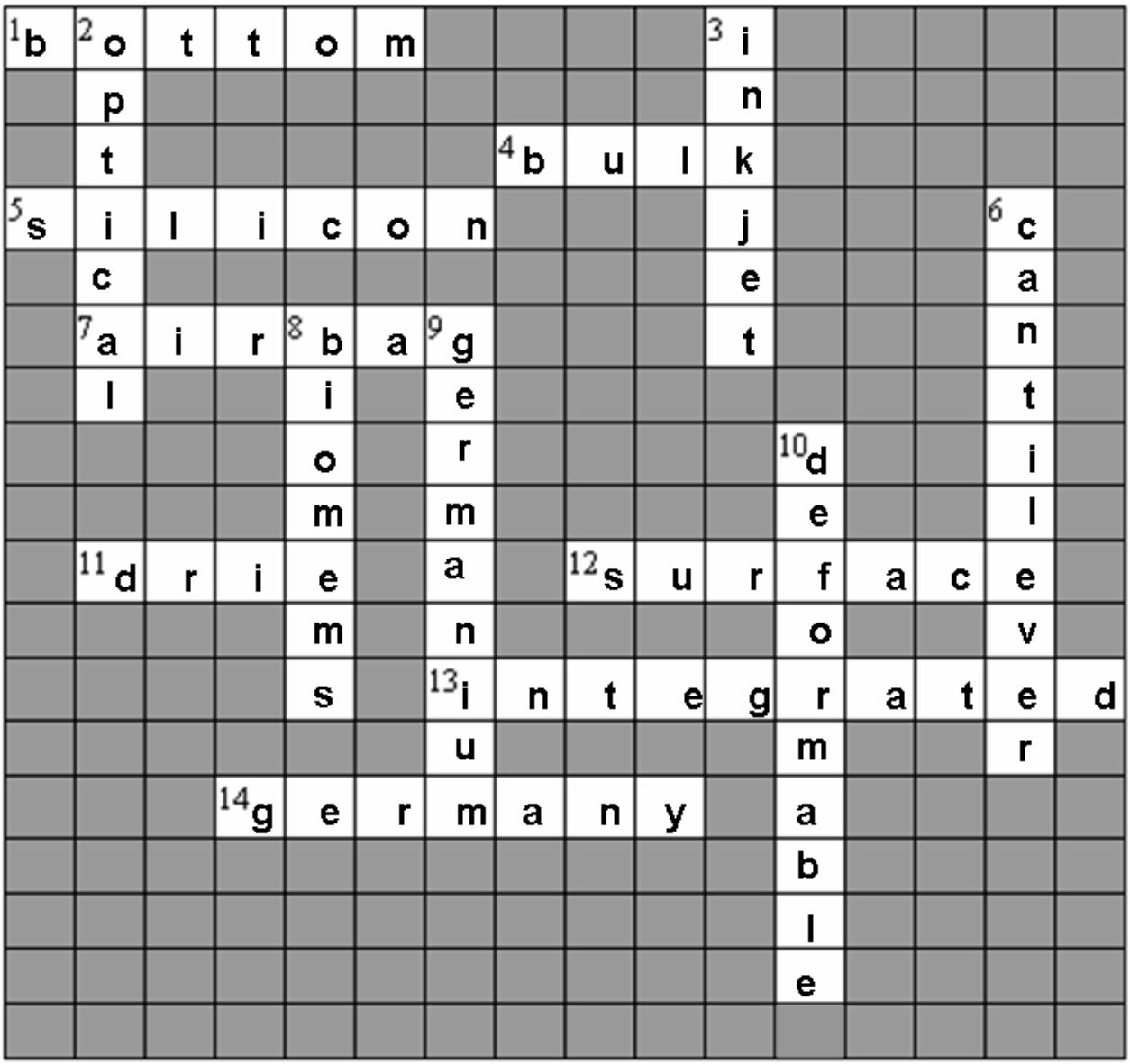
It would be helpful to review the following material:

- History of MEMS Primary Knowledge

Supplies

- A printout of the crossword puzzle
- Pencil
- The Research Activity Questions

What Do You Know About MEMS History? ***Crossword Puzzle ANSWERS***



MEMS History Crossword Puzzle

Across

1. Richard Feynman's talk was entitled "There's Plenty of Room at the _____".
4. _____ micromachining utilizes the anisotropic etching of silicon.
5. This crystalline material is commonly used as a MEMS substrate.
7. The first high volume surface micromachined accelerometer is used in this common automotive safety device.
11. This high aspect ratio anisotropic process creates deep trenches.
12. The resonant gate transistor demonstrated _____micromachining techniques.
13. This type of circuit includes the transistors, resistors, capacitors, and wires needed to interface with a micromechanical device.
14. The LIGA process was developed in this country.

Down

2. Lucent developed this type of network switch.
3. This type of printer uses MEMS technology.
6. The atomic force microscope uses this type of MEMS structure.
8. This area of study combines biological concepts with MEMS technology.
9. C. S. Smith discovered the piezoresistive effect in silicon and _____.
10. The _____ grating light modulator is a MOEMS device.

Research Activity / Answers

Locate the transcript of a talk given by Richard Feynman entitled "There's Plenty of Room at the Bottom". Read the transcript and answer the following questions. Some of the questions require the use of the web for additional information. Please cite references when necessary and feel free to quote passages with proper references.

1. What does Feynman mean when he says "The resolving power of the eye is about 1/120 of an Inch"?

Resolving power is the ability of an imaging device, for instance, the eye, to measure the angular distance between two points. The term resolution refers to the minimum resolvable distance between two distinguishable objects in an image. "The resolving power of the eye being 1/120 of an inch" means that the angular distance between the two points that the eye can distinguish is 1/120 of an inch.

2. If the diameter of a human hair is approximately 80 microns, what is the diameter of hair in angstroms?

There are 10,000 Angstroms in 1 micron, therefore, 80 microns = 800,000

3. What do you think Dr. Feynman implied when he commented that lubrication may not even be necessary as a machine gets very small?

Answers may vary, but may include:
At such a small scale, the forces and heat effects on microscopic machinery are minimal; therefore there would be little or no need to lubricate such parts.

4. In this paper, Dr. Feynman mentions that the internal combustion engine would not function if made very small. Why?

The internal combustion engine requires the combustion of a fuel. Feynman explains that at such a small scale, the rapid heat loss in small machinery would prevent the fuel from exploding. Therefore, the internal combustion engine could not be miniaturized.

5. Can our current technology "rearrange atoms"? (Justify your answer with an explanation and supporting sources.)

Answers may vary

6. What is "Van der Waals" attraction? What were Feynman's concerns about Van der Waals in reference to micro systems?

Van der Waals attraction is the attraction between molecules, atoms, and surfaces. Intermolecular forces consist of electrostatic interactions, induction or polarization, and dispersion. Feynman stated that at such a small scale, the Van der Walls forces would cause the tiny parts basically to stick together since gravity at that scale is not appreciable.

7. What did Dr. Feynman's friend, Albert Hibbs, suggest as a possible use of these relatively small machines?

He described medical procedures that involve tiny machines performing diagnostic and corrective surgery, in particular correcting faulty heart valves.

8. In Feynman's paper what do servo motors and pantographs have in common?

Answers may vary, but may include:
A servo motor, as Feynman describes, acts as a transducer, converting mechanical energy into an electrical current. A pantograph has the ability as a mechanical device to amplify the movement of a specified point. So the two serve as devices that convert mechanical energy into another form. He is using the pantograph as an example of how perhaps a servo motor could be used to make tiny machines.

9. Feynman mentions the possibility of biological computers. Do they exist today, and if so, what is their current level of technology and what are their applications?

Answers may vary, but may include:
Artificial DNA
Systems built from DNA and Neurons that can solve problems on their own

10. Who is William McLellan and what connection does he have to Microsystems?

William McLellan answered Feynman's challenge and collected the $1000 prize for being the first person to build a working electric motor that would fit inside a cube with sides 1/64 inches.

References

"There's Plenty of Room at the Bottom". Richard P. Feynman.
http://www.zyvex.com/nanotech/feynman.html

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).