Exercises for Module 1

of

Micro and Smart Systems NPTEL Course

(The following problems are taken from instructors' book entitled "Micro and Smart Systems", John Wiley, 2012.)

1.1 Which of the following transduction mechanisms can be used to realize a micromachined accelerometer? (a) piezoresitivity, (b) piezoelectricity, (c) Peltier effect, (d) Hall effect, and (e) photoelectric effect. For those transduction techniques useful in making an accelerometer, draw a sketch and explain how such an accelerometer would work.

1.2 As compared with the size of the other components (e.g. fan, lamp, lens, etc.) in a digital projector, the size of the micromirror array chip is quite small. Argue why it is necessary to make the chip so small. What happens if the size of each mirror is increased?

1.3 Collect data on electrostatic comb-drives to answer the following questions:
a. Why is a comb arrangement with many interdigitated fingers used?
b. Is the force vs. deflection characteristic of a comb-drive actuator linear?
c. How much force and displacement can be generated with a typical comb-drive?
d. Will a comb-drive work in aqueous environments?

1.4 We discussed a conductometric gas sensor in this chapter. What are other methods that are used to detect gases? Which one has been used in microsystems? Which ones could be used and which ones cannot be used? Support your answers with suitable arguments.

1.5 Find an used inkjet print head. Break it open to see where the chip is and how it is connected to the components that are around it. Do the same for the ink-cartridge. Identify different components that make the microsystems chip in them useful in practice. Comment on the importance of packaging in microsystems in this example.

1.6 Visit a molecular biology laboratory that uses a PCR system and discuss with its users how they use it and what for what purpose. If they are using a system that does not use microsystems components, how would you convince them to switch over to a microsystems-based PCR system?

1.7 This chapter included a description of smart materials. A beam made of a ''normal'' material bends when a load is applied to it. A beam made of a ''smart'' piezoelectric material not only bends but produces an electric charge when a load is applied. Both materials behave in their specific ways. Then, why is that we consider some materials to be smart? Does smartness lie in the way we use the material or in their very nature?

1.8 Search the literature and identify a few devices that use smart materials. Which of these have been miniaturized using microsystems technology?

1.9 Choose a system that you consider ''smart'' and explain why you think it is smart. Is mobile phone a smart system? Is a motorcycle a smart system? How about a washing machine and a home water-purifier?

1.10 Are biological materials smart in the sense we call some materials smart? Explain with examples.

1.11 State some applications of smart materials in bioengineering and medicine.

1.12 State how one can use smart materials in energy harvesting.

1.13 What are the essential difference between Piezoelectric and Electrostrictive material?

1.14 Can shape memory alloy wires be used as a sensor? If so what property of the SMA wires can be used for sensing?

1.15 What are the issues that a designer has to consider if the smart sensors need to be embedded in structures made of laminated composites?

1.16 Is signal processing critical for smart structures applications? If so, state where it is critical with some example applications?

1.17 Highlight the role of control theory in smart structures and systems applications?

1.18 State the difference between active and passive sensing, especially in the structural health monitoring applications

1.19 State principle on which the laser doppler vibrometer works.