



16 - Microelectromechanical Systems (MEMS)

Miniaturisation of electronics has provided the world with a higher standard of living. Now the miniaturisation of mechanical systems has the potential to also change the way we interact with our physical world.

While seeming to be part of science-fiction, nanotechnology has entered into mainstream industrial applications primarily through microelectromechanical systems (MEMS). These devices are very small physical devices that are built into a microprocessor and enable the merging of sensing, actuation and computing that provide for enhanced perception, control and performance.¹ The size of the moving parts can range from less than one-millionth of a millimetre to a millimetre.²

The development of MEMS allows designers to integrate analogue signals with digital circuitry in one device. These devices have been used in mass quantities for the deployment of automobile air-bags and for measuring pressures within mechanical systems. It is estimated that one-third of all MEMS are expected to be used in the automotive industry.

Background to MEMS Development

The development of the silicon microprocessor led to a number of manufacturing techniques using the elements germanium and silicon. In 1954, developers discovered that an electrical resistance would allow pressure to be measured in microsensors that used germanium and silicon. These devices were able to be fashioned into strain gauges that provided greater sensitivity than the existing devices.³ These sensors were developed by National Semiconductor in volume in 1974 for use in thermostats.

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A second development in manufacturing MEMS was the use of micromachining in which a layer of silicon would be removed through a chemical process. This process uses an etching process and removes the unwanted portion of silicon with the mechanical device remaining. A third development has been the use of layers of a material on the silicon that are removed during an etching process that leaves the remaining substrate able to move freely. This process is known as the sacrificial layer technique.⁴

The use of the sacrificial layer process provides for mass production processes and for the integration of digital circuits and analogue devices to be on one silicon chip.⁵ These manufacturing techniques have allowed for the development of MEMS to be at a level in which replication of MEMS presents little technical difficulty. With these maturing manufacturing techniques improving there is an expected 20 per cent annual increase in the market to between \$26 to 50 billion.⁶

Current and Future Applications

As mentioned above, MEMS have been used in thermostats and air-bag deployment devices but there are many more applications. Many inkjet printer heads uses MEMS as well as hard disk drives and blood pressure monitoring devices. Future applications are largely in the hands of designers and is expected to include consumer electronics, biotechnology and further automotive applications such as tyre-pressure and temperature monitoring.⁷

One industry likely to have a significant use for MEMS is in telecommunications - especially within the optical networks. This is important as the current method of switching in an optical telecommunications network is to convert the optical data stream into an electrical data stream, to read this and then re-convert this back into an optical signal so that it can continue to its destination. This type of switch is known as an optical-electrical-optical (OEO) switch.

The optical-electrical-optical switches are currently in use but with the demand for faster networks, there is the desire to do away with the intermediate step and just have an "all optical" switch (known as an OOO switch for optical-optical-optical). While this holds great promise, there is a concern that it will be more difficult for network managers to "read" the signal for fault correction purposes and network performance.⁸ There is some suggestion that by having mirrors attached to a rotating mechanical device the optical signal could be redirected without converting the signal into an electrical data stream.

Other applications will become available during the next five years that are likely to be closely guarded commercial secrets. The development of the majority of MEMS went from the research laboratory to commercial application within the space of ten years. With the microprocessor manufacturer Intel intent on developing the ability to place a radio on each microprocessor,⁹ there are many possible applications possible in the next five years.

Summary

The purpose of this chapter is to raise the awareness of individuals in the Shared Technology Industries to the expected development and employment of these systems. The expected rapid development into industry areas will require an additional underpinning knowledge of technicians regarding microprocessors and how these devices operate.

While it is not necessary to know exactly how a microprocessor works to use a computer, it is important to understand what technology is being employed. It is also important to be able to make intelligent and informed decisions in relation to the installation, repair, maintenance and upgrade of electronic systems.

IMPLICATIONS FOR THE SHARED TECHNOLOGIES INDUSTRIES

Automotive

This industry current has one of the largest uses of MEMS of all of the Shared Technology industries. The expected increase in use within automotive equipment will require greater awareness and sensitivity to the maintenance and repair of motor vehicles.

Building and Construction

This technology is widely used within thermostats and other sensing devices. Continued development is expected that will require the awareness of systems and their interaction with the environment.

Electrical

This technology has the potential to significantly transform the technology for switching equipment. It may be possible to remove macro-switches and replace these with microprocessors. Technicians in this area will need to be aware of the likely transition from these larger devices to computer-driven microsystems.

Electronics

This industry will see an expansion in the range of devices in consumer electronics and telecommunications that will impact on this industry area. This increase in applications will require technicians in this industry to continue with professional development.

Engineering

This industry has the potential to have many structural changes take place. As much of process and manufacturing automation is based upon digital signal processors, the ability to have both electromechanical and digital process on one silicon chips can create substantial change. Conservative

views may have to give way to these newer and highly-sensitive microprocessors.

Information Technology

While this technology is essentially a microprocessor, the information technology industry is unlikely to be greatly affected. The reason for this is that information technology is primarily a static, non-analogue industry and therefore applications are limited.

Telecommunications

The move to an “all optical” communications network will see the need for faster switching capabilities. While this technology is not yet mature in optical switching, the demand for a solution will see vendors pursuing this goal. Additionally, it is likely that current multi-processor devices will compact into single “system-on-a-chip” microprocessors that will combine the current range of digital signal processors. The technician in this area will need to continue with professional development.

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