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Smart Materials: A Primer

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Abstract— Smart materials are those that change one or more of their properties (shape, color, size, etc.) when subjected to an external stimulus. These materials possess adaptive capabilities and perform better than ordinary, dumb materials. They are considered smart because their in-built sensing and actuation capability. This paper provides a brief introduction to the properties and applications of smart materials.

Keywords— Smart materials, smart systems, intelligent structures, active/adaptive materials

I. INTRODUCTION

The need for new generation of advanced materials in modern applications has led to the development of the smart materials. The idea of smart materials originated in mid-1980s. Their perception implies an ability to be clever, active, and sophisticated [1]. Smart materials are unique in that they exhibit different properties when there is change in their environment. They react to changes in temperature, stress, moisture, pressure, light, electric or magnetic field. This peculiar property makes them useful for certain applications. Their degree of smartness is dictated by their responsiveness to environmental stimuli. Structures that are made from smart materials are referred to as smart structures.

Smart materials are often composite materials. They have several advantages over conventional materials. These include lighter weight, no corrosion, and increase in lifespan of the structures that use them. They have an active role to play in shaping our world, whether in designing clothes, infrastructure, cars or airplanes.

II. TYPES OF SMART MATERIALS

There are different types of smart materials. Each type exhibits different characteristics that can be changed. Some examples include [1, 2]:

- *Piezoelectric*: These are materials (mainly crystals) that produce electric voltage when stress is applied. Conversely, applying a voltage across a piezoelectric material causes a change in the shape. Piezoelectric materials are lightweight and compact. They are used in microelectronics, optics, biology, medicine, and mechanical engineering. Piezoelectric devices can act as transducers between electric potential and frequency.
- *Electrostrictive*: Electrostriction is present in dielectric materials such as lead magnesium niobate (PMN). Both piezoelectric and electrostrictive materials belong to the same ferroelectric family. But electrostrictive materials may be more reliable than piezoelectric materials due to some physical properties.
- *Magnetostrictive*: These are the magnetic analogue of electrostrictive materials. They are ferromagnetic materials that change in shape when magnetic field is applied. They can convert magnetic energy to kinetic energy. They are used in constructing sensors and actuators.
- *Shape memory alloys* (SMA): This is the class of adaptive materials that are thermally activated and can transform thermal energy into mechanical work. They are unique metallic alloys. These materials exhibit high power volume ratio. They are recognized for their unusual thermo mechanical properties, memory form effect, and damping capacity. A typical example is nickel-titanium alloy (NiTi). Some of the applications of SMA take advantage of their superelasticity [3]. This property enables the smart material to go back to its original dimension after stress-induced changes.
- *Optical fibers:* These are dielectric structures designed to guide light. They possess lightweight, geometrical flexibility, and low attenuation. They have high bandwidth and are immune to electromagnetic interference. The emergence of optical communication has led to the development of embedded optical sensors. Optically smart structures can automatically change color to match their background.

Smart materials are either active or passive. Active materials have the inherent ability to transduce energy, while passive do not. Examples of active smart materials are piezoelectric materials, while fiber optic is passive. Passive materials can be used as sensors but not as actuators [4].

III. APPLICATIONS

Smart materials have found some commercial and industrial applications. Engineering applications can be broadly divided into two classes: (1) sensors or sensing devices, (2) motors and actuators. They have been applied in medicine (pediatric devices), civil engineering (building, dams, highways, and bridges), automotive industry (brakes, shock absorbers, smart cars and trucks), and skin-diagnostics. They are also used in making smart material interface and smart vacuum cleaner [5]. The basic properties of smart materials, including superelasticity and shape memory, are leveraged in some of these applications.

IV. CONCLUSIONS

The dumb, conventional materials of the past are now becoming smart. Smart materials are the next generation of materials that have a potential to impact different fields including science, engineering, medicine, and automotive industry. They will have significant impact on civilization.

The technology of smart materials is an interdisciplinary, emerging field. A number of technical, peer-reviewed journals are dedicated to publishing information on smart materials. Three of such are *Smart Materials and Structures*, *Smart Material Research*, and *Journal of Intelligent Material Systems and Structures*.

REFERENCES

[1] H. J. Tzou, H. J. Lee, and S. M. Arnold, "Smart materials, precision sensors/actuators, smart structures, and structronic systems," *Mechanics of Advanced Materials and Structures*, vol. 11, no. 3-5, 2004. pp. 367-393.

[2] B. Sun, *Smart Materials and Structures*. Cape Town, South Africa: Cape Peninsula University of Technology, 2015.

[3] P. Gumpel and J. Strittmatter, "Smart materials: opportunities and applications in some fields," *Australian Journal of Mechanical Engineering*, vol. 7, no.1, 2009, pp. 99-109.

[4] S. Kamila, "Introduction, classification and applications of smart materials: an overview," *American Journal of Applied Sciences*, vol. 10, no. 8, 2013, pp. 876-880.

[5] D. Vyas et al, "Smart material interfaces: a new form of physical interaction,"*CHI '12 Extended Abstracts on Human Factors in Computing Systems*, May 2012, pp.1721-1726.

