Applications of Smart Materials

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The kind of **‘smartness’** shown by these materials is generally programmed by material composition, special processing, introduction of defects or by modifying the micro-structure, so as to adapt to the various levels of stimuli in a controlled fashion. Like smart structures, the terms ‘smart and ‘intelligent’ are used interchangeably for smart materials. intelligent materials are materials which respond to environmental changes at the most optimum conditions and manifest their own functions according to the environment. The feedback functions within the material are combined with properties and functions of the materials.

Smart systems also sense their environment and respond, but are not constructed from a single material. They may incorporate smart materials, but can also be constructed using traditional technology. Pacemakers are a smart system designed to respond to an irregular heart rate with an electrical impulse that regulates it. smart system refers to a device which can sense changes in its environment and can make an optimal response by changing its material properties, geometry, mechanical or electromagnetic response. Both the sensor and the actuator functions with their appropriate feedback must be properly integrated. the system could lose its application or could be dangerous if the response is too slow or too fast. Some common smart materials and associated stimulus response are listed in figure (Fig. 1)

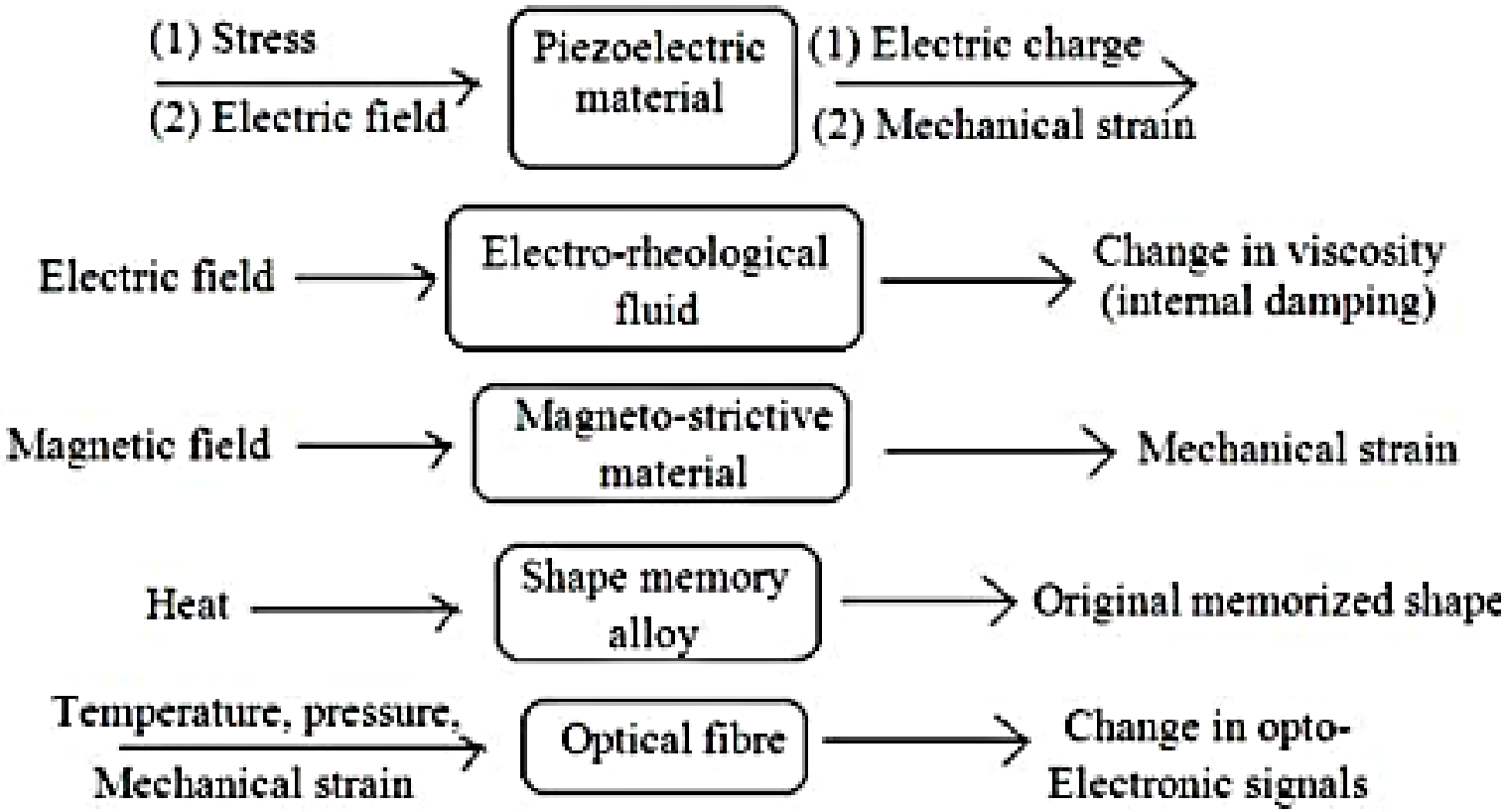

Fig. 1. Common smart materials and associated stimulus-response

Smart materials and systems have a wide range of applications. Investment in research and development is driven by factors such as legislation, reducing waste and demand for higher quality of life. Structures such as buildings, bridges, pipelines, ships and aircraft must be strongly designed and regularly inspected to prevent ‘wear and tear’ damage from causing disastrous failures. Inspection is expensive and time consuming, while designing to prevent damage can compromise performance. With some modern materials, damage can be internally serious but leave very little surface evidence.

1- Structural Health Monitoring:

Embedding sensors within structures to monitor stress and damage can reduce maintenance costs and increase lifespan. This is already used in over forty bridges worldwide.

2- Self-Repair:

One method in development involves embedding thin tubes containing uncured resin into materials. When damage occurs, these tubes break, exposing the resin which fills any damage and sets. Self-repair could be important in inaccessible environments such as underwater or in space.

3-In the Field of Defense and Space:

Smart materials have been developed to suppress vibrations and change shape in helicopter rotor blades. Shape-memory-alloy devices are also being developed that are capable of achieving accelerated breakup of vortex waves of submarines and similarly different adaptive control surfaces are developed for airplane wings. Besides, present research is on its way to focus on new control technologies for smart materials and design methods for placement of sensors and actuators.

4- In Nuclear Industries:

Smart technology offers new opportunities in nuclear industrial sector for safety enhancement, personal exposure reduction, life-cycle cost reduction and performance improvement. However, the radiation environments associated with nuclear operations represent a unique challenge to the testing, qualification and use of smart materials. However, the use of such smart materials in nuclear facilities requires knowledge about the materials respond to irradiation and how this response is influenced by the radiation dose.

5- In Structural Engineering:

These materials also find application in the field of structural engineering. They are used to monitor the civil engineering structures to evaluate their durability. Not only the smart materials or structures are restricted to sensing but also they adapt to their surrounding environment such as the ability to move, vibrate and demonstrate various other responses. The applications of such adaptive materials involve the capability to control the aero elastic form of the aircraft wing to reduce the pull and improve operational efficiency, to control the vibration of satellites' lightweight structures, Smart structures are also being developed to monitor structural integrity in aircraft and space structures. Effort has been made to investigate certain piezoelectric materials to reduce noise in air conditioners. Besides, in civil engineering, these materials are used to monitor the integrity of bridges, dams, offshore oil-drilling towers where fiber-optic sensors embedded in the structures are utilized to identify the trouble areas.

6- Biomedical Applications:

In the field of biomedicine and medical diagnostics, still investigations are being carried out. Certain materials like poly-electrolyte gels are being experimented for artificial-muscle applications, where a polymer matrix swollen with a solvent that can expand or contract when exposed to an electric field or other stimulation. In addition, due to biodegradability of these materials, it may make it useful as a drug-delivery system.

7- Reducing Waste:

All over the world, the electronic wastes are the fastest growing components of domestic waste. During disposal and processing of such wastes, hazardous and recyclable materials should be removed first. Manual disassembly is expensive and time consuming but the use of smart materials could help to automate the process. Recently fasteners constructed from shape memory materials are used that can self release on heating. Once the fasteners have been released, components can be separated simply by shaking the product. By using fasteners that react to different temperatures, products could be disassembled hierarchically so that materials can be sorted automatically.

8-Reducing Food Waste:

Food makes up maximum waste among all others. Most of the food grown for consumption is thrown away without consumption due to their reaching of expiry date. These dates are conservative estimates and actual product life may be longer. Manufacturers are now looking for ways to extend product life with packaging by utilizing smart materials. As food becomes less fresh, chemical reactions take place within the packaging and bacteria build up. Smart labels have been developed that change color to indicate the presence of an increased level of a chemical or bacteria in it. Storage temperature has a much greater effect than time on the degradation of most products. Some companies have developed ‘time-temperature indicators’ that change color over time at a speed dependent on temperature.

9- Health:

Biosensors made from smart materials can be used to monitor blood sugar levels in diabetics and communicate with a pump that administers insulin as required. However, the human body is a hostile environment and sensors are easily damaged. Some researches on barrier materials are going to protect these sensors. Now-a-days different companies are developing smart orthopedic implants such as fracture plates that can sense whether bones are healing and communicate data to the surgeon. Small scale clinical trials of such implants have been successful and they could be available within the next five years. Other possible devices include replacement joints that communicate when they become loose or if there is an infection. Current technology limits the response of these devices to transmitting data but in the future, they could respond directly by self-tightening or releasing antibiotics. This could reduce the need for invasive surgery.

10- The Ageing Population:

There are now more people aged over 60 in almost every part of universe than children, creating a new market for products that make life easier for the elderly. Many of these could use smart materials and systems to include added functionality. For example, shape memory materials could be used in food packaging that automatically opens on heating for people with arthritis. Smart homes have been developed by researchers for people with dementia that uses sensors to monitor behavior and to ensure that the resident is safe.