A Study of Smart Materials, Classification and Applications : A Review

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ABSTRACT: *Smart materials are the key to 21st-century in this technology competitive era due to their extrinsic and intrinsic properties. Different smart materials are used to improve lifetime reliability and efficiency significantly increases levels of functionality. "Smart Materials" will play important role in building technology development, manufacturing technology. Smart materials are the part of a smart structural system that has the capability to sense the change in environment, so that these materials can function like living systems. The terms 'smart' and 'intelligent' was firstly used the 1980"s by the US defense. Different groups of smart materials consisting of particular properties are using in a variety of high-tech and everyday applications. The different type of smart materials such as shape memory alloys, piezoelectric materials, magneto-rheological and electro-rheological materials, magneto-strictive materials and chromic materials which change their shape , size and colour in reaction to various environmental conditions.*

Keywords: Smart materials, Shape Memory Alloy (SMA), Stimuli, Piezoelectric Materials

Introduction: The term 'intelligent' 'adaptive' and 'organic' are defined to highlighting the difference with the term 'Smart'. Many research use the word 'intelligent' and 'smart' as interchangeably while the term 'adaptive' and 'organic' become lesser known(Roger et al., 1988). Smart materials refers to those materials which are able to sense change in environment and make an optimal response by changing their shape , mechanical and materials properties(Vardan and Vardan , 2000).

In this review paper the authors mainly deals with previously explained idea by various researcher, scientist, research scholar and ignited mind student.[review a]

3.1. Definitions of smart materials

NASA defines smart materials as "materials that configurations and can conform to them when given a specific stimulus" [1].

Encyclopedia of chemical technology defines smart materials and structures; are those objects that sense environmental events, a process that sensory information, and then act on the environment [1].

In architectural definition, smart materials are high technological materials that when placed in a building they respond intelligently to the climatic changes, in different seasons [1].

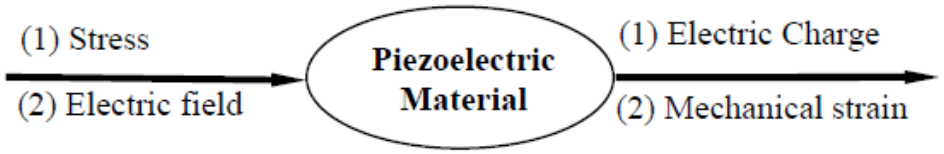
Smart materials have extrinsic and intrinsic properties which means that their properties can be change by an external or internal conditions such as light, temperature, electricity, or pressure. This change is vice versa and can be repeated many times.

Types of smart materials

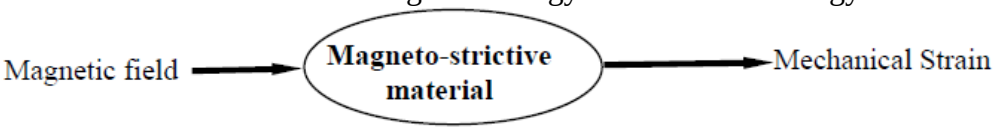
Smart materials are classified into two groups -

Type I

This types of Smart materials converts one form of energy to another without alter the material, it stays the same, but the energy undergoes a change, include the following
Piezoelectrics materials - These materials converts an input of elastic energy(stress) into output of an electrical charge(mechanical strain). Most piezoelectrics materials are bi-directional.
It works on piezoelectric effect that is if a mechanical force is applied to the material to change its shape.

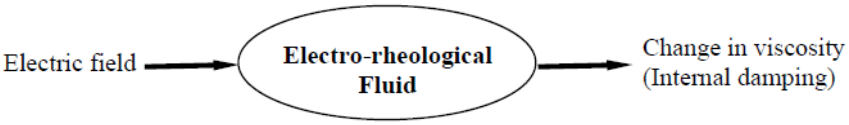


Stimulus response of Piezoelectric Material
Magneto-strictive materials - These materials converts an input of a magnetic field into output of mechanical strain(elastic energy) which deforms the shape of the material.
It works on magneto-strictive effect in which materials convert magnetic energy to mechanical energy or vice versa.

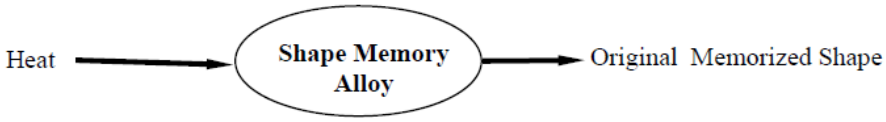


Stimulus response of Magneto-strictive Material

Electro-strictives materials - These materials converts an input of electric field into output of internal damping(change in viscosity) which deforms the shape of the material.
It works on electro-strictive effect in which materials convert electrical energy to mechanical energy or vice versa.



Stimulus response of Magneto-strictive Material
Shape memory Alloy– These materials converts an input of heat(electrical current) into output of a temperature differential on opposite sides of the material .
It works on thermo-strictive effect in which materials convert electrical current(heat) energy to temperature difference or vice versa.



Stimulus response of Shape memory alloy

Type II

Materials undergo changes in one or more of their properties like chemical, electrical, magnetic, mechanical, or thermal in direct response to a change in external stimuli in the surrounding environment. It includes the followings.
Mechanochromics – This type of materials change colour due to imposed stresses or deformations.

Chemochromics - This type of materials change colour when exposed to specificchemical environments.
Electrochromics - This type of materials change colour when a voltage is applied.
Phototropics –This type of materials change color when exposed to light.

Characteristics of smart materials

Immediacy - Smart materials has ability to response quickly as change in environment in real time.
Transiency - Smart materials has ability to response in a number of environmental state.
Self –actuation - Smart materials are so smart that it can resolve a problem internally.
Selectivity - Smart materials are so able that there response are different andobservable.

Advantages of smart materials

Smart materials may offer a wide range of benefits in field of mechanical engineering including following.

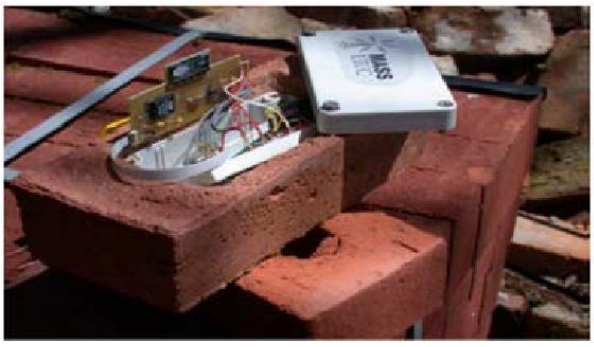
- Smart materials consist of superior strength and ductility.
- Smart materials have better service life.
- Increased resistance to abrasion, corrosion, chemicals, and fatigue.
- Smart materials have better life-cycle cost efficiencies.
- Smart materials can be easily of manufacture and application or installation.
- Smart materials product are Aesthetics.
- Smart materials have ability for structural control.

Applications of smart materials

Smart materials consists of a wide range of applications due to their unique response to external changes such as light, temperature, electricity, or pressure. The different areas of application can be in our day to day life, Biomedical, aerospace, Health, military, civil engineering applications and stealth applications. Smart materials are also use for creation of new products to solve engineering problems with efficiency to generate revenue. Different types of smart structures are being used in space systems, military aircrafts, naval vessels, civil structures, machine tools, recreation and medical devices.

3.5.1 Civil Engineering

Smart bricks consist of sensors, some wireless communication devices and signal processors to measure hidden stresses, or damage after natural disaster such as earthquakes. A number of different sensors are also used to measure the force, stress and detecting the humidity, moisture and sound. In a smart building temperature monitoring sensors are used to collect the information regarding the safety of building related to the fire.



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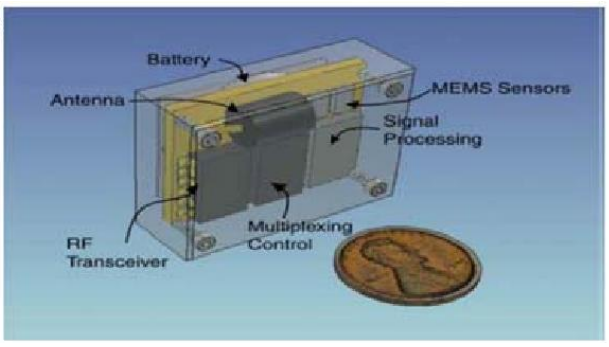

Mechanical Engineering

Leaf springs are made of the composite materials of shape memory alloys. Shape memory alloys can easily regain their original properties that's why it is used in the leaf springs.Shape memory alloys have ability tobear the high stresses and toughness so leaf springs prevent the passengers from shock. In any critical conditions, if leaf spring deformed or broke down then it can be easily regain its original properties by introducing the shape memory alloys after heating.

Medical Science

Different Surgical tools, those used in key hole surgery may be made from shape memory alloy because it can easily bent in a particular shape for individual patient and after use it can return to their original shape. The shape memory alloy material is activated by the temperature of the mouth that's why it used for the desired shape of the teeth. The shape memory alloyexerts enough force as it contracts to move the teeth slowly and gradually.

Aerospace Engineering

The aerospace industry is highly interested in smart materials due to light weight , reduction in the complexity of product and effective material properties. Various smart materials are being used by Engineers at Boeing, General motors, and lock had martin . For controlling the flaps on the trailing edge of aircraft wings the wire made of SMA is used which reduced the component

size , complexity, functionality , reliability, design flexibility, and reduce weight. While on the other hand ,in conventional method it was control by the hydraulic systems.

Fig. Trailing edge of aircraft made of SMA [7]

Stealth Application

In this technology an object is operate without giving the indication of their presence or hide to enemy force which is achieve by make them less visible to the detection methods such as inferred , radar and sonar.

Development of stealth technologies in the US began in 1958 during cold war.

The good examples of this technology are bomber B-2 and fighter jet F-117.

Future scope A number of scientist, researcher, research scholar and ignited mind students expressed their visionary idea about the future application of smart materials in international conferences and seminars held by different institutes. Some of the possible application from them are as follows

Thermal mitigation: It is the thermal property which enable the material to make them usable up to ultra-high temperature(above 135C) by transforming their composition.

Damage arrest : It is the mechanical property which enable a material to restrain the propagation of cracks by producing compressive stress.

Shock absorber : It is the mechanical property which enable a material to generate a force against the sudden load applied.

Self-Healing material: It is the

Conclusion

The term “Smart materials” is use for a wide group of different substances. But the common feature of smart materials are that they have extrinsic and intrinsic properties which means that their properties can be change by an external or internal conditions such as light, temperature, electricity, or pressure.

The present age is considered to be the smart materials era because as being discussed that various applications of smart materials in the different fields are starting from engineering to the day to day life.

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