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Smart Materials- Types & Applications

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Abstract: ***Smart Materials are also known as advanced materials or intelligent materials or responsive materials. These materials can be defined as advanced materials that can respond smartly to environmental changes. The general feature of all smart materials is the fact that one or more properties might be significantly altered under controlled conditions by external stimuli such as stress, moisture, electric fields, magnetic fields, light, temperature etc.. This study focuses on Smart Materials types and applications in various fields.***
Keywords: Actuator, Piezoelectric, Sensors, Shape Memory Alloys, Smart Materials.

I. INTRODUCTION

Smart Materials (SMs) are defined as the materials that change their behaviour in systematic manner as a response to specific stimulus which could be altered. Thousands of years ago human beings used materials for different causes due to which there was an enhancement in their living standards. Even civilizations were divided on the basis of their discovery of materials like the first age was the Stone Age. The most revolutionary age was the Bronze Age because Bronze was durable and harder. From the past two decades, science and technology have made great improvements in synthesizing the new materials. They are divided mainly into 4 categories which are Polymers, Ceramics, Metals and Smart Materials.

Smart Materials are becoming more popular because they have various applications as compared to standard materials. These special materials can change their properties such as materials which can change its shape just by adding some heat or can change its phase instantly when placed near magnet.

The new era of Smart Materials will have a great impact on mankind, for example some of them can change their properties according to the environment and some of them have sensory capabilities some of them can repair automatically and some of them have self-degradation, these extraordinary capabilities of Smart Materials will have an impact on all aspects of civilization.

II. CLASSIIFICATION OF SMART MATERIALS

Smart Materials are categorized on the basis of their properties such as Active and Passive. Active Smart Materials possess the capability of modifying their geometric and material properties under the application of electric, thermal or magnetic fields there by acquiring an inherent capacity to transduce energy. Passive Smart Materials lack the inherent capability to transduce energy. The three basic components of smart system are sensor, processor and actuator.

III. TYPES OF SMART MATERIALS

All types of Smart Materials can think on their own and have mental alertness, quick perception, speed activity, effectiveness, spirited liveness and intelligence. The different types of Smart Materials are:

A. Shape Memory Alloys (SMAs)

Shape Memory Alloys are a unique class of metal alloys that can recover apparent permanent strains when they are heated above a certain temperature.

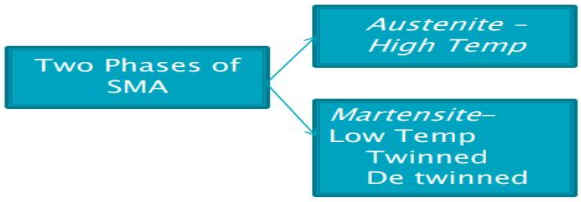

Fig. 1: Two Phases of SMA

A phase transformation which occurs between these two phases upon heating/cooling is the basis for the unique properties of the SMAs.

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B. Piezoelectric Materials

The term piezoelectricity is a blend of two terms: “piezo” which is a Greek term meaning pressure and “electricity” referring to electric charges. By the application of stress or strain piezoelectric material changes the mechanical energy into electrical energy and vice-versa. Similarly, piezoelectric actuators convert electrical signals into a mechanical movement which is used for adjusting mirrors, lenses and various automotive parts.

C. Magneto-Rheological Fluids

Magneto-Rheological Fluids (MRFs) will change their rheological properties like stress and viscosity on the application of the magnetic field. Magneto-Rheological Fluids (MRFs) are also called Magneto-Sensitive Smart Materials. Magneto-Rheological Fluids (MRFs) have the properties such as visco-elastic in nature, magnetic property, light in weight, controllable modulus and excellent sound absorbing.

D. Electro-Rheological Fluids

The Electro-Rheological Fluids (ERFs) is the suspension of very small particles in electrical insulating fluid when the electric field is applied, they will rapidly form a solid-like structure in the direction of the field. Electro-Rheological Fluids (MRFs) have the properties such as stiff, damping coefficient is changed in the electric field, high dielectric constant, interfacial bond strength, constable rheology and dielectric in nature.

E. Optical Fiber

A flexible and transparent fiber which is made by drawing glass/ plastic to a diameter slightly thicker than the diameter of the human hair is called Optical Fiber. These are used quite often to transmit the light between the ends of the fiber.

IV. APPLICATIONS OF SMART MATERIALS

A. Application of Shape Memory Alloys (SMAs)

Shape Memory Alloys has wide applications in various fields like Biomedical, Aerospace, Robotic, Automotive etc. Shape Memory Alloys have been used in robotic application since 1980s. However, the robots can be divided into several groups depending on their movement techniques and applications, for example jumper, crawler, fish, walker, flower, medical and biomimetic robotic hand.

Muscle wire is a NiTi alloy which can be stretched upto 8% of its length and still recover. When a small current is passed through the wire it becomes much harder and return to its original length with a reasonable force. A battery and switch are connected to muscle wire and a small weight stretches the muscle wire. A clever use of muscle wire and a micro-controller circuit is a ‘Robotic Hand’.

A robotic hand has stretched muscle wires attached to the base of each finger. When current is applied to the muscle wire it contracts to its natural length by pulling on the ordinary wire. The micro-controller is programmed to give five of the outputs with switch on and off options. This makes the fingers of the hand move.

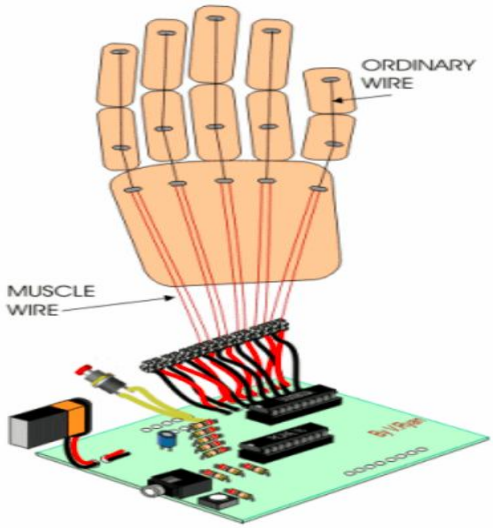

Fig. 2: Application of SMA in making Robotic Hand

B. Application of Piezoelectric Materials

In lighters or portable sparkers with a piezo fuze a sudden and strong pressure is used to produce a voltage. The spark then ignites the gas. A piezo motor is based on the change in mechanical shape of a piezoelectric material when an tension is applied. The material produces ultrasonic or acoustic vibrations and produces a linear or rotary motion. Piezo elements are used in music for acoustic instruments. They are inserted in stringed instruments such as guitar, violin. The dynamic deformation/vibration of the cords is converted into a small alternating voltage.

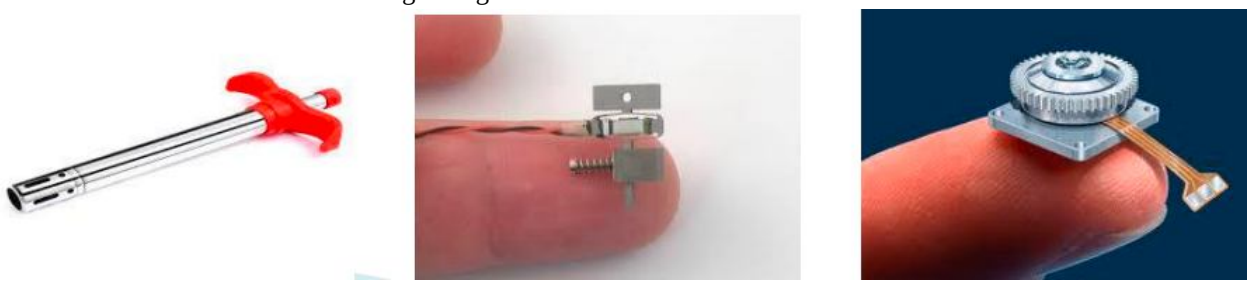

Fig. 3: Application of Piezoelectric Materials

C. Application of Magneto-Rheological Fluids

Magneto-Rheological Fluids have wide application Automotive Industry, Civil Engineering, Household Appliances, Biomedical etc. The MR fluid damper is used in the washing machine to reduce vibrations during spin. The application of semi active control in household applications is still a long way journey; the discussions are only in those areas where the research is primarily about tub dynamics at low spin, about the main drum's resonance frequency. Instead, this work mainly focuses on the vibrations induces due to high rotational velocity.

Fig. 4: Application of Magneto-Rheological Fluids in Household Appliance

D. Application of Electro-Rheological Fluids

There are various applications of ERFs in vibration isolators, the automotive industry, shock absorber, clutch. They are also used in building base-isolation and electro-active actuators due to their ability to overcome defects caused by particle aggregation and sedimentation that affects the electro-rheological performance of ERFs building base-isolation and electro-active actuators because they can overcome the defects due to particle aggregation and sedimentation that adepts the electro-rheological performance. Electro-Rheological Fluids have wide application in Hydraulic Industry, Automobile Industry, Fluid Sealing Industry, Robot Industry.

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E. Application of Optical Fiber

Fiber optic cables find many uses in a wide variety of industries and applications. Some uses of fiber optic cables include: Medical, Defense, Data storage, Telecommunications, Networking and Broadcast. Optical Fiber cables are used to transmit high definition television signals which have greater bandwidth and speed. Optical Fibre is cheaper compared to the same quantity of copper wires. Broadcasting companies use optical fibres for wiring HDTV, CATV, video-on-demand and many applications.

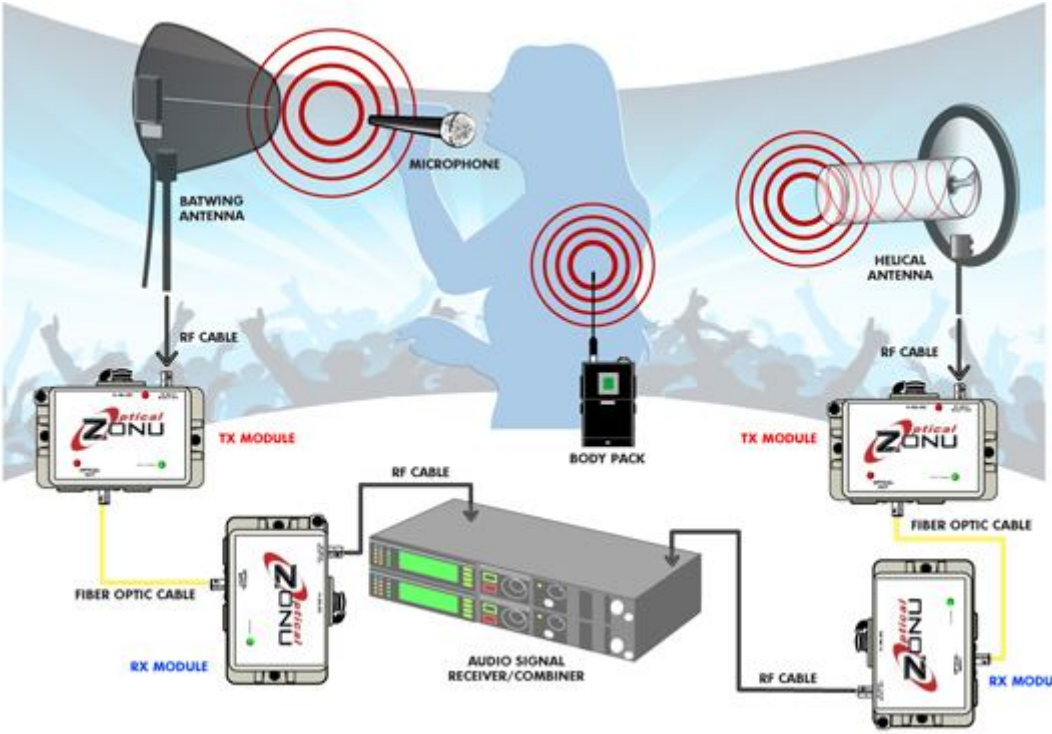

Fig. 5: Application Optical Fiber in Broadcast Industry

V. CONCLUSIONS

The technology of smart materials by its nature, is a highly interdisciplinary field. Starting from the field of basic sciences such as physics, chemistry, mechanics, computing and electronics it also covers the applied sciences and engineering such as aeronautics and mechanical engineering. Understanding and controlling the composition and microstructure of any new materials are the ultimate objectives of research in this field and is crucial to the production of good smart materials.

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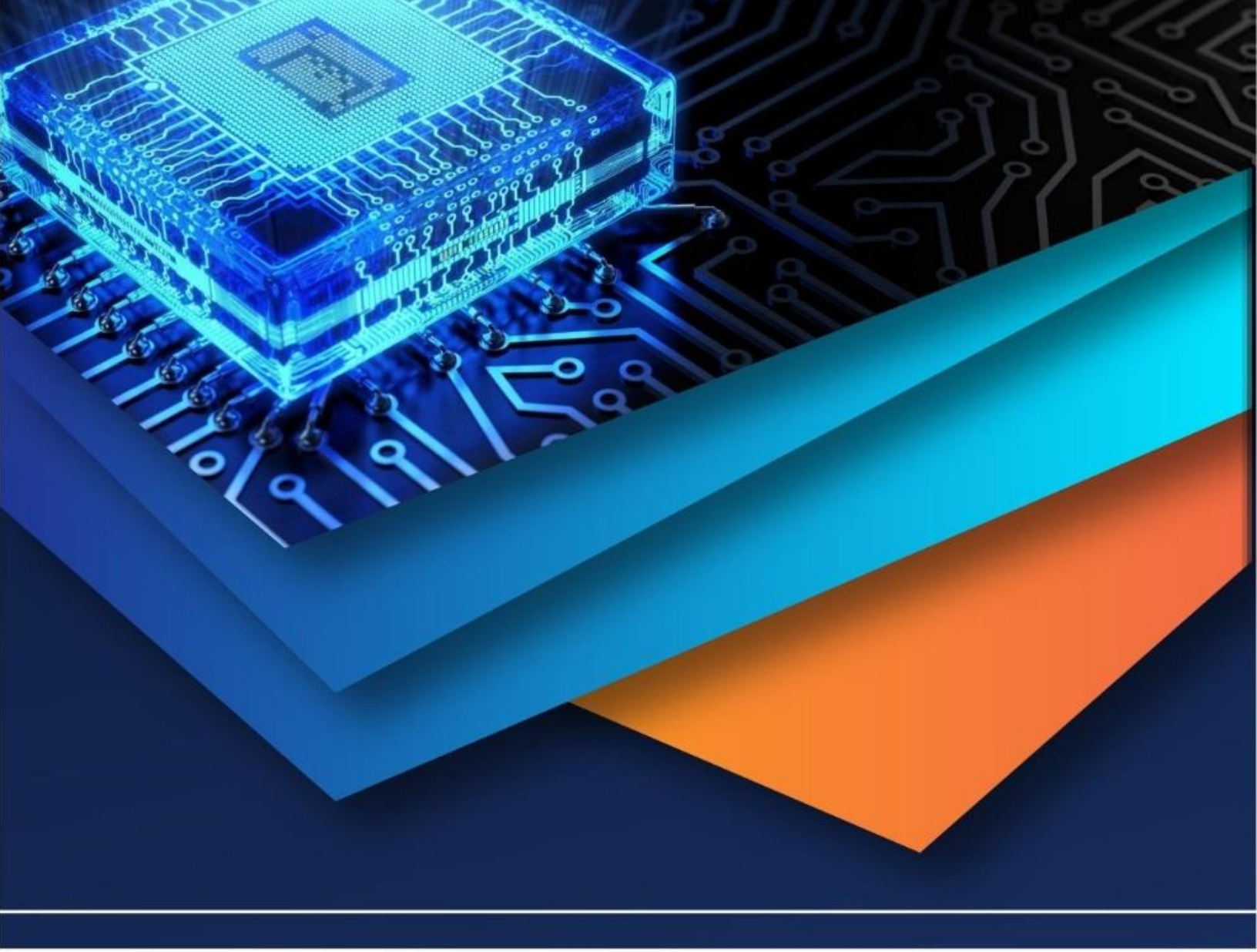

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