# Piezoelectric Material

Subjects: Engineering, Electrical & Electronic
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Piezoelectric materials can be called“the top of the crop” of smart materials. Piezoelectric materials have emerged as the most researched materials for practical applications among the numerous smart materials. They owe it to a few main reasons, including low cost, high bandwidth of service, availability in a variety of formats, and ease of handling and execution. Several authors have used piezoelectric materials as sensors and actuators to effectively control structural vibrations, noise, and active control, as well as for structural health monitoring, over the last three decades. These studies cover a wide range of engineering disciplines, from vast space systems to aerospace, automotive, civil, and biomedical engineering.

Keywords: piezoelectric material ; vibration control ; noise control ; active control ; damage structure ; SHM

## 1. Introduction

The direct piezoelectric effect is the capability of piezoelectric materials to create an electric field under the influence of mechanical stress. This property of the piezoelectric materials is utilized for the generation of electrical energy. The reciprocal of the direct piezoelectric effect is the inverse piezoelectric effect in which mechanical strain is developed in response to the electric field. These effects are strongly dependent on the crystal orientation with respect to the strain or electric field [1][2][3][4][5][6]. The direct effect makes it possible to use them as sensors, and the converse effect as actuators (Figure 1). The designed structures constructed using piezoelectric materials can be bent, expanded, or contracted upon the application of voltage, and they can be used for sensing and actuating [7] purposes and for easy control [8]. Piezoelectric patches (or films) are thin ceramic strips that are either intended to be bonded to the substructure surface or to be inserted within the structure. The stacks instead are built by piling up multiple piezoelectric layers of alternating polarity [9]. The piezoelectric materials are widely used in valves, micropumps, earphones and speakers, ultrasonic cleaners, emulsifiers, and sonic transducers.

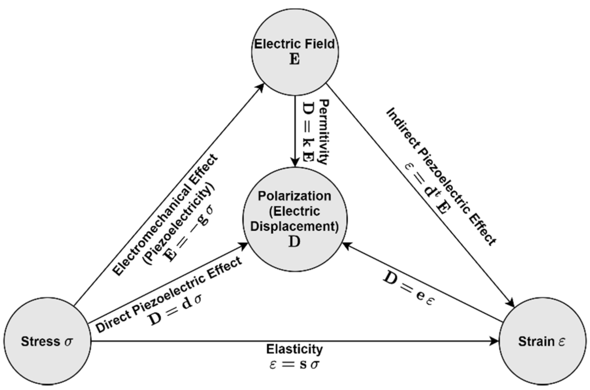


**Figure 1.** Effect of Piezoelectric material [5]. Reprinted under the Creative Commons (CC) License (CC BY 4.0).

In addition to piezoelectric ceramics, piezoelectric polymers are another group of piezoelectric materials that have found widespread use. Polyvinyl fluoride (PVDF) is versatile and light in weight in comparison to piezoelectric ceramics. Because of this, thin films of any desired form can be drawn into them, giving them an advantage over piezoceramics in various applications involving complex designs of sensors or actuators. Besides being versatile and lightweight, however, they have lower electromechanical coupling compared to piezoelectric ceramics, and the other characteristics that make the piezoelectric polymers attractive are their low electrical permittivity, low acoustic impedance, high voltage sensitivity, and relatively lower cost. An updated overview of the applications of piezoelectric polymers in touch devices, pyroelectric infrared sensors, property measurement with photopyroelectric spectroscopy, and shock sensors can be observed in the article by Lang and Muensit [10].

## 2. Structural Health Monitoring

Generally, SHM used in wide applications with its advanced technologies and a number of research studies has been reported in the literature over the last two decades. For the sake of piezoelectric material application, this review has reported with some fundamentals/methodologies/overview used to perform SHM on a damaged structure and its enhancement. The enhancement of orthotropic and isotropic material for piezoelectric transducers can improve its properties significantly. The structural strength and stiffness of the material together make it a high-performance material. Delamination in composite structures plays a key role in reducing structural strength and rigidity, subsequently reducing device integrity and reliability so that the lamb-wave technique can be efficiently produced using piezoelectric transducers embedded within a composite plate for health monitoring [11]. The SHM is an innovative technique built from non-destructive testing (NDT), blends sophisticated sensor technologies with intellectual algorithms to cross-examine systemic health conditions [12]. Statistical model creation is concerned with the implementation of algorithms that use the extracted features to measure the extent of the damaged structure. These algorithms can be classified into two classes, as shown in Figure 2. To improve the damage detection process, all of these algorithms test statistical distributions of the measured or derived features. A broader and more comprehensive discussion can be found in [13][14], which are two fundamental texts for all people working on SHM. Moreover, supervised learning strategy for classification and regression tasks applied to aeronautical SHM problems was discussed in detail by Miorelli et al. [15].

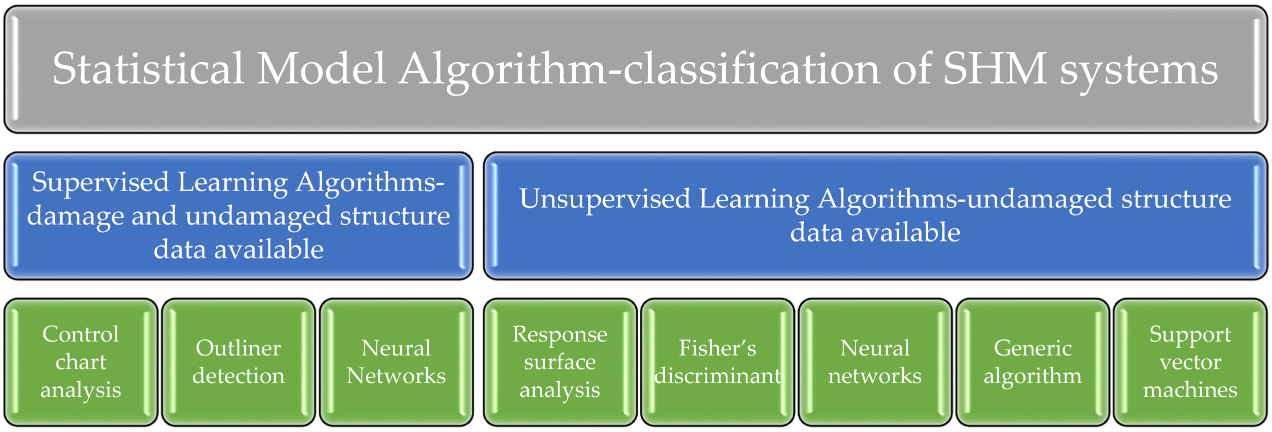


**Figure 2.** Algorithms classification for Statistical Model Development for SHM.

## 3. Conclusions

- The procedure of control and repair used to preserve the structural integrity of damaged components is distinctive. It is established on the converse piezoelectric effect, in which the local moment and force induced in the piezoelectric materials by an applied electric field would make it easier for the structure to prevent the development of high stress and strain levels because of external load and thus lessens the criticality of the damage.

- Structural health monitoring is also proving highly significant in avoiding the premature collapse of structures based on aerospace and civil industries such as offshore platforms, houses, bridges, and underground structures.

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