

Preface

Great interest and considerable research funding has focused on the development of engineered systems that convert stray energy into useful energy to increase energy security or mitigate further increases in atmospheric CO₂ levels. We are all familiar with photovoltaic cells that convert sunlight into electricity, solar to heat systems for heating and hot water, wind and sea turbines that convert a flowing fluid into energy and natural systems such as photosynthesis in plants that produce hydrocarbons from H₂O, CO₂ and sunlight.

However, this book instead focuses on devices that convert stray vibrations and movement directly into electricity. This process can take many forms and is the basis for most power generation around the world where steam is used to spin a turbine and thereby produce power. These devices rely on a variety of physical processes that can convert energy from one form to another, such as capacitive, electrostatic or electromagnetic systems, or the use of piezoelectric materials at a variety of length scales. Due to large number of systems available this book will focus on the new breed of nanostructured piezoelectric generators for small-scale device applications, and aims to provide the reader with a brief history and highlights some of the recent developments in understanding.

A piezoelectric material benefits from a crystallographic peculiarity in which a dipole is formed when the material is pressed. Without knowing it many of us have experienced this in our daily lives when lighting a gas cooker, or driving a diesel car, or perhaps when having an ultrasound scan. In these cases large or macroscopic crystals of the piezoelectric material are manufactured to give the unique response that is required in the device. When the crystal is miniaturised it remains piezoelectric and so even a nanostructured system responds in the same way as a bulk system. Many piezoelectric materials lend themselves to processing at the nanoscale and it is this combination of availability of processing and unique materials properties that has led to the increased interest in nanostructured materials for kinetic to electrical energy conversion.

In this book we will briefly describe some of the physical phenomena associated with piezo (and ferro) electric materials, illustrate what types of devices have been produced and highlight where the future of the technology may lie. We will also try and demystify some of the processes used to produce devices and indicate how advances in processing can lead to the development of devices that have a number of niche applications.

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Nanostructured Piezoelectric Energy Harvesters

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