Chapter 14

Functionalization of Specific Electrostrictive Polymers for High Power Harvesting

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ABSTRACT

The energy harvesting based on electrostrictive polymers has great potential for remote applications such as in vivo sensors, embedded micro-electro-mechanical systems devices. The harvested energy and action are controlled by the permittivity, the Young’s modulus and their dependence on frequency and level of stress. One should use a model which takes into account mechanical losses in order to obtain efficient devices. This chapter provides a brief overview of the methods for harvesting mechanical to electrical energy using electrostrictive polymer. The second paragraph presents two new techniques which enable the improvement of the electromechanical performance of electrostrictive polymers in order to demonstrate their potential for the vibrational energy recovery. Based on the strong relationship between the frequency of operation and the mechanical strain from one could improve the electromechanical conversion. The development of a new prototype based on electrostrictive polymers for increasing the conversion AC–DC power is discussed.

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1. INTRODUCTION

Over the past 30 years, technological advancements have driven great changes in the communications, consumer electronics, medical, automotive as well as the leisure industry. During that time, sensor technology experienced substantial growth, both in use and development, thanks in large part to the implementation and large-scale commercialization of Micro Electro-Mechanical Systems or MEMS.

The invention of the transistor in 1947 by John Bardeen and Walter Brattain of Bell Labs marked the beginning of a revolution in electrical engineering that eventually led to the birth of Micro-electromechanical systems (MEMS). Soon after this pivotal discovery, a research ensued at a frenzied pace in the development of microelectronics resulting in the introduction of commercial silicon transistors in 1954 and the invention of the first integrated circuit (IC) by Jack Kilby of Texas Instruments in 1958. One of these early pioneers, Gordon Moore, made an astute observation in 1965 that the number of components per IC would double every 2 years. Moore’s prediction, now popularly known as Moore’s Law, is not completely correct and actually follows an 18-month doubling trend. Even so, this phenomenal growth rate means that we are now able to enjoy personal computers that run on the computing power of tens of millions of transistors in centimeter scale CPU packages (Nguyen & Werely, 2002).

As semiconductor technology developed, Micro-electric mechanical Systems (MEMS) emerged, combining mechanical structures and electronics on the micrometer scale. MEMS stops just short of being nano technology with feature sizes generally in the range of 1 to 100 micrometers. Examples of MEMS device applications include inkjet-printer cartridges, accelerometers, miniature robots, micro engines, locks, inertial sensors, micro transmissions, micro mirrors, micro actuators, optical scanners, fluid pumps, transducers, and chemical, pressure and flow sensors. New applications are emerging as the existing technology is applied to the miniaturization and integration of conventional devices. These systems can sense, control, and activate mechanical processes on the micro scale, and function individually or in arrays to generate effects on the macro scale. The micro fabrication technology enables fabrication of large arrays of devices, which individually perform simple tasks, but in combination can accomplish complicated functions. MEMS are not about any one application or device, nor are they defined by a single fabrication process or limited to a few materials. They are a fabrication approach that conveys the advantages of miniaturization, multiple components, and microelectronics to the design and construction of integrated electromechanical systems.

The MEMS industry has an estimated $10 billion market, and with a projected 10-20% annual growth rate, it is estimated to have a $34 billion market in 2002 (Micromachine Devices, 1997). The 2009 economic crisis has hit hard the semiconductor industry with a fall in turnover of 23%. Over the same period, the market for MEMS related to consumer applications, get out pretty well, since it will have helped generate $1.2 billion, with an upward trend. The study by ISuppli expected by 2013 that this market will represent $2.5 billion, driven by the development of devices (microphones, accelerometers, gyroscopes...) and telecommunications (BAW filters, RF Switch,...) (HIS Technology, 2012). The year 2012 was also a key date for the MEMS industry. This date corresponds in effect to the implementation of European laws on compulsory measure tire pressure in real time (TPMS), a measure that is likely to be achieved using MEMS (in force in the United States since 2007). Currently, the largest MEMS manufacturers are Hewlett Packard and Texas Instruments. MEMS have created numerous start-ups and it is possible to count today 300 companies working in this sector. However, only 10% of them is responsible for 90% of world-wide turn over.
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