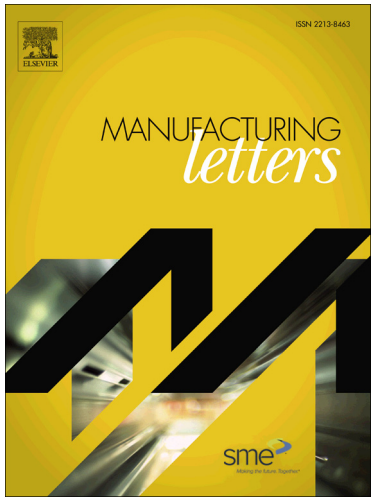

Letters

A view into additive manufactured electro-active reinforced smart composite structures

I.T. Garces, C. Ayranci

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A view into additive manufactured electro-active reinforced smart composite structures

Authors: Garces. I.T.[1] and Ayranci, C.[1]*
[1] Department of Mechanical Engineering, University of Alberta, Edmonton, Alberta, Canada
* Corresponding author (cayranci@ualberta.ca)

Abstract

Shape Memory Polymers (SMPs) and their composites (SMPCs) offer great properties, such as low cost and tailorability. Heat-activated SMPs and SMPCs are widely studied under controlled laboratory conditions, but their field applications did not receive thorough attention because manufacturing them with integrated heating elements for this use is very challenging. This work proposes and demonstrates an alternative novel solution to manufacture and activate a SMPC through resistive heating by using extrusion based additive manufacturing. Successful manufacturing of these materials can lead to broader use in strategically critical applications (biomedical stents, sports equipment, and unmanned air vehicles (UAVs)).

Keywords: Shape Memory Polymers, Additive Manufacturing, Electro-active Shape Memory Polymer Composites, 4D printing

1. Introduction

Shape Memory Materials (SMMs) have been proposed as prime candidates to substitute common mechanical actuators in many engineering applications. In contrast to mechanical actuators, these materials have the potential to reduce weight, cost and energy losses due to friction. SMMs have the ability to store a temporary shape and recover their original permanent shape upon the application of a stimulus such as temperature, uv-light exposure, pH and moisture content [1]. The phenomenon of storing a temporary shape is often referred to as the Shape Memory Effect (SME).

A temperature activated SME can be achieved in two major steps: i) Setting of the temporary shape and ii) activation of the SME. The temporary shape is set by increasing the temperature of the material above its transition temperature, sequentially applying and holding a mechanical strain and decreasing the temperature below the transition temperature. Increasing the temperature above the transition temperature can later activate the SME, i.e. the temporary shape of the material can be recalled.

Some of the most commonly used SMMs are Shape Memory Ceramics (SMCs), Alloys (SMAs) and Polymers (SMPs). Among these, SMPs often have more desirable features such as biocompatibility, recyclability, ease of manufacturing for thermoplastic SMPs, and tailorability in comparison to metallic or ceramic SMMs. Applications of SMPs have focused on strategically important applications such as morphing origami-like structures [2], self-deployable antennae for space applications [3], crawling robots [4], self-actuated hinges [5], wings for gliders and micro aerial vehicles [6]-[8] and medical devices such as stents, surgical sutures, among others [9], [10]. Other applications in the fashion industry include jewelry and textiles [11] [12].