Materials and Design 32 (2011) 1577–1581

Contents lists available at ScienceDirect

Materials and Design

journal homepage: www.elsevier.com/locate/matdes

Short Communication

Material selection for electrostatic microactuators using Ashby approach

Ojasvita Parate, Navneet Gupta *

Electrical and Electronics Engineering Group, Birla Institute of Technology and Science, Pilani, Rajasthan, India

ARTICLE INFO

Article history:
Received 7 May 2010
Accepted 8 September 2010
Available online 21 September 2010

ABSTRACT

Due to variety of materials available to any designer for a particular application, there is a need for a proper technique to select. This paper focuses on the optimum selection of materials for electrostatic microactuators using Ashby approach. In this work, performance indices and material indices have been developed for electrostatic actuators and thereafter material selection chart is plotted. The selection chart shows that for high actuation voltage and high actuation force, diamond is the best possible candidate followed by silicon carbide and silicon nitride. On the other hand, if high speed electrostatic actuator is desired, then aluminum is the best possible candidate followed by nickel and copper.

1. Introduction

Electrostatic actuation is the most widely used driving force in the design of radio frequency microelectromechanical systems (RF-MEMS) like microresonators, microswitches, micromirrors, tunable capacitors, accelerometers, etc. [1–4]. Almost every kind of microactuator has one or more electrostatic actuation based version. Electrostatic actuator uses electrical energy to produce motion (actuation). An electric charge creates an electric field around it, which applies a force to the charged particle and this produces motion. This is the basic principle behind electrostatic actuation.

Material selection is a critical step in the design of any engineering product. The set of materials available to any microsystem designer is continuously increasing. Techniques now exist to introduce and integrate a large number of metals, alloys, ceramics, glasses, polymers, and elastomers into microsystems, motivating the need for a rational approach for materials selection in microsystems design. The selection of materials for micromechanical system is complicated by the highly integrated multifunctional roles of the components. The conventional set of MEMS materials like silicon compounds, metals and alloys, ceramics/glasses, polymers and composites [5,6] although compatible with the traditional micro machining techniques, are not an optimal choice for the maximum performance of the devices. The growing interest in developing thin films of arbitrary materials on various substrate presents an opportunity to improve the performance of MEMS device by optimal material selection. Hence, identifying and ranking promising candidate materials give the best performance for actuation, which is required as driving force in various MEMS devices. As MEMS technology is evolving, new techniques for optimum material selection techniques like knowledge based system (KBS) [7] and decision making approach [8,9] can be thought. However these techniques of material selections are limited to bulk designing only. For MEMS based design the Ashby approach is widely accepted [5,6]. This paper present a detailed analysis of material selection for the electrostatic microactuators based on the electrostatic actuation model compatible with Ashby approach and also assesses the influence of various parameters on the achievable performance of the device.

This paper is organized as follows; Section 2 presents a brief description about the material and their properties, Section 3 explains the Ashby Approach, Section 4 gives a brief explanation of electrostatic actuators, Section 5 include application of Ashby approach for material selection in electrostatic microactuators. Section 6 explains the discussion and finally section 7 gives the conclusion of the study.

2. Materials and properties for MEMS devices

Many processing technologies exist today that have made it possible to give materials shape and integrate a large number of engineering materials into MEMS elements. These materials are traditionally grouped under four classes: metals and alloys, glasses and ceramics, polymers and elastomers, and composites. The properties of materials commonly studied while designing are Young's Modulus (Y), Poisson's ratio (ν), fracture strength (σ_F), yield strength, fracture toughness, coefficient of thermal expansion and residual stress (σ_R) [10]. Using Ashby approach, the designers consider all the materials and study their properties to optimize the design performance and reliability. Certain other properties like electrical resistivity and conductivity are also considered while dealing with the electrical aspects.

In comparison to the bulk properties, the properties of micro-scale structures can differ in accordance to their length and

* Corresponding author. Tel.: +91 9772976336; fax: +91 1596244183.
E-mail addresses: ojasvita.parate@gmail.com (O. Parate), ngupta@bits-pilani.ac.in (N. Gupta).

0261-3069/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.matdes.2010.09.012