Author's Accepted Manuscript

www.elsevier.com/locate/ijmecsci

Resonance vibration of a thermally-actuated optical fiber with arbitrary periodic excitation: analysis and optimization

Mojtaba Komeili, Carlo Menon

PII: S0020-7403(17)30442-3
DOI: http://dx.doi.org/10.1016/j.ijmecsci.2017.02.019
Reference: MS3604

To appear in: *International Journal of Mechanical Sciences*

Received date: 25 April 2016
Revised date: 8 January 2017
Accepted date: 20 February 2017

Cite this article as: Mojtaba Komeili and Carlo Menon, Resonance vibration of thermally-actuated optical fiber with arbitrary periodic excitation: analysis an optimization, *International Journal of Mechanical Sciences* http://dx.doi.org/10.1016/j.ijmecsci.2017.02.019

Resonance vibration of a thermally-actuated optical fiber with arbitrary periodic excitation: analysis and optimization

Mojtaba Komeili, Carlo Menon

MENRVA Research Group, School of Engineering Science Simon Fraser University, Metro Vancouver, Canada

ABSTRACT

Transient (time-history) response of an optical fiber, vibrating in its resonance frequency, using thermo-mechanical actuation is studied in this paper. The optical fiber is modeled as a cantilever beam that is excited via expansion/contraction cycles, from internal heat generation in the actuator. To simulate this system, time-dependent heat conduction equation, under internal heat generation, is solved for the actuator system. The outcome is heat distribution and thermal expansion (actuation) in the actuator, as a function of time. Then, the full dynamic model is developed using a continuous beam equation, which represents the optical fiber; the beam formulation takes into account the hydrodynamic forces from the surrounding fluid medium. The latter equation is solved with respect to its boundary condition to attain the time-dependent dynamic response of the optical fiber. Laplace transformation and its numerical inverse via direct integration are used to tackle the time-dependency of the partial differential equations. The resultant thermal actuation is calculated, and recommendations to improve performance of actuator are presented. Analytical solution for dynamic model is validated against 3D Finite Element (FE). Then, the effect of surrounding medium on the performance of the system is evaluated.

Keywords: Micro-Electro-Mechanical Systems (MEMS); Thermal Excitation; Resonance Vibration; Laplace Transformation

1 Introduction

Optical fibers have various applications in high-tech industries including bio-medical image acquisition [1]. They are used as the core component of scanning fiber endoscopy systems [2–4]. In this technique, light is conducted through a miniature-sized fiber that vibrates in high frequency. A computer program analyzes the light captured by the fiber and generates an image of the internal organs [5]. The optical fiber can be excited via piezoelectric [2,5,6], magnetic [4], electrostatic [7,8], and other types of actuators. Generally, the these actuation techniques take