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Thermal Actuation of Clamped Silicon Microbeams

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A report on the theoretical and experimental investigations of the basic aspects of thermal actuation of clamped silicon microbeams is given. The mechanical properties of the beams over a wide frequency range including resonance are studied first. The experimental confirmation of the theoretical predictions serves as a reference for further steps. These include the introduction of a thermal moment and the translation of this concept into (local) bending moments. In this way the dynamic behaviour of thermally actuated beams can be properly described. Both a thermal sheet source ("bimetal") and a distributed source (as generated by radiation) are treated. The characteristic features are investigated theoretically and confirmed by experiments.

1. Introduction

Clamped silicon microbeams, excited by means of a thermal actuator (Fig. 1), are useful in a static or low-frequency mode (causing small displacements[1]), in a switching mode (guide for fluid flow) or in a dynamic or resonant mode (part in resonator-type sensors or actuators[2,3]). Apart from these application-oriented modes, the simple clamped beam lends itself as an analytical tool for characterizing material and device parameters and studying excitation mechanisms.

The thermal excitation is very simple from the point of view of technological implementation, as well as from that of system modeling and design. It is evident that the thermal transduction mechanism is inefficient with respect to energy consumption. On the other hand, the total amount of energy consumed by a microdevice