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Viscous Air Damping in Laterally Driven Microresonators

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A systematic experimental study of viscous air damping in laterally moving planar microstructures is reported. Previous studies indicated that Couette and Stokes flow models underestimate microstructural damping. To investigate this discrepancy, a series of lateral resonant microstructures with different damping plates and combs was fabricated by polysilicon surface micromachining. The resonant frequencies and quality factors of the structures were measured electrically. By analyzing these data, the damping effects due to different geometries were elucidated and compared to theory. The results indicated that if edge and finite-size effects are included in the model, reasonably accurate predictions of the quality factors can be obtained even for small geometries and comb drives. An empirical formula that predicts the quality factor for a range of plate sizes and comb designs was derived. The damping effects as functions of structural thickness and structure-to-substrate separation are also reported.

1. Introduction

Surface-micromachined, laterally driven microstructures have served as important research vehicles for many microactuators and microsensors.[1] In these devices, the damping level determines their amplitude response and stability, and therefore is a crucial parameter in their functionality. In contrast to vertically driven devices, in which squeeze film damping is the major source of energy dissipation,[2] viscous drag of the ambient fluid is the dominant dissipative source in laterally driven structures. Damping in laterally moving microstructures was previously investigated with Couette[3,4] and Stokes flows[5] as the models. The estimated quality factors Q based on both models were consistently higher