

# Principles of a High-Bandwidth Microactuator Producing Supersonic Pulsed Microjets

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**This paper explores the principles of a high-bandwidth microactuator that potentially can be used for the active control of high-speed shear and boundary layer flows. The microactuator is capable of producing pulsed microjets at a desirable frequency (1-60 kHz), with high unsteady momentum and energy suitable for controlling the unstable structures of supersonic flows. In principle, the actuator consists of a source microjet that underexpands into a cylindrical cavity with multiple micro-nozzles at the opposite side through which the unsteady microjet array emanate. A lumped element modeling (LEM) approach is used to explore the characteristics of the actuator. The natural resonance frequency of the actuator system is derived from the basic principles of physical acoustics and compared with the experimental data for actuators with different geometries. While good agreement is found for cavity volumes of less than 5 mm<sup>3</sup> and the overall trend is correctly predicted, the deviations for large actuator cavities are significant, suggesting that model refinement is needed for handling these cases.**

## I. Introduction

**T**HE need for high-amplitude, high-bandwidth actuators for the effective and efficient control of high energy structures in the shear/boundary layers of supersonic flows has driven considerable research initiatives in recent years<sup>1-5</sup>. In pursuit of developing simple and robust actuator technologies suitable for high-speed flow control applications, a systematic study has been carried out in the Advanced Aero Propulsion Laboratory of Florida State University, to understand the resonance phenomena at micro scales. Its objective was to understand and take advantage of micro-scale resonance phenomena for developing unsteady microactuators for supersonic flow control. Three canonical configurations – a supersonic microjet impinging on a flat surface, expanding into a short cavity and grazing a sharp edged orifice – were chosen for the initial experiments. These configurations have been studied extensively at large scales and found to produce significant aero-acoustic unsteadiness.<sup>6, 7</sup> A microjet impinging orthogonally to a flat surface is a typical configuration that produces high-amplitude and high-frequency acoustics. Interestingly, the other elementary configurations tested also generated unsteady flowfield. More details of the experiments are available in reference 8. Preliminary design principles for the actuator were derived from these basic experiments. The microactuator presented here essentially produces supersonic pulsed microjets with high amplitude unsteadiness. The pulsing frequency of the microjets can be tuned appropriately to match the natural resonance characteristics of the flow field to be controlled.

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