The Summer Undergraduate Research Fellowship (SURF) Symposium
6 August 2015
Purdue University, West Lafayette, Indiana, USA

DSMC Simulation of Microstructure Actuation by Knudsen Thermal Force

Aaron J. Pikus, Israel B. Sebastiao, Andrew Strongrich, Alina Alexeenko
School of Aeronautics and Astronautics, Purdue University, West Lafayette, Indiana 47907, USA

Abstract

In many industrial and research applications there is a need for vacuum sensors with higher accuracy and spatial resolution than what is currently available. Examples of target applications include high-altitude platforms, satellites and in-vacuum manufacturing processes such as freeze-drying of food and pharmaceuticals. In this connection, a novel pressure sensor, named Microelectromechanical In-plane Knudsen Radiometric Actuator (MIKRA), has been developed by at Purdue University. MIKRA is based on Knudsen thermal forces generated by rarefied flow driven by thermal gradients within the microstructure Thus, the goal of this work is to model the rarefied gas flow in the MIKRA sensor under development. The Direct Simulation Monte Carlo (DSMC) solver SPARTA is employed to numerically calculate the distribution of the flowfield and surface properties. The resulting forces on the colder shuttle beam are calculated and compared to the available experimental data as well as other numerical solvers. The DSMC numerical results suggest that the maximum forces occur at a Knudsen number of approximately 1. The streamlines indicate the presence of two small vortexes between the heated beam and the colder shuttle beam and a larger one above the two beams. These simulations help understand
the experiments that have been done to design and validate the MIKRA concept.

Keywords

MIKRA, Knudsen thermal force, Knudsen force, rarefied gas flows, Direct Simulation Monte Carlo (DSMC)