Finite Element Modeling of MEMS Chevron Thermal Actuators for Strain Engineering of Graphene

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Abstract

Graphene, a single layer of carbon atoms, has demonstrated extremely high electric and thermal conductivities, tensile strength, and is therefore an exciting novel building block in the world of 2D flexible electronics. We propose the integration of graphene with MEMS devices to investigate the strain dependence on graphene material properties, such as electrical and thermal conductivity, index of refraction, mechanical elasticity, and band structure, to name a few. Electro-thermal Chevron actuators provide the most accessible framework to study strain in graphene due to their ease of integration on chips, and high output force displacements for low input power. Here, we simulate suspended graphene on Chevron actuators using COMSOL Multiphysics® software to accurately capture their effect on the MEMS devices, while under the external force of the 2D material. Using finite element analysis, we analyze the Chevron actuator IV characteristics, displacement and temperature responses, and compare the behavior to our fabricated devices showing very good agreement. Through thin film membrane simulations, we observe different strain configurations in single-layer graphene through integration of thermal, electrical and structural modeling. Both simulations and measurements support the viability of integrating 2D materials on a MEMS platform as a viable option for constructing novel strain engineered devices.

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