MEMS-Suspended Bowtie Antenna Array for Microbolometer mmW Imaging Device

Mark Lust*, Shangyi Chen, and Nima Ghalichechian
ElectroScience Laboratory, Department of Electrical and Computer Engineering
The Ohio State University, Columbus, OH 43212, USA

Millimeter wave (mmW) imaging technology is a highly viable solution to problems such as security screening, visibility through fog in airplanes, and reconnaissance through walls. Microbolometers are a good candidate to execute such goals. A bolometer is a thermal sensor that uses a variable resistance to passively detect the blackbody radiation emitted from objects. To create an image, multiple bolometers are arrayed in a grid, and each sensor is attached and matched to a receiving antenna. The sensors in this case are made of vanadium dioxide (VO_2), which is a phase change material with a large, sharp contrast in resistivity across its metal-insulator transition at ~68 °C.

The bowtie antenna is designed to operate over 60-90 GHz band. Because the silicon substrate of the bolometer array has a high dielectric constant $\varepsilon_r = 11.7$, it has a high Q factor, thus reducing the bandwidth. The large bulk of the silicon also creates a challenge of radiation efficiency due to its intrinsic losses. To combat this, the antenna was designed with an array of deep trenches in the silicon underneath to make the permittivity closer to that of air. These trenches are made using the micro-electro-mechanical systems (MEMS) technique of deep reactive ion etching (DRIE). The bolometer sensor and antenna are supported by a thin film of alumina (Al_2O_3) on top of the silicon, which acts as a membrane across the gaps created in the substrate (MEMS suspension). Because of the high resistivity contrast of VO_2, the antenna must operate across a large range of bolometer impedances. The antenna array has 8×8 elements, with 90 GHz half-wavelength spacing in both horizontal and vertical directions. Future work will include integrating the array with the microbolometers and performing multiphysics simulation, and fabricating and testing the bolometer device. The electromagnetic simulated results of this array, along with multiphysics results and fabrication plan will be presented at the conference.