High Sensitivity Uncooled Microcantilever Infrared Imaging Arrays

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Abstract
Multispectral Imaging, Inc., is developing and manufacturing infrared focal plane arrays (FPAs) of 160 x 120 pixels, based on an advanced bimorph microcantilever design. The bimorph design utilizes a combination of metallic and dielectric materials to create a temperature-sensitive structure that serves as the moving element in a variable-plate capacitor. The microcantilevers are integrated directly onto a complimentary metal oxide semiconductor (CMOS) integrated circuit, and all microcantilever materials are compatible with standard silicon IC foundry processing.

Summary
Uncooled vanadium oxide (VOx) and amorphous silicon (a-Si) microbolometers are presently the technologies of choice for thermally sensing and imaging long wave infrared radiation. However, the performances of these devices have not improved significantly in recent years and studies indicate that these technologies may be reaching their performance limits [1, 2]. Our proposed technique makes use of MEMS structures that respond mechanically to the absorption of infrared radiation. These structures were invented at the Oak Ridge National Laboratory (ORNL) [3] in the mid-1990s. Multispectral Imaging, Inc., (MII) has licensed the ORNL technology [4-6] and is pursuing its commercialization using the resources at Cornell NanoScale Science and Technology Facility (CNF).
Each pixel of our sensing array comprises the following components: an anchor, which elevates the sensing element above the substrate; a thermally isolating dielectric element of the paddle support arm; a thermally sensitive bimorph element of the paddle support arm; and the paddle itself. The gap between the paddle and the substrate serves as a resonant cavity for infrared radiation, and enhances the absorption of energy by the paddle. Heat flows from the paddle to the relatively cooler substrate through the thermally sensitive part of the support arm, causing the support arm to bend and the paddle to change its height relative to the substrate. The heat sensing bimorph microcantilever structures are fabricated directly onto the CMOS control and amplification electronics to produce a high performance, low cost imager.

MII has fabricated the first batches of fully integrated 160 x 120 FPAs at CNF with typical pixel functionalities ranging from 80% to > 95%. MII has an ongoing development program with Dalsa Semiconductor to commercialize this technology and we expect pixel yields of > 99% when in full production. Positional responsivities of greater than 0.3 $\mu$m/K have been modeled and measured for 50 $\mu$m pitch pixels, corresponding to a temperature coefficient of capacitance, $\Delta C/C$, (equivalent to TCR for microbolometers) above 30%/K. This responsivity, along with noise-equivalent capacitances of 15 fF, give modeled noise-equivalent temperature differential (NETD) of < 20 mK for these devices.

Preliminary infrared imagery has been obtained with a recently fabricated imaging array, assembled camera and control system with NEDTs in range of 350 mK using f/0.86 optics.

References