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COOPERATIVE RESEARCH AND DEVELOPMEMT AGREEMENT

AIR FORCE AND MICHIGAN STATE

University Research Results in Programmable MEMs Developments

CONTRACT NUMBER:

15-075-RY-01

COMPANY NAME:

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East Lansing, MI

TECHNICAL PROJECT OFFICE:

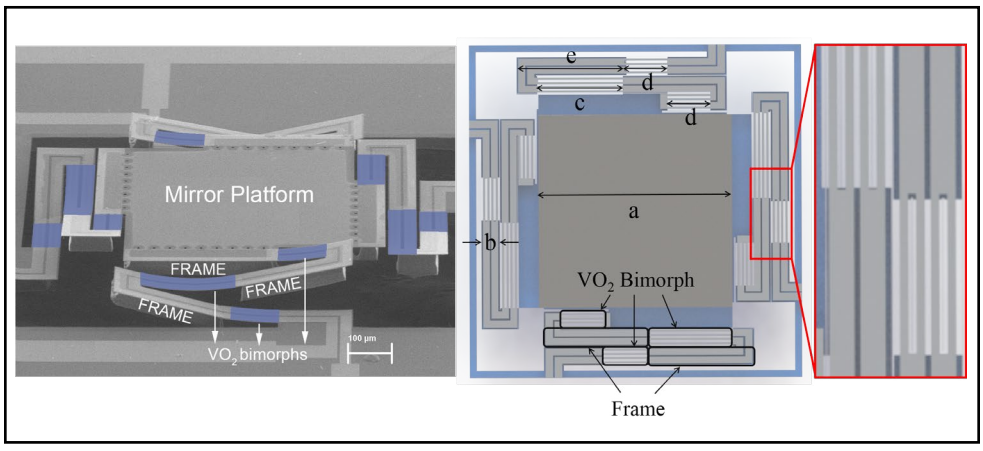
AFRL
Sensors Directorate
WPAFB, OH

PUBLISHED:

May 2017

WRIGHT-PATTERSON AIR FORCE BASE, Ohio – Under a Collaborative Research and Development Agreement, a team of scientists from the Air Force and Michigan State University produced first generation smart-material based micro-electrical mechanical mirror devices (MEMS).

The Air Force Research Laboratory Sensors Directorate, Integrated Circuits and Microsystems branch (AFRL/RYDI) has explored MEMS mirrors for electro-optical military applications, specifically the use of vanadium dioxide as a microactuator for the MEMS technology. The microactuator supplies power to the device. Vanadium dioxide – also known as VO2 - is unique because it is considered a "smart" material, meaning it responds rapidly to stimulus, and it is also considered to be multifunctional because many of its properties change simultaneously to the stimulus. It requires little energy to power – at least much less than other technologies.



On the left, an image of the final VO2 based MEMs device with the bimorph in blue. On the right, a top view of the device. This device was created under a cooperative research and development agreement between the Air Force Research Laboratory Sensors Directorate and Michigan State University. (Image courtesy of Michigan State University)

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88ABW-2017-2271

MEMS are miniaturized mechanical or electromechanical devices or structures that are created through microfabrication. The devices are usually a combination of microsensors, microactuators, microelectronics and microstructures on a substrate. They can measure anywhere between several millimeters to one micrometer. MEMS mirrors are used in multiple fields including optical phased-arrays, spectroscopy, optical switches, track positioning, microscopy, optical displays, and medical imaging.

Because Michigan State University scientists possess vast experience in the deposition and characterization of VO2, as well as the material's integration into micrometer-sized devices, the two parties entered into a five-year CRADA. The agreement allowed MSU scientists to have access to Air Force facilities, personnel, and materials in order to create thin VO2 films and integrate them onto MEMS devices for testing. Air Force personnel participated in the device testing, data analysis and new process design.

"Our collaboration with Michigan State University has been invaluable in advancing the science and technology of micro actuators and micro mirrors," said Dr. John Ebel from the Sensors Directorate. "Their expertise combined with AFRL's unique fabrication capabilities and talents has greatly accelerated the pace of research for MEMS actuators and mirrors."

In the first year of the agreement, the team developed first generation VO2-based MEMS mirror devices. The device showed a great deal of movement from minimal power during phase transition. During testing it showed vertical movements and tilt angles of 75 micrometers and 5.5 degrees. Through the course of the research the material displayed hysteretic behavior, meaning the response to force or stimuli was dependent on the previous response. Going forward the researchers can predict how the device will react to certain electrical signals and they can "program" the devices for specific responses.

"This CRADA has allowed for the use of unprecedented mechanisms in the operation of MEMS mirrors. The actuation of such devices using smart phase-change materials represents a new operating principle that enables their programming and reduces power consumption," said Nelson Sepulveda, a professor of electrical and computer engineering at Michigan State University.

"We have also made promising advances in implementing new techniques that can significantly advance military technologies, such as the use of smart windows that could potentially serve for cloaking applications," Professor Sepulveda explained.

A paper detailing the research results was published in the Journal of Microelectromechanical Systems. Moving forward, the research will focus on developing programmable MEMs mirrors and improving the device design to allow for better device control and larger movements. The team is also investigating VO2 for use in variable optical attenuators.

For more information about technology transfer partnering opportunities with the Air Force, call the Air Force Technology Transfer Program Office at 937-904-9830.