Novel optical MEMS research with commercial potential

Micromechanical actuators are the motors of microsystems. Converting energy into motion, micro-actuators make possible the myriad of actions that drive our smart technologies, from positioning the switches that enable telecommunications, to activating the autofocus in our smart-phone cameras. But in the microsystems world, where miniaturization and power savings spell success, microactuators are not without their challenges.

One of those challenges is now being addressed with considerable success by a University of Toronto doctoral candidate. Faez Ba Tis’s award-winning research focuses on harnessing the extremely limited power of electrostatic actuators to move objects. “Electrostatic micro-actuators have advantages: They are very fast, very precise and they use less power. But the drawback is they provide a very small force—not enough to displace mass and make an object move. I wanted to overcome this,” he says.

Mr. Ba Tis recently won The Huawei Microsystem Design Award for developing an electrostatic actuator that can move a lens in a miniature camera. The award, presented at CMC Microsystems’ 2014 Symposium, recognized Mr. Ba Tis’s exceptional results with commercial applications. The judges were impressed by the student’s efforts to overcome the limitations of electrostatic actuators.

Currently, miniature cameras on cell phones or ski helmets use electromagnetic actuators for autofocus and optical image stabilization. But they consume a lot of energy and can be slow to respond, says Mr. Ba Tis. “If you move your mobile phone to another scene, it takes one second to shift focus. Electrostatic actuators offer a very nice performance. They consume 1/100th the energy and can shift focus in a millisecond.”

In his prize-winning submission, Mr. Ba Tis described how he developed, fabricated and tested a prototype for a novel, large-force electrostatic actuator for Micro-Electro-Mechanical Systems (MEMS), working under the supervision of University of Toronto Mechanical Engineering Professor Ridha Ben Mrad.

Recognized with a U.S. patent last year, the novel electrostatic actuator features three degrees of freedom and uses a piston tube configuration that enables the use of wide area electrodes on the actuator, allowing it to generate enough force to displace a mass of a few milligrams.

“With the first prototype, for my Master’s degree, a mass of one milligram was translated to 24 microns at 80 volts, showing proof of concept that the actuator could provide high output force,” Mr. Ba Tis says. An improved version, which he is working on for his doctorate, can move a mass of five milligrams.

A unique feature of the student’s work was being able to successfully prototype it as part of a test run of a new MEMS process offered by Canadian commercial foundry partner Micralyne. The prototype was fabricated using the Micralyne MicroGEM-Si™ MEMS Fabrication Process, in which the pistons and tubes are fabricated in the device’s layers of two bonded silicon on insulator (SOI) wafers. Ba Tis was one of three researchers across Canada who took part in the test run, which was arranged in partnership with CMC Microsystems and Micralyne. The researchers were able to use the platform to advance their investigations into optical MEMS devices and Micralyne received validation that their innovative process worked.

Ba Tis credits CMC with helping him fabricate the prototype and with supporting him as he refines it. There are a number of challenges that must be addressed before the actuator can be commercialized, including integrating it with the multiple lenses that are required for multiple actions such as autofocus and zoom.

“The opportunity to participate as a lead client and trial new technology emerging from a Canadian foundry was an enriching experience, and the research using the Micralyne MircraGEM-Si™ has yielded quality results,” he says. In his doctoral work, Mr. Ba Tis will continue to explore the capabilities of this technology and leverage design tools and support available through CMC to advance his MEMS research.