

## RESEARCH BRIEF

# POWER MEMS AND MICRO-BALL BEARING TECHNOLOGY

### The potential

Ball bearing mechanisms increase long-term reliability and efficiency of micromachines through minimizing friction and wear. They provide high stability for moving parts such as rotor while avoiding fabrication complexities. This makes their use on a smaller scale ideal for microelectromechanical systems (MEMS).

Microball bearing technology is expected to have a pivotal impact in MEMS applications, allowing engineers and researchers to shrink the size and weight of large electromechanical systems such as electric motors, generators, and turbomachines while maintaining the efficiency and performance to achieve a high power density that greatly reduces the cost of manufacturing, operation, and maintenance.

As the technology progresses, microball bearings will be important in the development of micro-coolers, micropumps, microgenerators, and other applications.

### The challenge

As mechanical systems become smaller, friction takes on a much more significant role in how it affects the dynamics of a given system. The more friction present, the more wear within the system, which leads to longevity/reliability issues. Micro-tribology, the science of interacting surfaces on the microscale is to be used for understanding and modeling the friction and wear phenomena in microstructures.

When engineers reduce the size of electromechanical systems to MEMS, ball bearing materials and structures that work in larger systems exhibit high friction and can no longer be designed, modeled and manufactured with conventional tools. A microfabrication process needs to be developed that will enable precisely-fabricated microball bearings to function with a low friction in a power MEMS device, while maintaining the efficiency and reliability present in larger electromechanical systems.

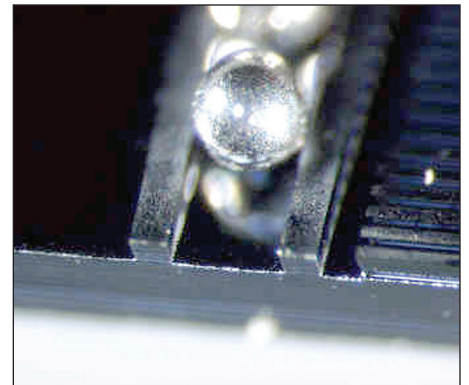
### The research

Using gray-scale lithographic technique and deep reactive ion etching (DRIE) of silicon, Dr. Reza Ghoddsi and researchers in the MEMS Sensors and Actuators Lab (MSAL) have demonstrated a functional microball bearing system.

Gray-scale lithography, a process that enables fabrication of 3-D structures in a photoresist layer, allows the research team to produce arbitrary angled rotary 'V-groove' patterns. Once the 3-D structures are patterned in photoresist, they are then transferred into silicon through DRIE. This enables the researchers to create V-grooves necessary to house the microballs, stabilize the rotor position, and minimize the friction.

V-grooves are a preferred means of housing microballs because they enable the balls to roll rather than slide, contacting only the walls of the groove. Rolling bearings exhibit lower friction than sliding bearings. The advantages in stability and reliability over non-contact bearings (such as air bearings) make rolling bearings the preferred candidates for friction reduction in MEMS devices.

Once the microtribological challenge was addressed, researchers needed to find a way to incorporate the breakthrough into a power MEMS device: a 6-phase, bottom-drive, linear, variable-capacitance micromotor (VCM). Their continuing



**An optical micrograph of a linear microball bearing integrated in the rotor of a bottom-drive, linear, variable-capacitance micromotor. The stainless-steel microball has a diameter of 285 Qm, sitting in a 85 Qm deep, 290 Qm wide silicon micromachined trench fabricated using deep reactive ion etching (DRIE).**

research in the fabrication of this device has a primary goal of developing the first microball bearing-supported MEMS-based micromotor.

### **Awards**

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### **Web links**

Dr. Ghodssi's home page

[www.ece.umd.edu/~ghodssi/](http://www.ece.umd.edu/~ghodssi/)

The MEMS Sensors and Actuators Lab

[www.ece.umd.edu/MEMS/](http://www.ece.umd.edu/MEMS/)

Micro-ball bearing project

[www.ece.umd.edu/MEMS/projects\\_powerMEMS.html](http://www.ece.umd.edu/MEMS/projects_powerMEMS.html)