# Piezoelectric Microactuator Technologies for Space Applications

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We have developed micro and nano devices for space applications. Active wavefront control is required subsequent to reflection from the primary mirror, particularly to overcome the potentially large spatial frequency errors anticipated with Gossamer type structures. Development of new, low-mass technologies is essential for wavefront correction for next generation optical instruments in Space. Inchworm actuators are required to provide the fine shape correction of primary apertures for future space telescopes. Since conventional inchworm actuator technologies are bulky, there is considerable incentive to develop miniaturized inchworm motors (or actuators). We are developing an inchworm microactuator technology with large linear motion. We have also demonstrated a large aperture continuous membrane deformable mirror (DM) with a large-stroke piezoelectric unimorph actuator array. The DM consists of a continuous, large aperture, silicon membrane "transferred" in its entirety onto a 20 × 20 piezoelectric unimorph actuator array. A PZT unimorph actuator, 2.5 mm in diameter with optimized PZT/Si thickness and design showed a deflection of 5.7 μm at 20 V. An assembled DM showed an operating frequency bandwidth of 30 kHz and influence function of approximately 30 %. High-pressure microvalve will be required for lightweight spacecrafts with an extremely limited power budget. We have demonstrated low-power, leak-tight, piezoelectric microvalve at high-pressures. The microvalve consists of a custom-designed piezoelectric stack actuator bonded onto silicon valve components with the entire assembly contained within a metal housing. Leak testing of the microvalve, conducted using a Helium leak detector, showed a leak rate of approximately $5x10^{-3}$ sccm at 800 psi for the gas-compatible version and a leak rate of approximately $3 \times 10^{-6}$ scc/sec at 50 psi for the liquid-compatible version, respectively. Dynamic microvalve operations (switching rates of up to 1 kHz) have also been successfully demonstrated. The measured power consumption, in the fully open state, was 3 mW at an applied potential of 30 V.

**Biography: Dr. Eui-Hyeok Yang** is an Associate Professor in the Mechanical Engineering Department, Stevens Institute of Technology. He received his Ph.D degrees in the Department of Control and Instrumentation Engineering from Ajou University, Korea. In 1996, he joined the Fujita MEMS research group at the Institute of Industrial Science, University of Tokyo, Japan, as a Visiting Postdoctoral Researcher in 1996. In 1999, he was employed at JPL, where he initiated the development of MEMS actuator-based adaptive optical devices. Dr. Yang was a Senior Member of the Engineering Staff at NASA's Jet Propulsion Laboratory (JPL) and the task manager for several technology development projects in the area of micro and nano technologies. He led the development of MEMS-based deformable mirrors and actuators for future large aperture telescopes and MEMS-based piezoelectric valves for future microspacecraft applications. He participated in the technical evaluation of MEMS mirror array technologies being developed for the Multi Object Spectrometer (MOS) project for the James Webb Space Telescope (JWST). Dr. Yang has been successful in winning extremely competitive major research grants which represents an exceptional achievement and productivity within NASA. He was a technical monitor for a NASA SBIR project, and was a Research Adviser for National Research Council (NRC) in the area of microactuators for active-mirror technologies. His current research interests include all aspects of microsensors/actuators, microfluidics, adaptive optics, micro/nano energy conversion, and nano-manufacturing technologies. Dr. Yang has published about 90 papers in the field of MEMS, and has 6 patents issued or pending. He is a Senior Member of IEEE. He is a member of the Technical Program Committee (TPC) of the IEEE Sensors Conference. He is a Topic Organizer of the Micro and Nano Devices Topic, within the MEMS Division, of the ASME International Mechanical Engineering Congress and Exposition. He has been serving as a referee for several archival journals, international conferences and proposals. In recognition of his excellence in advancing the use of MEMS–based actuators for space applications, he received the Lew Allen Award for Excellence for 2003 at JPL.