STEVENS Institute of Technology

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DEPARTMENT OF MECHANICAL ENGINEERING

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Development of Microactuator Technologies for Space Applications

Dr. Eui-Hyeok Yang
NASA Jet Propulsion Laboratory (JPL)

We have developed a number of 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. Extremely small 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 a linear 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 ~30%.

We have demonstrated 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 5×10^{-3} sccm at 800 psi for the gas-compatible version and a leak rate of approximately 3×10^{-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.

We have successfully demonstrated a novel assembly process for fabricating nanowire arrays in cost-effective matter using template-directed electrodeposition and magnetic assembly techniques. The nanowires were assembled across a pair of ferromagnetic Ni electrodes by applying external magnetic fields.

Dr. Eui-Hyeok Yang is currently the task manager for several MEMS technology development projects, including the development of MEMS-based wavefront correction devices for future large aperture telescopes, and the development of multi-functionalized nanowire sensor arrays for astrobiology applications. He was involved with the technical evaluation of MEMS mirror array technologies being developed for the Multi Object Spectrometer (MOS) project for James Webb Space Telescope (JWST). Dr. Yang received his B.S, M.S, and Ph.D degree in the Department of Control and Instrumentation Engineering from Ajou University, Korea in 1990, 1992, and 1996, respectively. He joined the Fujita MEMS research group at Institute of Industrial Science, The University of Tokyo, Japan as a visiting postdoctoral researcher in 1996 to 1998. Since 1999, he has been employed at NASA's Jet Propulsion Laboratory (JPL), where he initiated the development of MEMS adaptive optical devices. He is a member of the Technical Program Committee for IEEE Sensors Conference and the Program Committee for the SPIE MOEMS-MEMS Conference. He is a Co-Organizer of Micro Nano Devices Topic of the ASME International Mechanical Engineering Congress and Exposition 2005. He is a recipient of the *Lew Allen Award for Excellence* for 2003 at JPL.