Microelectromechanical Systems (MEMS)
Room Hall A-C - Session MM-TuP

Poster Session

MM-TuP1 Electrostatic Actuation in BioMEMS, ***T.L. Sounart,*** *T.A. Michalske,* Sandia National Laboratories

Electrostatic MEMS actuators exhibit fast response times and are easily integrated into microsystems because they can be fabricated with standard silicon IC micromachining processes. Although electrostatic actuators have been used extensively in "dry" MEMS, they have received little attention in microfluidic bioMEMS, despite the added advantage of 80 times the energy density in water relative to that in air. This is probably because electrostatic actuation in most liquid media presents new challenges such as electrolytic gas generation, anodic oxidation, and electrode polarization. Electrolysis is avoided completely at O(1) V electrode potentials, and although such potentials are also too low for actuation in air, they are sufficient to actuate many devices in water. Unfortunately, at equilibrium ionic solutes in conducting fluids screen the electrode potential (electrode polarization) and disable the actuator. We are currently investigating electrostatically-driven biological sensors and other bioMEMS devices by employing ac drive signals to prevent charge screening, which enables electrostatic actuation in many liquids, at potentials low enough to avoid electrochemistry. Here we measure the frequency response of an interdigitated silicon comb drive actuator in liquids spanning a decade of dielectric permittivities and four decades of conductivity, and present a simple theory that predicts the characteristic actuation frequency. The analysis demonstrates the importance of the native oxide on silicon actuator response, and suggests that the actuation frequency can be shifted by controlling the thickness of the oxide. For native silicon devices, actuation is initiated at frequencies less than 10 MHz, in electrolytes of ionic strength up to 100 mmol/L, and thus electrostatic actuation is feasible in many bioMEMS and other microfluidic applications.

MM-TuP2 Capillary Electrophoresis On-chip: Glass and Polymeric Materials for Cell Fabrication, ***Y. Mourzina,*** *A. Offenhaeusser,* Research Centre Juelich, Germany

The advances of bioanalytical chemistry and biotechnology stimulated interest in on-chip integrated microfluidic systems and analytical techniques for accurate, precise and high-effective analysis of proteins. Capillary electrophoresis on chip is rapidly developing field by learning on fabrication technologies in the field of MEMS. In the present work, two approaches to realize 3-D microstructures in glass wafers or polymeric materials for on-chip capillary electrophoretic separation of proteins are presented. The microchannel configurations in Pyrex glass wafers have been realized by means of photolithography, thin film deposition and etching steps. The dimensions of the channels are 6 to 16 µm depth and 40 to 120 µm width. Different processing sequences are compared. The structures have been visualized by means of REM to observe the profile and the edge roughness. Special attention has been paid to the optimization of the deposition of the metal thin films as sacrificial layer for glass etching, and to the influence of the composition of the etch solution on glass etch velocity, undercut phenomenon and the quality of the structures. Soft lithography is presented as an alternative approach to realize microfluidic channels in polymeric material. The master has been fabricated of the high aspect ratio SU 8 photoresist on Si wafers. Depending on the type of photoresist and the parameters of processing, the masters with different height of the structures (10 to 25 µm) have been obtained. The master has been used for microreplication in polymer PDMS. The dimensions of the separation channels of the polymeric devices are 10 to 25 µm depth and 20 to 80 µm width. Fluorescent microscopy was used to visualize the microchannels. To validate the performance of on-chip electrophoresis, the results of the separation of phosphoproteins in the prepared devices will be compared with the resolution of the conventional gel electrophoresis.

MM-TuP3 Stiction Measurements Made with an Atomic Force Microscope on Test Structures Mounted with Various Die-Attach Materials, ***E.J. Thoreson,*** Worcester Polytechnic Institute*; J. Martin,* Analog Devices*; N.A. Burnham,* Worcester Polytechnic Institute

An atomic force microscope (AFM) was used to determine the stiction between silicon oxide tips and silicon oxide substrates coated with a few angstroms of phenylsiloxane. The substrates were mounted in their usual packaging with three different types of die-attach materials, which were silicone, polyimide silicone, and silver glass. There was also a control group in which the substrates were not attached. The packages were opened and an AFM determined the adhesive force between the AFM tip and the substrate in force spectroscopy mode. A preliminary data set showed that the adhesive force normalized to the tip radius was respectively twice and four times as big for the polyimide silicone and silver glass as for the control group and silicone, the latter two being close in value. The percent variations in the measurements were 70% to 80% percent for the control group and silicone, 150% for polyimide silicone, and 25% for silver glass. Further work will verify these initial results and also study the dependence of adhesive force upon the tip radius.

MM-TuP4 Vacuum Encapsulation of Micron-Sized Vacuum Field Emission Triodes, ***S.J. Randolph,*** University of Tennessee, Knoxville*; M.A. Guillorn,* University of Tennessee, Knoxville and Oak Ridge National Lab*; M.D. Hale, P.D. Rack,* University of Tennessee, Knoxville

In recent years, carbon nanotubes have shown promise for use as stable field emitting elements in gated cathode devices. Vacuum conditions are ideal for the operation of field emission triodes, however, issues of practicality require that they be able to function outside the confines of a vacuum chamber. For this reason, a microfabrication technique has been developed for encapsulating a field emission triode in a micron-sized, vacuum-sealed environment. Patterned photoresist is thermally treated in order to form a temporary structural mold covering the device. The effects of photoresist thickness and geometry are being studied in order to minimize the duration and temperature requirements of this treatment process. The photoresist mold is then metallized and a reactive ion etch (RIE) process is used to create vias for photoresist removal. Also under investigation are the relationships between the film stresses and structural stability of the devices. Upon removal of the photoresist, a final metallization by an evaporation process is used to seal the structure under vacuum conditions. In this presentation the process flow for the vacuum micro-encapsulation package will be described and the materials requirements will be enumerated.

MM-TuP5 Investigation on Metal-coated Nano-aperture Array, ***D.W. Kim,*** *J.T. Ok, S.S. Choi,* Sun Moon University, Korea*; J.W. Kim, J.H. Boo,* Sungkyunkwan University, Korea*; C.K. Chun,* Sun Moon University, Korea*; J.S. Yang,* Myongji University, Korea

There have been considerable interests in the nano-aperture due to its potential application for promising near-field optical recording. Near-field optical recording can increase the data storage density drastically as it circumvents the diffraction limit. For the development of the practical optical storage device, a parallel processing technique based on nano-aperture array has been being investigated. In this work, the controllable method for the fabrication of metal-coated nano-aperture array and its optical characteristics in the far-field regime will be presented. At first, the arrays of inverted pyramidal structures were generated by anisotropic etching using 5 µm size pattern. Next, the stress-dependent oxide growth on the concave Si surface of the hollow pyramids was performed at 1000 °C. Backside Si etching by alkaline solution was followed and released the hollow oxide pyramids array with intentionally designed convex lens-like facets. Nano-apertures have been opened at the apices of pyramids by 50:1 diluted HF solution and the relation between the aperture diameter and the etch time showed good linearity with the aperture opening rate of ~25 nm/min. Finally, Al thin layer was deposited on the outer surface of oxide pyramid by PVD for the purpose of further reducing the aperture diameter, which will play the role of a wave-guide as well. The diameter of the completed aperture was observed to be inversely proportional to the thickness of Al layer. The details of the fabrication procedure and the far-field optical characteristics will be reported.

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