Thursday Afternoon Poster Sessions

MEMS and NEMS
Room: Southwest Exhibit Hall - Session MN-ThP

MEMS and NEMS Poster Session

MN-ThP1 A Novel Micro-droplet Proteomic Identification Chip for Protein Digestion and MALDI-TOF MS, ***T.T. Huang***, Instrument Technology Research Center, Taiwan, Republic of China

Proteomic identification at the point of care would be valuable for a wide variety of applications and importance, including clinical diagnostics, food safety, and environmental monitoring. Traditional proteomic identification makes use of protein digestion of interesting sample and could be detected using matrix assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF MS). Protein digesting reaction in vitro often wastes much time (usually overnight) and reagent volume, and then the reaction products should be transferred to the MS sample plate and air-dried. The analysis process is not effective for convenience and wastes time and analysis sample.

For more effective protein identification, we construct a novel micro-droplet chip system with auto-positioning and enriching the sample for rapid analysis. Presently, MALDI-TOF MS has been widely used in proteomic research, and it is the important issue to identify the micro sample. Utilizing the novel micro-droplet chip, protein sample would be co-crystallized with MS matrix and concentrated on the detection area. Through drying the sample and matrix mixture, protein digestion would be reacting at the same time. The sample would be digested to smaller dried peptides on chips and then detected with matrix assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF MS). Comparing to the traditional methods, the proteomic identification chip offers four advantages: 1. shortening reaction and analysis time (total ~2.5 hours); 2. auto-positioning and enriching the sample concentration; 3. lower reaction volumes (1~5 μL); 4. entire process sequentially on the chip.

MN-ThP2 Test Instrument for the Mechanical Strength of Micro-Nano Materials, ***A. Kasahara***, *H. Suzuki, M. Goto, H. Araki, M. Tosa*, National Institute for Materials Science, Japan

There is considerable research at present on the performance and properties of nanosheets, nanofibers and other functional nanomaterials such as fullerenes and nanotubes. This is particularly true of carbon nanotube, made from carbon atoms, where many research projects throughout the world are looking at measurement techniques for evaluating electrical and electronic characteristics with a view to developing electronic device applications such as high-intensity field-emitted electron sources and ultra-fast transistors. We have prepared long crystal silicon wires with a diameter of several tens of nano meters at a temperature lower than 523k by using the low-pressure low-temperature CVD method. To use these as materials for application to micro-nano electromechanical system, we need to fully understand their electric, chemical and mechanical properties. However, we have not yet to see a genuine, flexible methodology for evaluating the key characteristic of mechanical strength essential to micro-nano structural materials development the nanoscale equivalent of mechanical strength testers for ordinary materials. This is due to the inherent difficulties associated with the manipulation and transportation of materials at the micro-nano scale level.The most difficult part of the handling of small materials is to fix material samples.

We have improved it to the device with an easy fixation of the sample from the last time. Here, we will discuss our recent results on mechanical strength measurement of micro-nano wires in diameter several nm through several thousand nm and in length several mm by means of prepared micro-nano tensile strength tester device.

MN-ThP3 A Micro-droplet PCR Device with Low Volume Reaction and Rapid Amplification, *T.T. Huang,* ***Y.C. Ou***, Instrument Technology Research Center, Taiwan, Republic of China

Nucleic-acid amplification and analyses techniques have become the most significant tools for many important applications. Besides the frequent molecular diagnosis of diseases and assessments of therapies in clinics and hospitals, they are also broadly applied in environment surveillances, food processing industry and agricultural researches. The amplification of the amount of nucleic-acid analyte in the test sample is essential for sufficient detection. Polymerase chain reaction (PCR) is the major process to amplify interesting nucleic-acid. However, it always spends too much analyte volume and 3~4 hours for carrying out the reaction. In the study, we construct a novel micro-droplet PCR device and PCR chips utilizing MEMS techniques.

The temperature variation of the micro-droplet PCR device achieves 1 ℃ per second. Moreover, we develop the micro-droplet PCR chips fabricated by silicon wafer with two concentric circles structure. Then, the chip is coated with a layer of PPFC (plasma polymerization fluorocarbon) film on its surface. Utilizing the MEMS process, the solution of nucleic-acid reactants is concentrated in the inner circle and 5μL the mineral oil in the outer circle is covered on the reaction solution. Comparing to the traditional PCR method, the micro-droplet PCR device and chips have the advantages of extremely low-volume reaction solution (only 1~2μL) and rapid amplification time (~30 minutes). The novel micro-droplet PCR device is quite promising to efficiently DNA amplify.

MN-ThP4 Boundary Slip and Nanobubble Study in Micro/Nanofluidics with Atomic Force Microscope, ***B. Bhushan***, The Ohio State University

The boundary condition at the liquid-solid interface in micro/nano scale is an important issue in micro/nanofluidics systems. Recent studies have shown that the fluid velocity near solid surfaces is not equal to the velocity of the solid surface on hydrophobic surfaces, which is called boundary slip. The degree of boundary slip is evaluated by a slip length. Theoretical and experimental studies suggest that at the solid-liquid interface, the presence of nanobubbles is responsible for the breakdown of the no-slip condition. Nanobubbles are long lasting on hydrophobic surfaces, and movement and coalescence of nanobubbles are observed with higher scan loads during imaging with tapping mode AFM.

In this study, both contact and dynamic AFM methods have been applied to study the boundary slip on hydrophilic, hydrophobic, and superhydrophobic surfaces. An AFM based technique is developed to study boundary slip. Nanobubble movement and coalescence, as well as tip-bubble interaction, are studied in detail. The physical interaction between nanobubbles and the surfaces supporting them is investigated.

MN-ThP5 Rapid Point-Of-Care (POC) Diagnostics by Droplet-Based Detection Instrument, ***C.S. Yu***, *Y.C. Hu, H.-S. Huang, J.-S. Kao*, ITRC, Taiwan, Republic of China

This paper proposes a novel point-of-care (POC) instrumentation, provides fast, simple, low cost detection and easy used. This instrument including three main parts, micro fluid chip module, electronic module and optics detection module. We use the standard the LIGA-Like process to complete the micro fluid chip. Metal master which using the electroplating technology, the massive manufactures uses the Hot-Embossing process. We characterize a gradient of surface tension force to manipulation droplet and a droplet-based reagent can be transported, precisely positioning, and mixed on the detection zone without any power source. A variety of applications are also possible such as food testing, drinking water testing, alcohol testing, anti-oxidation measurement and cosmetic analysis.

MN-ThP6 Absorption and Emission of Plasmonic Antenna Arrays, ***K.E. O'Brien***, *M.R. Davidson, P.H. Holloway*, University of Florida

New and more portable means of generating narrow band radiation is of interest, especially in the terahertz (THz) range. One potential method for generating radiation involves photo-mixing over nano/micro scale plasmonic structures. The plasmonic structures can serve as antennas for absorbing incoming photons and conversely emit radiation of a lower frequency. Designs include 2-dimensional and 3-dimensional arrays of theses resonant structures fabricated on Ag thin films using electron-beam lithography and lift-off. Patterns vary from arrays of structures of identical lengths and widths, to those with alternating and increasing lengths and widths. We have shown emission of visible radiation from similar structures when excited by space charge from electrons. The absorption and emission of light by the arrays has been measured. The effect of different antenna structures on the in absorption and emission will be discussed.

MN-ThP7 Biomimetic Application of Localized Hydrophobicity for Increased Drag Reduction Performance on Shark Skin-Inspired Riblet Surfaces, ***B. Dean***, *B. Bhushan*, The Ohio State University

The skin of fast swimming sharks exhibits riblet structures aligned in the direction of flow which are known to reduce skin friction drag in the turbulent flow regime. Fish secrete mucus through their skin which greatly reduces drag during swimming. Small amounts of mucus have been seen on the scales and riblets of fast swimming sharks, which affect the near-skin flow properties in some way. The drag reduction effect of this trace amount of mucus on the surface of the shark skin is approximated by the slip length present in water flowing over a hydrophobic surface. A biomimetic study is done in which the drag reduction benefit of localized and non-localized hydrophobic surface applications onto drag reducing riblet structures are

studied. The combined effect of turbulent drag reduction by localized or non-localized hydrophobicity and by riblet mechanisms is presented.

MN-ThP8 Development of High-Density Cylindrical Ion Trap Array for Mass Spectrometer, ***T. Wu***, *A. Chaudhary, F. Amerom, T. Short, J. Wang*, University of South Florida

This paper presents the development of high-density cylindrical ion trap array for mass spectrometer (CIT-MS).The previous research has mainly focused on the adjusting the ring electrode radius r_0, cylinder length z_0, and endplate hole electrode r_H (Figure 1) and developing a fabrication process involving a back-to-back bonding of two half CIT structures. However, recently it has been noticed that a key factor that limits the performance of the CIT is the high capacitance between endplate electrodes and ring electrode due to the small gap; besides, the back-to-back bonding of two half structures could bring a maximum 5 micron misalignment. Based on these concerns, a new geometry of CIT array for mass spectrometer has been designed; also a new fabrication process has been developed accordingly.

In the newly developed generation of CIT-MS, the geometry design of CIT has been focusing on increasing the gap between the ring electrode and endplate electrode. Several simulations have been done on this subject. Other important improvements include better ring-to-endplate aperture alignment using dedicated alignment marks during flip-chip bonding, hexagonal orientation of traps leading to smaller pitch between each trap to increase density (thereby more trapping volume per unit area of wafer), larger vacuum gaps for operation at higher voltages for increased mass range and selective metallization using lithography techniques to reduce the overlap area of ring and endplate electrodes for lower capacitance.

A new fabrication process has been designed to achieve the improvements mentioned above. A suspended endplate electrode structure, using KOH/DRIE etching techniques, was used to increase the gap and reduce the overlapping area at the same time. To avoid surface charging of the dielectric surface that is exposed to ions, Atomic Layer Deposition (ALD) was investigated to deposit highly resistive (ZnO) layer on the dielectric surface to dissipate charge, while adding minimum to the capacitance. Flip-chip bonding was used to bond the ring-electrode and endplate electrodes and minimize the misalignment between the two substrates. With these considerations, both the esolution specificity and sensitivity are expected to improve. The design of optical mask for this process is underway and we report preliminary progress based on the latest findings.

MN-ThP9 Development of Optimum Ti/TiN Dark Reference Structure to Improve Dark Leakage Characteristics in CMOS Image Sensor, *S.-Y. Kim,* Korea Polytechnic College IV, Republic of Korea, ***N.-H. Kim,*** Chonnam National University, Republic of Korea, *K.-G. Oh*, Chosun University, Republic of Korea

Dark leakage is one the most effective factors influencing the characteristics of CMOS image sensor (CIS), which makes the unrelated signals instead of the when the low intensity of illumination lighted up to image sensors. To solve this problem, there are so many efforts into changing the designs and fabrication processes. One of these efforts is the usage of dark reference to improve the dark leakage characteristics. In this study, the CIS including dark reference was fabricated. The dark reference located in the edge of the valid pixel makes no sigmal from light through perfectly blocking out light, which is used to by using the metal thin films. For easy fabrication and excellent stability, Ti/TiN structure was employed in this experiment. The dark reference by Ti/TiN structure showed the lower leakage characteristics the under-lying photodiode than that of the valid pixel in the general H_2 annealing time (30 min). The dark leakage characteristics were improved by increasing the H_2 annealing time; however, the increased annealing time lead the fabrication ability and yield to be lower. Therefore, the optimized thickness (150 nm) of Ti/TiN structure were obtained by theoritical estimation for the under 0.01% transmittance. In experiment, the leakage characteristics were improved in the conventional H_2 annealing time by decreasing the thickness of Ti in Ti/TiN structure. Consequently, the dark leakage characteristics and SNR of CIS were improved by optimization of Ti/TiN thickness with the short fabrication/annealing time.

MN-ThP10 Improvement of Optical Properties in 3D CMOS Image Sensor (CIS) by Using Insertion Structure of Metal Slot, *S.-Y. Kim,* Korea Polytechnic College IV, Republic of Korea, ***G.-M. Han***, *N.-H. Kim*, Chonnam National University, Republic of Korea

High integrated CMOS image sensor (CIS) has contimuously decreased the area of photodiode in CIS structure. This is the origitnated reason to decline the optical characteristics of CIS including optical generation collection efficiency (CE), and crosstalk. Although the conventional structure used the PD structure with shallow trench isolation (STI) for pixel-to-pixel isolation, this structure brought out the high leakage characteristics. To improve this leakage problem, the conventional process employed the counter-doping method of impurities; however, this method could not solve the crosstalk problem by the obliquely incoming light. In this study, both the counter-doping of impurities and insertion of metal slot into the center of counter-doping were proposed to form the pixel-to-pixel isolation. This structure carried out the role of wave-guide with the excellent light reflection characteristics of metal as well as the conventional ground of contact. The crosstalk issue was successfully improved with the enhancement of the optical generation characteristics of 3D CIS by using this novel structure instead of the conventional STI pixel-to-pixel isolation method.

MN-ThP11 Modeling of Diffusion, Nucleation and Growth in the Chemical Vapor Infiltration of Vertically-Aligned Carbon Nanotube Forests for MEMS, ***A.M. Konneker***, *D.D. Allred, R.C. Davis*, Brigham Young University

We present preliminary results using computer simulation of chemical vapor deposition into vertically aligned carbon nanotube (VACNT) forests. The model is based upon deposition processes used in the carbon nanotube templated microfabrication (CNT-M) process. It utilizes VACNT arrays as a framework into which matter is infiltrated via a chemical vapor deposition (CVD)-type process to create solid microstructures and microelectromechanical systems (MEMS). These can have large aspect ratios (200:1) and startling heights (to date up to a mm). Long nozzles with narrow ID and other structures have been made that would be difficult by subtractive techniques. One of the biggest advantages of CNT-M is the promise of being able to prepare MEMS from any desired solid material that can be deposited by CVD, though to date this has only been amorphous and polycrystalline Si, SiO2, SiC, silicon nitride and amorphous carbon.

This work was inspired by the desire to understand how the gas diffusion, reaction and nucleation and growth models used to describe, mostly 2-D, thin-film CVD can be applied to understanding growth on the individual carbon nanotubes and nanotube bundles that make up a VACNT structure. This scaffolding is 3-dimensional, but "rarified"- that is > 99% empty and geometrically complex, and is vital for use of the CNT-M process. How it changes from mostly emptiness to a filled structure was a puzzle. Without optimized growth parameters, deposition is limited to the exterior of the VACNT forests and the structural integrity of the MEMS is poor. In addition, the adhesion of the MEMS devices to the substrate is often inadequate, which leads to low yields and frequent device failure.

Our model explores how the deposition rate, VACNT geometry, and VACNT forest density affects the filling of the forest. We base the parameters in our model on data from the TEM analysis of MEMS devices fabricated using the CNT-M process with CVD-deposited polysilicon, amorphous carbon, and silicon nitride.

Authors Index

Bold page numbers indicate the presenter