NEMS/MEMS AND MICROTAS

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INTERNATIONAL CONFERENCE ON MATERIALS FOR ADVANCED TECHNOLOGIES

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Organised by

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NANYANG TECHNOLOGICAL UNIVERSITY

NEMS/MEMS and microTAS

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[1]*Institute of Microelectronics, Agency for Science, Technology and Research, Singapore,* [2]*Fabs, Institute of microelectronics, Singapore,* [3]*Fabs, Institute of microelectronics, Agency for Science, Technology and Research, Singapore*

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[1]*Temasek Microelectronics Center, Temasek Polytechnic, Singapore,* [2]*Temasek Polytechnic, Singapore*

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Jumril YUNAS[1*], Juliana JOHARI[1], Ali Reza BAHADORIMEHR[1], Burhanuddin YEOP MAJLIS[1], Ille GEBESHUBER[1]

[1]*Institute of Microengineering and Nanoelectronics, Universiti Kebangsaan Malaysia, Malaysia*

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[1]*Research and Development, Gelest Inc, United States,* [2]*College of Nanoscale Science and Engineering, State University of New York, United States*

MEMS Sensors

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[1]*Advanced Concepts Group, Data Storage Institute, Singapore*

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[1]*Institute of Microelectronics, Singapore,* [2]*Sensors and Actuators Microsystems, Institute of Microelectronics, Singapore,* [3]*Institute of Microelectronics, Agency for Science, Technology and Research, Singapore*

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[1]*Electrical, Electronic and Information Engineering, Kanagawa University, Japan*

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[1]*School of Electrical and Electronics Engineering, Nanyang Technological University, Singapore,* [2]*Institute of Microelectronics, Agency for Science, Technology and Research, Singapore,* [3]*Global Foundries Singapore Private Limited, Singapore,* [4]*School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore*

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[1]*Electrical, Electronic and Information Engineering, Kanagawa University, Japan*

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S.H. Sophia LEE[1*], Saif A. KHAN[2], T. Alan HATTON[3]

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Jitkai CHIN[1#*], Kean How CHEAH[2], kai Seng KOH[2]

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Praveen KUMAR SAMPATH[1#*]

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Jafar ALVANKARIAN[1], Mitra DAMGHANIAN[1], Burhanuddin YEOP MAJLIS[1#*]

[1]Institute of Microengineering and Nanoelectronics, Universiti Kebangsaan Malaysia, Malaysia

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Subodh SRIVASTAV[1#*], Sumit KUMAR[1], Vipin Kumar JAIN[1], YK VIJAY[1]

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On the Way to the Bionic Man - A Novel Approach to MEMS Based on Biological Sensory Systems

Salmah B. KARMAN[1], Mark O. MACQUEEN[2], Tina R. MATIN[1], S. Zaleha M. DIAH[1], Jeanette MUELLER[4], Jumril YUNAS[1], Teresa MAKARCZUK[5], Ille C. GEBESHUBER[1,5#*]

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G11-7

Investigation of Simple Process Technology for the Fabrication of Valveless Micropumps

Jumril YUNAS[1*], Juliana JOHARI[1], Ali Reza BAHADORIMEHR[1], Burhanuddin YEOP MAJLIS[1], Ille GEBESHUBER[1]
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Micropumps are essential components of the miniaturization of fluidic systems to enable liquid injection from the storage to a fluidic system and to control fluidic flow in a variety of applications, such as integrated fluidic channel arrangements in chemical analysis systems or electronics cooling, as well as for drug delivery systems. Micropumps offer important advantages because they are compact and small in size. They can operate using small sample volumes and provide rapid respond time. In this paper we discuss a simple and rapid process technique for the fabrication of valveless micro-pumps. The technique utilizes standard MEMS technique by using a double sided wet etching technique with an additional adhesive bonding technique. Anisotropic wet etching at both sides of silicon substrate is implemented at the same time which reduce the processing steps up to 50%. The diffuser and a nozzle element of the pump, as well as a 150 μm thick silicon membrane are designed and fabricated using only 3 pattern process steps. An actuator-chamber and a pump-chamber with a depth of 250 μm respectively is formed after 250 minutes KOH etching, while the diffuser/nozzle element with a depth of 50 μm are sequentially formed after chambers forming. A piezoelectric disc working at the frequency 1.5 kHz is bonded on to the back side of the silicon membrane using conductive epoxy material. Finally, the use of a standard thick photoresist as the adhesive material for the bonding will also be discussed in detail. The flow rate was measured and the process reproducibility was proven which show a good prospect for the future development of miniaturized pump for biomedical application.

G11-8

Hydridosilane Modification of Metals: An Exploratory Study

Janis MATISONS[1*], Barry ARKLES[1], Yun Mi KIM[1], Youlin PAN[1], Eric EISENBRAUN[2], Alain KALOYEROS[2]
[1]Research and Development, Gelest Inc, United States, [2]College of Nanoscale Science and Engineering, State University of New York, United States
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The interaction of hydridosilanes with oxide-free metal substrates was evaluated in order to determine their potential for surface modification analogous to alkoxysilanes with metal oxide substrates. Under mild conditions, trihydrido-silanes interact with a variety of clean, hydrogenated and fresh metal and metalloid surfaces, including titanium, silicon and gold. In contrast, monohydrido-silanes appear to have minimal interaction. All classes of hydrido-silanes have minimal interaction with anhydrous oxide surfaces. Results suggest that surface modification with trihydrido-silanes may provide a route for generating self-assembled monolayers on metal substrates. The synthesis of new trihydrido-silanes is described, while contact angle, FTIR and XPS data for all modified surfaces are provided.

G-PO3-47

On the Way to the Bionic Man - A Novel Approach to MEMS Based on Biological Sensory Systems

Salmah B. KARMAN[1], Mark O. MACQUEEN[2], Tina R. MATIN[1], S. Zaleha M. DIAH[3], Jeanette MUELLER[4], Jumril YUNAS[1], Teresa MAKARCZUK[5], Ille C. GEBESHUBER[1,5#+]
[1]*Institute of Microengineering and Nanoelectronics, Universiti Kebangsaan Malaysia, Malaysia,* [2]*Aramis Technologies Sdn. Bhd., Malaysia,* [3]*Zoology Museum, University of Malaya, Malaysia,* [4]*Trustroom, Austria,* [5]*Institute of Applied Physics, Vienna University of Technology, Austria*
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The human senses are of extraordinary value, but we cannot change them, even if this proves to be a disadvantage in our modern times. However, we can assist, enhance and expand these senses via MEMS. A push-pull analysis was performed to investigate market needs in relation to biological senses reported in the literature. Some animals and even humans (with artificial lenses after cataract surgery) can see in the infrared and ultraviolet range; related MEMS with IR/UV sensitivity might assist to determine the status of organisms. The hearing capabilities of bats (ultrasound) can inspire echolocation. Butterflies have exquisite thermoregulation; this might lead to MEMS that are better protected from overheating and undesirable convection. Mice can smell important information about another mouse's immune system and mosquitoes detect minuscule amounts of carbon dioxide and lactic acid; such bio-inspired MEMS could serve as medical or environmental scanners. The senses for magnetism, vibrations and electroreception that are used by animals might satisfy the need for MEMS for navigation and orientation.

MEMS that are skillfully added to the human body can provide additional perceptory data. The challenge here will be to process the MEMS generated data into readily understandable information and provide them to the user as an add-on within an already existing sensory bandwidth. This can happen in three ways: the expensive method adds information to the upper or lower end of the (compressed) sensory bandwidth; the additive method enhances the original information by transforming it and in the mutative method completely reformats the available information. The extraordinary plasticity of the human brain will allow the user to adapt to the amended sensory environment relatively fast, providing unparalleled novel abilities. Future research will identify where already available MEMS excel and which outstanding properties of sensory systems can easily be replicated by 'off the shelf' systems.

G-PO3-48

Biomolecule Separation Using Electrophoresis Enhanced Deterministic Lateral Displacement

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Biomolecules such as Deoxyribonucleic acid (DNA), Ribonucleic acid (RNA) and proteins are key analytes in medical diagnostic, therapeutic and research processes. Separation of these biomolecules in its native state would greatly enhance downstream testing and analysis. This project proposes a novel method of a native biomolecule separation technique employing the use of deterministic lateral displacement (DLD) separation enhanced with electrophoresis. With reported particle size deviation of less than 20nm and potential analyte purity of greater than 99%, DLD has the capacity to accurately separate particle based on size. The trade-off for such high precision and efficiency would be a very limited separating range for each DLD device. Hence a proposed use of electrophoresis is needed to enhance the potential of DLD device to selectively control the separation of charge biomolocules (DNA, RNA and Proetins). The method proposed in this project would

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greatly enhance the flexibility of the DLD device to allow separation of a wide range of biomolecules. With the addition of another separating mechanism, its combined effect of electrophoresis and DLD would significantly increase the range of particle separating applications and separation efficiency.

G-PO3-49

Silicon Probes for Cochlear Auditory Nerve Stimulation and Measurement.

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Cochlear Implant's (CI's) are devices that provides sense of sound to people who are deaf or severely hard of hearing. Electrode array, the main component is placed in close contact with neurons to provide reliable excitation to the auditory nerve. The important issue with CI's is electrode design and its placement. The array should be placed close to the modiolar wall of cochlea. Available cochlear arrays are hand assembled bundled wires coated with silicone for biocompatibility. These are limited in electrode count (16-24), due to their large size relative to the size of scala tympani (ST). Arrays should be flexible for easy surgical insertion and biocompatible in hostile and saline warm environment. Silicon semiconductor micro-fabrication is an promising technology for advanced CI electrode arrays which will replace the traditional fabrication method. We present a new design for silicon CI electrode array. It consists of a Silicon substrate on which 16 Platinum-Iridium contact points provides stimulation to nerve endings. Three different configurations are considered for current density distribution, as excess current causes overstimulation with damage to residual hearing. Prior to fabrication and placement in ST we will fabricate stiff probes which would puncture the cochlear auditory nerve. This is in order to check the stimulation pattern by passing current through the array and to realize the mechanical strength of the probe. Simulation of probe was done in the volume conduction cochlear model developed at LUMC. In this model to mimic the tonotopic organization of cochlea the fibers were arranged according to frequency. High frequency fibers at base and low frequency at apex of the model. A minimum current of 10^{-2} mA to a maximum of 0.5 mA is passed through the probe placed in the bundle of nerve fibers for stimulation at contact points of the probe.

G-PO3-50

NEMS-based Innervation of Materials

Ille C. GEBESHUBER[1,2*+], Jeanette MUELLER[3], Mark O. MACQUEEN[4]

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We propose a concept for a novel "homogenous" material that is assembled by billions of coupled reactive NEMS. This new approach shall enable the material to show specific reactions to external inputs. Since the NEMS can communicate with each other, the reaction to the external input can be local (indicator) or general (reactive). By implementing this material into buildings, clothing or even food, it would be possible to create a virtual neural system inobjects. The presentation will give an outlook on the potential of such an approach in art, science and technology and the possible impact on the life of future generations.
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G-PO3-51

Nano-scaled Optical Powermeter Development on Silicon Platform

Ji Fang TAO[1*+], Aibin YU[2], Hong CAI[3], Jian WU[4], Ai-Qun LIU[5]

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This paper reports a silicon-based MEMS optical power detector with on-chip measurement ability. The optical power is detected by an integrated electron-tunneling displacement transducer, in which optical force is employed as the bridge between optical energy and mechanical energy transition. Compared with the traditional optical power detectors which are based on photo absorption, this optical power detector has small size (0.08 mm × 0.3 mm), low thermal noise (0.03 V/°C), large measurement range (> 20 mW) and wavelength independence.

The proposed optical power detector consists of an optical waveguide, a cantilever beam, a pair of metalized nano-tips, and a parallel-plate electrostatic actuator. When the light transmits in the waveguide, its evanescent field can excite dipoles in the adjacent cantilever beam and generate an attractive optical force. Therefore, a small displacement of the cantilever beam is generated, whose magnitude is determined by the input optical power and the spring constant of the cantilever beam. In order to detect this displacement, a high resolution tunneling transducer, which consists of the metalized nano-tips and the parallel-plate electrostatic actuator, is integrated.

In conclusions, a high-performance silicon-based optical power detector has been developed by MEMS technology. As it possesses the advantages of small size (0.08 mm × 0.3 mm), large measurement range (> 20mW), and on-chip measurement ability, it has potential applications in silicon-photonics-integration chips and lab-on-chip analysis systems.

G-PO3-52

A Ring Resonator Pressure Sensor Based on Optical Force

Xin ZHAO[1+], Hong CAI[2], Ming Lin Julius TSAI[2], Xin-ming JI[3], Jia ZHOU[3], Min-Hang BAO[4], Yi-Ping HUANG[4], Ai-Qun LIU[1*]

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A Nano-opto-mechanical Systems (NOMS) ring resonator pressure sensor based on optical force is reported. This sensor array which is similar as Wheatstone-bridge pressure sensor.consists of a square diaphragm, a ring resonator and four waveguides. By applying a pressure ranging from 100 kPa to 800 kPa, the output intensity modulation of 60% is obtained. Compared with other single waveguide and ring optical pressure sensor, the proposed ring pressure sensor array has the advantages such as higher sensitivity and resolution, which could be applied to acoustic pressure sensor, cell mass measurement etc.

The ring resonator pressure sensor consists of a 500 × 500 μm2 diaphragm, a ring resonator and four waveguides. The waveguides coupled to each other through the ring resonator and forms four waveguide based interferometers with four input and two output ports.

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NEMS-based Innervation of Materials

Ille C. GEBESHUBER[1,2#+], Jeanette MUELLER[3], Mark O. MACQUEEN[4]

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We propose a concept for a novel "homogenous" material that is assembled by billions of coupled reactive NEMS. This new approach shall enable the material to show specific reactions to external inputs. Since the NEMS can communicate with each other, the reaction to the external input can be local (indicator) or general (reactive). By implementing this material into buildings, clothing or even food, it would be possible to create a virtual neural system in objects. The presentation will give an outlook on the potential of such an approach in art, science and technology and the possible impact on the life of future generations.