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MEMS & NANO TECHNOLOGY

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Abstract **:We have proposed a unified approach to the modeling and study of developments in the field of MEMS and Nanotechnology and its application in futuristic Nano-enabled Cells. We have proposed a novel to approach reliability of MEMS enabled fuel cells. We know that reliability and accurate prediction of properties in nano domains remains a major challenge where still theories are being developed to predict the accurate model for the system. The necessity of a nonporous membrane has been eminent in recent fuel cells.**

INTRODUCTION

EMS (Micro Electro Mechanical Systems) can be used for various areas that vary from sensing to micro fluidics and their impact on fuel cells is well known to us. Recently MEMS based fuel cell system has been proposed where the power density was stated to be 220 mW/cm2 when the potential was 0.65 V thereby showing the advantages of integration of MEMS based devices in fuel cell technology . Fuel cells have been the favorite candidates for portable electronics where indirect hydrogen, direct methanol and Nanotechnology based fuel cells have been of prime focus in recent years . The relationship between energy content and respective fuel volume used is shown in figure 1. Higher density, lower form factor and minimization of cost have remained the prime focus for fuel cells. Key requirements of micro fuel cell system for portable electronics incorporating MEMS technologies have been conferred and are being developed at Motorola TM . In recent years the development of hydrogen fuel cell cycle has been discussed from a thermo dynamical perspective and the challenges that exist for transformation from a fossil-fuel based economy to a hydrogen based economy. Also historical aspects in fuel-cell technology have been conversed . Various methods for generation of energy for portable devices
including fuel cell technology as a practical solution and hybrid of various technologies including like piezoelectric, photo voltaic are studied. Hence a comprehensive approach in the modeling of fuel cells is necessitated. MEMS based electrodes, PEM, pumps reactors have been proposed that make MEMS based fuel cell a possible candidate for future devices. The fabrication technology used here is same as one used in MEMS manufacturing.

What is MEMS Technology?

Micro-Electro-Mechanical Systems, or MEMS, is a technology that in its most general form can be defined as miniaturized mechanical and electro-mechanical elements (i.e., devices and structures) that are made using the techniques of micro fabrication. The critical physical dimensions of MEMS devices can vary from well below one micron on the lower end of the dimensional spectrum, all the way to several millimeters. Likewise, the types of MEMS devices can vary from relatively simple structures having no moving elements, to extremely complex electromechanical systems with multiple moving elements under the control of integrated microelectronics. The one main criterion of MEMS is that there are at least some elements having some sort of mechanical functionality whether or not these elements can move. The term used to define MEMS varies in different parts of the world. In the United States they are predominantly called MEMS, while in some other parts of the world they are called “Microsystems Technology” or “micro machined devices”. While the functional elements of MEMS are miniaturized structures, sensors, actuators, and microelectronics, the most notable (and perhaps most interesting) elements are the micro sensors and micro actuators. Micro sensors and micro actuators are appropriately categorized as “transducers”, which are defined as devices that convert energy from one form to another. In the case of micro sensors, the device typically converts a measured mechanical signal into an electrical signal.

RECENT TRENDS

Carbon Nanotube can be used for carbon storage has been given in a survey done by Banerjee st al. in The importance of simulations methods such as molecular dynamics and Monte Carlo simulation is eminent as shown in CNT storage technologies. Thus this is one of the applications of the CNTs which are seeing its application of many areas of energy. CNT based structure and MEMS membrane both holds an important role in designing the reaction device for micro DMFC which has been described recently in year 2008 . The recent trends and maturing research of Si nano composites and CNT based devices also integrated with MEMS will play a very important role in Nano enabled fuel cells .
Various types of DMFC are discussed with the application of micro machining in this regard is discussed in details of power generation and different modeling are described. Porous carbon–platinum proton exchange membrane fuel cell electrodes have been described in . Latest invention in Fuel Cell and related nanotech industries has been given in Details about leading fuel cell inventors are given and the leading patents makers. Also the key firms of nanotech involved in fuel cells are given in the same. Nano porous Silicon Membrane can be used to make electrode systems has been proposed for micro fuel cells due to its compatibility have been shown in , nano porous silicon is a primary candidate which can be simulated by our model as a proton conducting membrane material in a micro scale fuel cell membrane electrode assembly (MEA). Nano imprint technology could be utilized in MEMS-based fuel cell for large surface area

The nano imprint technology shows excellent process compatibility with both MEMS and fuel cell technology. The introduction of the nano imprint technology to the current fuel cell industry would not cause heavy capital investment.

Another merit of nano imprint technology is that the catalyst loading could be reduced owing to higher catalyst efficiency MEMS not only can be used for the membrane but also for electrodes with various proposed designs as shown in where a MEMS-based portable Direct Methanol Fuel Cell (micro-DFMC), featured by a platinum sputtered micro-column electrode and a built-in fuel chamber containing a limited

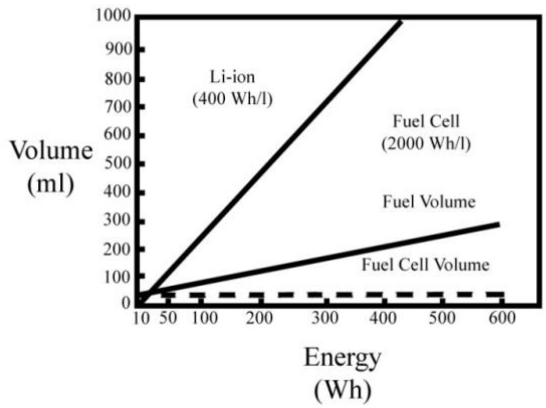

Figure 1. Comparison of fuel volume vs. energy for fuel cells and current lithium-ion cells

amount of methanol fuel and also presented is a micro-DMFCstack structure having a common electrolyte sandwiched by the micro-column electrodes. The maximum power density of 4-
cell stack is 15.7 times higher than that of the single cell. 4-cell stack produces the power capacity of 20.3mWh/g during 980min operation at the voltage of 450mV with the load resistance of 8OOQ.In SUGAR modeling we can use such type of materials for simulation which has been proposed in this paper, and the failure analysis of such electrodes is an important feature in such type of devices.

Application of MEMS Technology to Micro Direct Methanol Fuel Cell has been shown in the silicon processes for micro-fabrication of the micro direct methanol fuel cell (µDMFC) and fabrication of electro-catalytic electrodes using electroless plating platinum and ruthenium (Pt- Ru) co-deposition method over porous silicon (PS) substrates was used by them in their mode. Integrated MEMS based monolithic fuel cells has been shown
where the design, fabrication and performance of small fuel cells using Micro Electromechanical Systems (MEMS) technology described that consisted of three components layers, including those of an electromechanically integrated anodecathode, and polymer electrolyte membrane (PEM). In this work the models of polymer can be defined and their analysis can be done easily, where we define the material type in the library of our work.. Micro Diaphragm air pump for air supply of fuel cells has been described where Xing Yang et.al. presented a microdiaphragm air pump actuated by PZT bimorphs for air supply of micro fuel cell, , the air pump's flow is 85.3 m/min (the flow rate is about 0.2m/s) in resonance and its power consumption is only 3.1 mW such proposals needs to be worked out under the framework of reliability analysis before they can be implemented. Infrared Thermal Velocimetry in MEMS-Based Fluidic Devices has been shown where a wide range of the velocity (1 cm/s–1 m/s or higher) in silicon micro channels can be measured. An infrared camera records the radiative images from the heated flowing liquid and the steady flow velocity is obtained from consecutive radiative images.

MEMS AND NANOTECHNOLOGY APPLICATIONS

There are numerous possible applications for MEMS and Nanotechnology. As a breakthrough technology, allowing unparalleled synergy between previously unrelated fields such as biology and microelectronics, many new MEMS and Nanotechnology applications will emerge, expanding beyond that which is currently identified or known. Here are a few applications of current interest:

BIOTECHNOLOGY

MEMS and Nanotechnology is enabling new discoveries in science and engineering such as the Polymerase Chain Reaction (PCR) microsystems for DNA amplification and identification, enzyme linked immunosorbent assay (ELISA), capillary electrophoresis, electroporation, micromachined Scanning Tunneling Microscopes (STMs), biochips for detection of hazardous chemical and biological agents, and microsystems for high-throughput drug screening and selection.

MEDICINE

There are a wide variety of applications for MEMS in medicine. The first and by far the most successful application of MEMS in medicine (at least in terms of number of devices and market size) are MEMS pressure sensors, which have been in use for several decades. The market for these pressure sensors is extremely diverse and highly fragmented, with a few high-volume markets and many lower volume ones. Some of the applications of MEMS pressure sensors in medicine include:

The largest market for MEMS pressure sensors in the medical sector is the disposable sensor used to monitor blood pressure in IV lines of patients in intensive care. These devices were first introduced in the early 1980's. They replaced other technologies that cost over $500 and which had a substantial recurring cost since they had to be sterilized and recalibrated after each use. MEMS disposable pressure sensors are delivered pre-calibrated in a sterilized package from the factory at a cost of around $10.

MEMS pressure sensors are used to measure intrauterine pressure during birth. The device is housed in a catheter that is placed between the baby's head and the uterine wall. During delivery, the baby's blood pressure is monitored for problems during the mother's contractions.

MEMS pressure sensors are used in hospitals and ambulances as monitors of a patient's vital signs, specifically the patient's blood pressure and respiration.

The MEMS pressure sensors in respiratory monitoring are used in ventilators to monitor the patient's breathing.

MEMS pressure sensors are used for eye surgery to measure and control the vacuum level used to remove fluid from the eye, which is cleaned of debris and replaced back into the eye during surgery.

Special hospital beds for burn victims that employ inflatable mattresses use MEMS pressure sensors to regulate the pressure inside a series of individual inflatable chambers in the mattress. Sections of the mattress can be inflated as needed to reduce pain as well as improve patient healing.

Physician's office and hospital blood analyzers employ MEMS pressure sensors as barometric pressure correction for the analysis of concentrations of O2, CO2, calcium, potassium, and glucose in a patient's blood.

MEMS pressure sensors are used in inhalers to monitor the patient's breathing cycle and release the medication at the proper time in the breathing cycle for optimal effect. MEMS pressure sensors are used in kidney dialysis to monitor the inlet and outlet pressures of blood and the dialysis solution and to regulate the flow rates during the procedure.

MEMS pressure sensors are used in drug infusion pumps of many types to monitor the flow rate and detect for obstructions and blockages that indicate that the drug is not being properly delivered to the patient.

The contribution to patient care for all of these applications has been enormous. More recently, MEMS pressure sensors have been developed and are being marketed that have wireless interrogation capability. These sensors can be implanted into a human body and the pressure can be measured using a remotely scanned wand. Another application are MEMS inertial sensors, specifically accelerometers and rate sensors which are being used as activity sensors. Perhaps the foremost application of inertial sensors in medicine is in cardiac pacemakers wherein they are used to help determine the optimum pacing rate for the patient based on their activity level. MEMS devices are also starting to be employed in drug delivery devices, for both ambulatory and implantable applications. MEMS electrodes are also being used in neuro-signal detection and neuro-stimulation applications. A variety of biological and chemical MEMS sensors for invasive and non-invasive uses are beginning to be marketed. Lab-on-a-chip and miniaturized biochemical analytical instruments are being marketed as well.

COMMUNICATIONS

High frequency circuits are benefiting considerably from the advent of RF-MEMS technology. Electrical components such as inductors and tunable capacitors can be improved significantly compared to their integrated counterparts if they are made using MEMS and Nanotechnology. With the integration of such components, the performance of communication circuits will improve, while the total circuit area, power consumption and cost will be reduced. In addition, the mechanical switch, as developed by several research groups, is a key component with huge potential in various RF and microwave circuits. The demonstrated samples of mechanical switches have quality factors much higher than anything previously available. Another successful application of RF-MEMS is in resonators as mechanical filters for communication circuits.

INRTIAL SENSING

MEMS inertial sensors, specifically accelerometers and gyroscopes, are quickly gaining market acceptance. For example, MEMS accelerometers have displaced conventional accelerometers for crash air-bag deployment systems in automobiles. The previous technology approach used several bulky accelerometers made of discrete components mounted in the front of the car with separate electronics near the air-bag and cost more than $50 per device. MEMS technology has made it possible to integrate the accelerometer and electronics onto a single silicon chip at a cost of only a few dollars. These MEMS accelerometers are much smaller, more functional, lighter, more reliable, and are produced for a fraction of the cost of the conventional macroscale accelerometer elements. More recently, MEMS gyroscopes (i.e., rate sensors) have been developed for both automobile and consumer electronics applications. MEMS inertial sensors are now being used in every car sold as well as notable customer electronic handhelds such as Apple iPhones

CONCLUSION

This is only a very brief overview of the MEMS and Nanotechnology field. MEMS and Nanotechnology are still the subject of broad and diverse research efforts, and the field is constantly changing. Nanotechnology and MEMS enabled fuel cells will
have optimum characteristics and will have tremendous advantages which can take them toward commercialization.

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