World Academy of Science, Engineering and Technology
International Journal of Biomedical and Biological Engineering
Vol:13, No:06, 2019

A Robust Stretchable Bio Micro-Electromechanical Systems Technology for High-Strain in vitro Cellular Studies

Authors : Tiffany Baetens, Sophie Halliez, Luc Buée, Emiliano Pallecchi, Vincent Thomy, Steve Arscott

Abstract : We demonstrate here a viable stretchable bio-microelectromechanical systems (BioMEMS) technology for use with biological studies concerned with the effect of high mechanical strains on living cells. An example of this is traumatic brain injury (TBI) where neurons are damaged with physical force to the brain during, e.g., accidents and sports. Robust, miniaturized integrated systems are needed by biologists to be able to study the effect of TBI on neuron cells in vitro. The major challenges in this area are (i) to develop micro, and nanofabrication processes which are based on stretchable substrates and to (ii) create systems which are robust and performant at very high mechanical strain values—sometimes as high as 100%. At the time of writing, such processes and systems were rapidly evolving subject of research and development. The BioMEMS which we present here is composed of an elastomer substrate (low Young's modulus ~1 MPa) onto which is patterned robust electrodes and insulators. The patterning of the thin films is achieved using standard photolithography techniques directly on the elastomer substrate—thus making the process generic and applicable to many materials' in based systems. The chosen elastomer used is commercial 'Sylgard 184' polydimethylsiloxane (PDMS). It is spin-coated onto a silicon wafer. Multistep ultra-violet based photolithography involving commercial photoresists are then used to pattern robust thin film metallic electrodes (chromium/gold) and insulating layers (parylene) on the top of the PDMS substrate. The thin film metals are deposited using thermal evaporation and shaped using lift-off techniques The BioMEMS has been characterized mechanically using an in-house strain-applicator tool. The system is composed of 12 electrodes with one reference electrode transversally-orientated to the uniaxial longitudinal straining of the system. The electrical resistance of the electrodes is observed to remain very stable with applied strain—with a resistivity approaching that of evaporated gold—up to an interline strain of ~50%. The mechanical characterization revealed some interesting original properties of such stretchable BioMEMS. For example, a Poisson effect induced electrical 'self-healing' of cracking was identified. Biocompatibility of the commercial photoresist has been studied and is conclusive. We will present the results of the BioMEMS, which has also characterized living cells with a commercial Multi Electrode Array (MEA) characterization tool (Multi Channel Systems, USA). The BioMEMS enables the cells to be strained up to 50% and then characterized electrically and optically.

Keywords : BioMEMS, elastomer, electrical impedance measurements of living cells, high mechanical strain, microfabrication, stretchable systems, thin films, traumatic brain injury
Conference Title : ICBMEMSA 2019 : International Conference on BioMEMS Applications
Conference Location : Dublin, Ireland
Conference Dates : June 27-28, 2019