Abstract

Advances in flexible electronics have tried to exploit the benefit of spontaneous buckling of thin film of inorganic materials when deposited over soft flexible substrates. In addition, pre-stretching of elastomeric substrates followed by thin film deposition has enabled researchers to obtain high amount of flexibility. However, patterning techniques for miniature device realization is ether limited by the use of shadow mask which restricts the minimum feature size possible or use of high end custom build precise equipments. Hence, conventional lithography technique which allows direct transfer of pattern on the target substrate is a preferred solution. The aim of the present study is to develop a technology for micropatterning of sensors over pre-stretched non-planar PDMS elastomer with controlled thin film buckling and demonstrate its flexibility.

Surface modification of PDMS elastomer is an essential pre-requisite for deposition of thin metal films over it for realization of flexible sensors. In the present study wet chemical treatment using Piranha solution having H_2O_2 : H_2SO_4 in 2:3 ratio followed by a dip in KOH solution was investigated for suitable surface modification required for improved thin film adhesion over the elastomer. Subsequently nichrome thin film was sputter deposited under optimised conditions of low deposition pressure and plasma power to ensure crack free electrically continuous metal film with associated random buckles on its surface. Present study of the development of flexible sensor requires these buckles to be oriented parallel to each other and perpendicular to the bending direction. Hence, a non-planar ridge topology over the elastomeric surface was implemented to align the buckles. In addition, initial pre-stretching of the ridge structure was necessary to control buckle wavelength and amplitude for achieving greater flexibility of the devices.

Feasibility study of flexible flow sensor was conducted using a nichrome microheater fabricated over a 35% pre-stretched ridge elastomer and successfully mounted around a 2.5 mm diameter angiographic catheter for applications in measurement of body fluid velocity. Initially performance of the sensor was evaluated by wrapping the sensor around the catheter tip and tested under various flow conditions of dry air and under the presence of different degree of constriction in the flow over the sensors. The work has further been extended to demonstrate flexibility of the sensors bend around surfaces having radius of curvature less than 1mm ensuring electrical continuity. These initial research findings may thus successfully address the issues related to the feasibility of cost effective flexible microsensors for biomedical application.

Keywords: Flexible electronics, thin film deposition, surface modification, buckling, ridge topology, PDMS, lithography, microheater, flow sensor.