Low Temperature Electrical and Optical Characterization of Lithographically-Defined Au Microchannels on an Elastomeric Substrate

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Metal-polymer bilayer systems have been studied extensively in the past decade for applications in optoelectronics, flexible electronics, and microsensors [1,2,3] to name a few. Complete characterization and understanding of such metal-polymer bilayer systems is an important part of device design and ultimate optimization of key device parameters. Compressive stress in thin metal films has also been the focus of recent studies with a particular emphasis on the formation and characterization of uniaxial and biaxial buckles.

In this work, the electrical and optical response of an Au-PDMS bilayer system has been studied as a function of decreasing substrate temperature. Specifically, the effect of low temperatures on the electrical resistance of lithographically-defined conductive channels with decreasing channel width is studied as a function of the substrate temperature. The substrate temperature was lowered from room temperature down to approximately 80K by means of a cooling stage and cycled repeatedly. The electrical resistance of the microchannels was monitored and nonlinearities associated with buckle formation studied for varying channel widths. Simultaneously, interference patterns of the reflective surface were monitored and onset of buckle formation and the nature of the interference behavior was investigated.

Such thin conductive films on compliant substrates are attractive candidates for strain gauges where the “sensitivity” of the device can be preset by changing one of several key parameters including substrate thickness, channel width, and substrate stiffness. This study shows a highly non-linear electrical response that is dependent on the channel width suggesting increased sensitivity as structure size is reduced towards nanometer scales.

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1. Stafford, C. M. et al. 2004 A buckling-based metrology for measuring the elastic moduli of polymeric thin films. Nat. Mater. 3, 545–550.

2. Genzer, J. & Groenewold, J. 2006 Soft matter with hard skin: from skin wrinkles to templating and material characterization. Soft Matter 2, 310–323.

3. Rahmawan, Y., Moon, M.-W., Kim, K.-S., Lee, K. R. & Suh, K. Y. 2010 Wrinkled, dual-scale structures of diamond-like carbon (DLC) for superhydrophobicity. Langmuir 26, 484–491.