Novel Methods for Embedded High Resolution, High-Aspect Ratio Metal Lines in Plastic

Ankit Mahajan, C. Daniel Frisbie, and Lorraine F. Francis

Department of Chemical Engineering and Materials Science
University of Minnesota, Minneapolis, Minnesota 55455

Presented at the 17th International Coating Science and Technology Symposium,
September 7-10, 2014, San Diego, CA

In recent years, printing processes have gained interest as means to fabricate low-cost, large-area electronic circuits on flexible, plastic substrates. Conductive lines, which are the most basic element of an electronic circuit, require both narrow width for high-density circuitry, and sufficient thickness for high current carrying capacity. However, many devices require overlaying a thin organic film on conductive lines, and achieving uniform coating on surfaces with topography is challenging. In this work, two novel methods for processing embedded metal lines are presented.

In one method, high resolution and high-aspect ratio aerosol-jet printed silver lines are transferred from a donor substrate to a thin reactive polymer that is directly adhered to a flexible substrate. Due to the unique ability of the aerosol jet to print continuous lines on a low energy surface, a 100% transfer of the printed electrodes is obtained, as confirmed by electrical measurements. Moreover, the root-mean-square roughness of the embedded electrodes is less than 10 nm, which is an order of magnitude lower than that for their as-printed form.

In the second method, an aqueous silver ink in flowed, via capillarity, into micro-channels engineered in a thermoset polymer coating on a plastic substrate, followed by immersion in a copper electroless deposition bath. The silver layer acts as a seed layer for

selective deposition of copper in the channels. The resolution of the Ag/Cu conductors is determined by the width of the channel, and the thickness by the duration of the plating bath.

Lines as narrow as 2 microns were obtained using this method. Electrical measurements show that the conductivity of the lines is about 60 percent of bulk metal.

Reference: Mahajan, A.; Francis, L. F.; Frisbie, C. D. ACS Appl. Mater. Interfaces **2013**, 6, 1306.