BAPVC Annual Project Report

Project Title: Materials and Processes for High-Resolution Printed Bus Bars
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Summary:

In this project, researchers are developing materials and processes for high-resolution bus bars through a combination of development of high-resolution gravure printing and development of advanced nanoparticle conductor inks. In the last year, substantial progress has been made on improving the resolution of gravure printing. Sub-2µm features have been realized, printed at printing speeds of ~1m/s. This represents a world-record achievement for gravure. Additionally, we have shown that gravure can be used to print on flexible and rigid glass substrates.

Key Accomplishments:

In the area of high-resolution printing, significant progress has been made, going beyond even our previous world record achievements. Sub-2µm features have been realized using our previously reported custom gravure printing tool. Features sizes as small as 2µm have been realized with good line edge roughness and pattern fidelity, while maintaining high printing speeds of ~1m/s, as shown in figure 1. Good conductivity has been obtained using commercial nanoparticle inks.

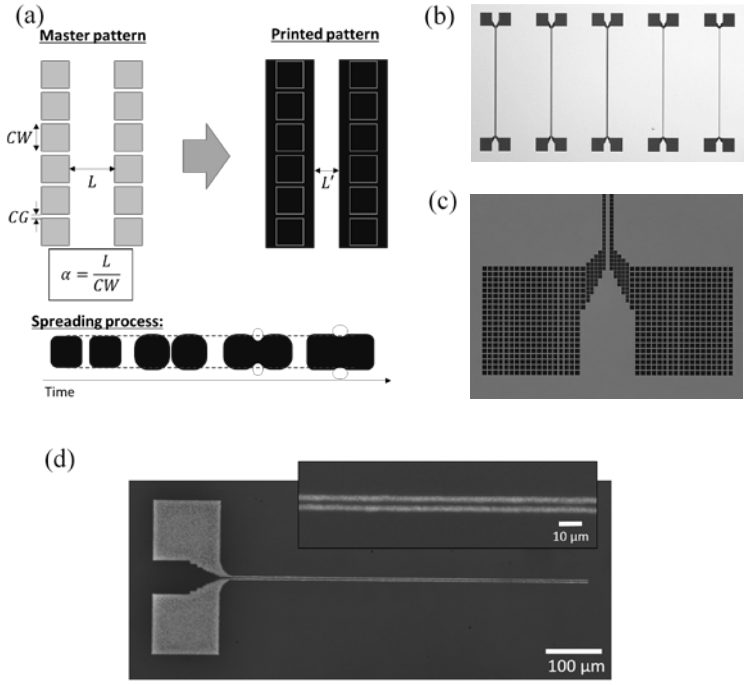

Figure 1: (a) Definitions of highly-scaled gravure patterns. Cell width and gap length are defined as width of square cells and spacing between cell edges, respectively. Printed gap length, L´, is smaller than defined gap length, L, due to the spreading process. (b) electrode patterns on a printing plate. Cell widths in lines are 6 to 2 µm from the left to right. (c) a close-up image highlighting cell arrangement of lines, contacts and taper joints. Cell widths in lines and contacts

are 5 and 4 µm, respectively. (d) A representative electrode pair after sintering of the smallest line width (2.38 µm) and gap length (1.7 µm).

Additionally, we have shown that gravure can be used to print on rigid and flexible glass. Specifically, as a demonstration, we have shown that sol-gel-derived transparent conductors can be printed on Corning Willow Glass (Figure 2) and on rigid glass slides.

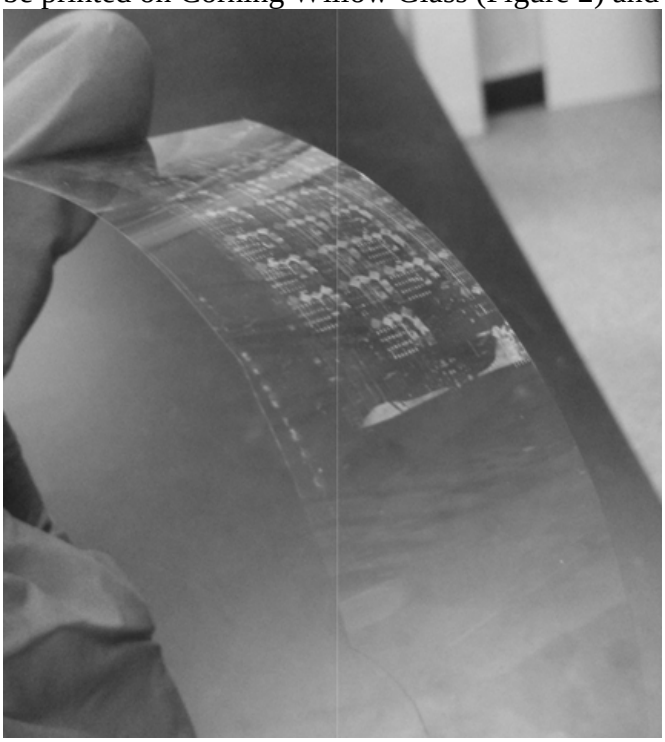

Figure 2: Gravure printing on Willow Glass

Future Work:

We are continuing to work on copper / silver alloys for low-cost conductor inks. In the future, we will integrate these alloyed particles into our printing processes to demonstrate the integration of all aspects of this work.