Inkjet Printing of Passive Microwave Circuitry

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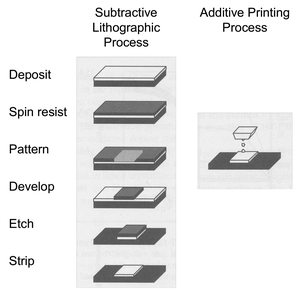
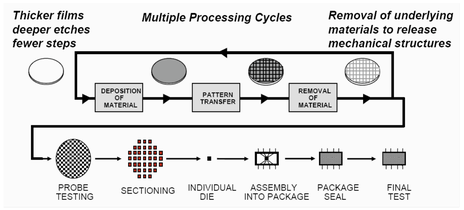
Introduction

Fabrication of passive microwave circuitry utilizes repeated cycles of deposit/pattern/etch processing steps to create multiple layers of patterned conductors. This process is very wasteful since the patterning and etching removes (subtracts) the already deposited material. Inkjet printing provides a more economical and less wasteful approach by allowing the deposition of materials only in the desired areas.

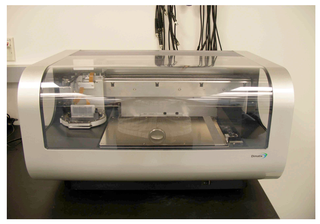


Additive Vs. Subtractive Processes

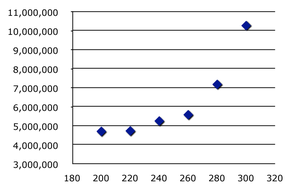


Printing Process

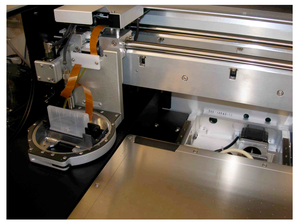
Silver nano-particle ink was deposited on a Corning #7740 glass wafer using the DMC-11610. The glass surface was treated to improve its adhesion properties. After deposition the ink is sintered from 200˚-300˚C. High sintering temperatures enable conductivity similar to that of bulk silver.



Dimatix DMP 2800



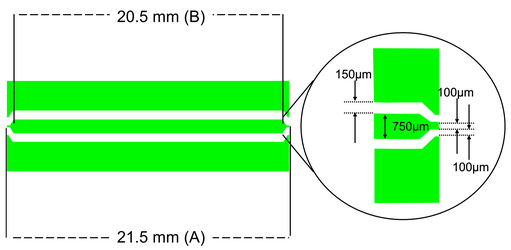
Ink Conductivity



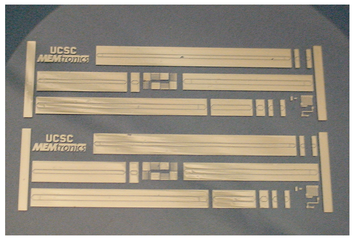
DMC-11610

DC Characteristics

Paths A and B in the figure below show a resistivity of 0.130 and 0.018 Ω/square, respectively. In comparison, a 3 μm tall electroplated copper CPW line had 0.0125 Ω/square of resistivity.



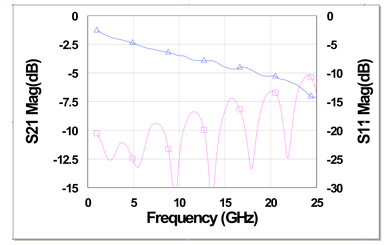
CPW Line Layout



CPW Lines on Wafer

RF Performance

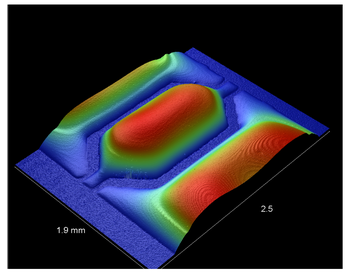
The results demonstrate an insertion loss of 1.62 and 2.65 dB/cm at 10 and 20 GHz, respectively. As a comparison, 3 μm tall electroplated CPW lines show 0.5 and 0.7 dB/cm at 10 and 20 GHz, respectively.



S11 and S21 of printed CPW lines

Resolution and Fluid Interaction

The resolution of the DM-11610 on surface treated glass is 50 μm but finer resolution can be achieved if the temperature of the glass is raised to 100˚C during printing. The figure below shows that there is considerable thinning at the edges of the CPW line. This is mainly due to the contact angle of the fluid and glass and may be controlled by varying the surface treatment.



3-D Image Of Printed Transmission Lines

Conclusion

Inkjet printing shows great potential for the fabrication of inexpensive passive microwave circuitry. The results of printing silver nano-particle ink show that resistivity similar to that of plated copper is possible. The RF properties of the printed CPW lines also show that improvement of the printing techniques will provide lower conductor losses and thus better passive devices.

Acknowledgment and References

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[1] L. Yang and M. Tentzeris, “Design and Characterization of Novel Paper-based Inkjet-Printed RFID and Microwave Structures for Telecommunication and Sensing Applications,” *2007 IEEE Intl Microwave Symp. Dig.*, pp. 1633-1636, Honolulu, HI, June 2007.
[2] http://www.dimatix.com/files/DMP-2831-Datasheet.pdf
[3] http://www.dimatix.com/files/Cabot-Spectra_PR.pdf