Manufacturing Capability of Micro-Transfer Printing

David Gomez[1], Tanya Moore[1], Matthew A. Meitl[1], Salvatore Bonafede[1], Andrew Pearson[1], Kanchan Ghosal[1], Brook Raymond[1], Erich Radauscher[1], David Kneeburg[1], Julia Roe[1], Alin Fecioru[2], Steven Kelleher[2], Antonio Jose Trindade[2,] and Christopher A. Bower[1]

1. X-Celeprint Inc., 3021 Cornwallis Road, Research Triangle Park, NC 27709, USA
2. X-Celeprint Ltd., Tyndall National Institute, Lee Maltings Complex Dyke Parade, Cork, Cork, T12 R5CP, Ireland

Dgomez@x-celeprint.com

Preferred Presentation Form: Oral

Abstract

Micro-Transfer printing is a mass transfer process that provides fast and precise assembly of micro-components onto non-native substrates. The process was originally conceived at the University of Illinois [1, 2], and has been developed at X-Celeprint. The process involves the fabrication of retrievable micro-components, elastomer stamp retrieval and transfer-printing of the micro-components to a non-native substrate and finally the interconnection [3]. With this process a large array of micro-components can be transferred at one time with an accuracy of +/- 1.5um 3 sigma and transfer yields exceeding 99%.

A pilot line for micro-transfer printing is being built in Erfurt, funded in part by the EU. This project, called Microprince, includes the technology transfer and scale-up of several applications such as printed GaN HEMTs and GaAs sensors. The pilot line will have 200 mm wafer capable transfer printing tool and equipment to interconnect the transferred devices to the target wafer. This paper addresses the manufacturing capability of Micro-Transfer Printing as it is scaled up.

Silicon nitride microchips of various sizes will be used as vehicles to release, pick and print arrays of chips in several learning cycles that will be used to qualify both the process and the equipment. Statistically significant transfer yield and print precision data for multiple chip sizes will be presented to benchmark the capability of the pilot line. Process throughput will be discussed, as a function of process tact time, density of micro-components, chip size and size of the transfer array. Figure 1 presents an example of the source material that will be used. Figure 2 presents examples of printed arrays that will be characterized as a part of pilot line qualification.

Elastomer stamp life time is an important consideration for manufacturing. Elastomer stamp lifetime will be studied by using the same stamp over thousands of print cycles. In a previous study [4], no change in the performance of the stamp was observed after more than 30,000 print cycles. The impact of scaling up the stamp size on print yield and precision will also be characterized.

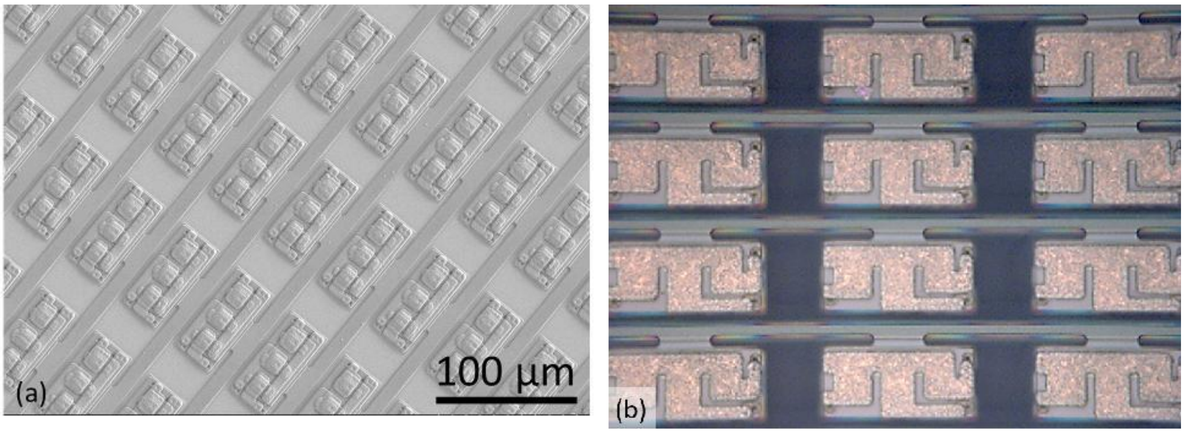

Figure 1: (a) SEM image of 70 µm x 35 µm chips before release and (b) optical image of the chips after release. The silicon nitride chips are at a pitch of 100 µm x 50 µm and are attached to the silicon substrate by anchors and tethers.

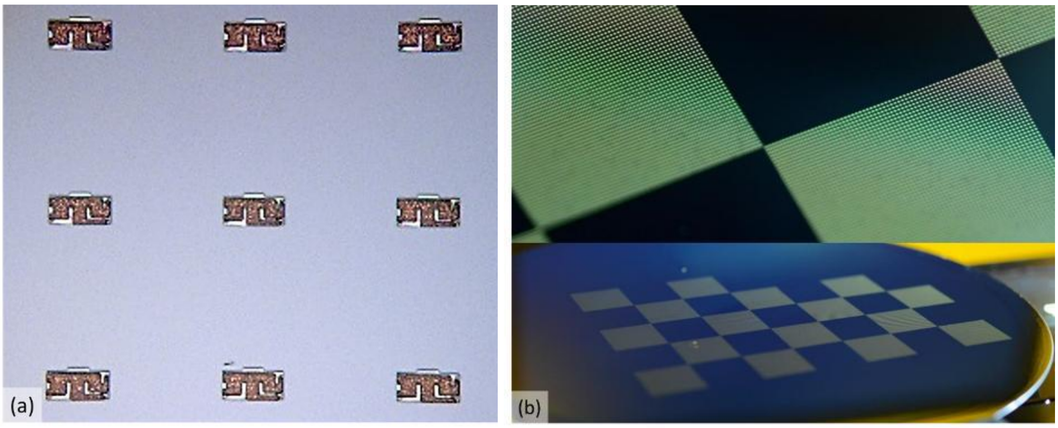

Figure 9: Print results from 70 x 35 µm chips in a 64x64 array (a) Image of printed 70 x 35 µm silicon nitride array (b) image of 16 printed arrays with a blow up of a section

References

[1] E. Menard, K. J. Lee, D. Y. Khang, R. G. Nuzzo, J. A. Rogers, Appl. Phys. Lett. 84, 5398 (2004)

[2] M.A. Meitl, Z. Zhu, V. Kumar, K.J. Lee, X. Feng, Y. Huang, I. Adesida, R.G. Nuzzo, J.A. Rogers, Nature Materials 5(1), 33 (2006).

[3] C. A. Bower, M. A. Meitl, S. Bonafede and D. Gomez, "Heterogeneous Integration of Microscale Compound Semiconductor Devices By Micro-Transfer-Printing", IEEE 65th ECTC Proceedings (2015).

[4] D. Gomez, K. Ghosal., M.A. Meitl . *et al.*, "Process Capability and Elastomer Stamp Lifetime in Micro Transfer Printing,*" 66th Electronic Components and Technology Conference (ECTC)*, 680-687 (2016).

The MICROPRINCE project has received funding from the ECSEL Joint Undertaking under grant agreement No 737465. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme and Germany, Belgium, Ireland.