Heterogeneously integrated magnetics-on-Silicon for future power supplies

Tyndall National Institute
Institiúid Náisiúnta

Challenge

A major challenge in realizing efficient granular power delivery at the system level is the difficulty associated with integration of bulky passive devices viz. inductors and capacitors as close as possible to the actual load.

In this regard, heterogeneous integration of passives – by co-packaging them with Power Management Integrated Circuits (PMICs) and processors, or by fabricating the inductors on silicon at the backside of PMICs have gained popularity. However, integrating a power converter close to the load demands innovative integration strategies. There are plenty of opportunities to enhance system efficiency while achieving higher level of miniaturization and integration.

Solution

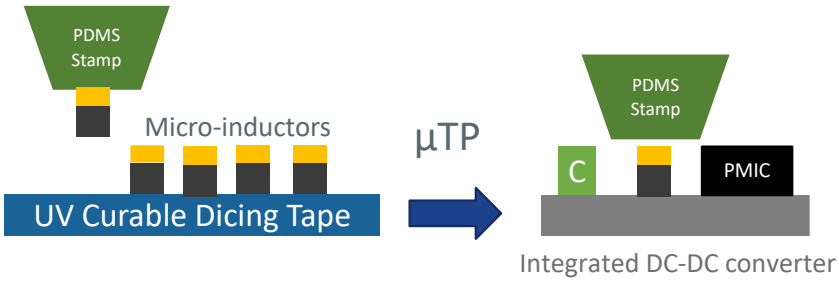
At Tyndall National Institute, we have been developing a novel heterogeneous integration strategy for power converters by adopting Micro-Transfer Printing (µTP) technology.

Individual circuit components such as PMICs, silicon capacitors, and on-silicon, thin-film inductors are pre-processed before being transfer-printed via a novel tether-less approach on to a target substrate. The printed components are then electrically connected via a planar metallization process on the target substrate.

The key challenges are to ensure system-level figure-of-merit by maintaining device performance integrity during the µTP of such large components and by fabricating low R_{DC} interconnects.

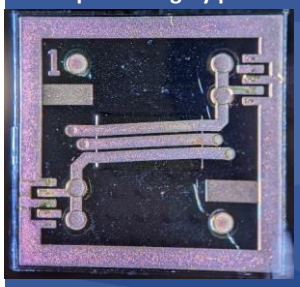
The key advantages of this approach is optimal usage of on-silicon space. It allows use of components fabricated off-silicon in a CMOS incompatible manner. This µTP based heterogenous integration strategy provides flexibility in choosing target substrates and topologies.

Integration Approach



Tyndall's On-silicon Inductors:

After processing by µTP



Single piece of on-silicon thin film solenoid inductor (3.5 mm x 3.5 mm) placed on a foreign silicon substrate after successfully completed µTP processing.

Benefits Summary

- Possibility to integrate low-profile on-silicon thin film inductors with other circuit components including PMICs and silicon capacitors on a target substrate
- Greater device density inside the package
- Smaller gap between power inductors and the load that leads to lower loss and better system efficiency
- More flexibility in the choice of target substrates and components
- Possibility to accommodate on-silicon integration of devices that require CMOS incompatible processing

Potential Applications

- IoT power delivery network
- Multicore-processor power delivery
- Magnetic sensors, and energy harvesting systems

Development Stage

- Novel µTP process for large-footprint magnetics-on-silicon is developed. Al-Interconnect process is being developed.

Contact

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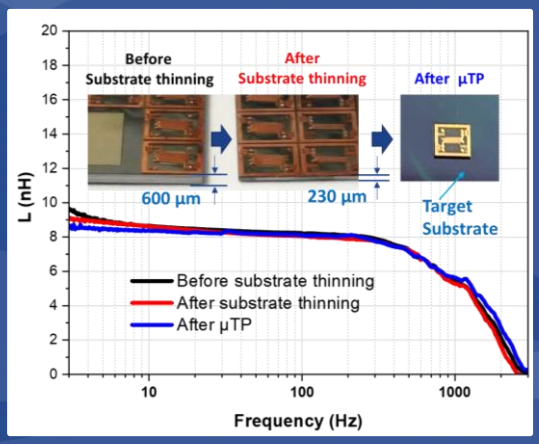

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