

Functional packaging of RF, mmW and photonic functions based on femtosecond laser micromachining

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The increasing difficulty to pursue the aggressive objectives of Moore's law (More-Moore) has in parallel favored the emergence of integration solutions grouped under the term More-than-Moore, allowing to enrich silicon technologies by heterogeneous co-integration with new functionalities. Still, it is clear that the performance of electronic systems (SoB - System-on-Board) is far from having followed the same progression, thus marking a gap with monolithic nanometer-scale CMOS technologies. To bridge this gap, it is now a question of producing gains in functionality, performance and compactness at the system level by heterogeneous integration of components into elemental system building blocks. Sometimes referred to as 'System Moore' [1], this approach thus conceives the package not only as a simple encapsulation function, but more precisely integrates the package as a functional system block. In this context, laser micromachining is an increasingly used tool for micro/nanostructuring of materials for the packaging of integrated functions in photonics, microelectronics, RF and mmW [2]. In this paper, we will first provide an overview of laser machining techniques in microelectronics. In a second step, we detail a selection of laser micromachining applications allowing either to increase the performance of RF and mmW components, or to introduce an innovative and distinctive manufacturing method promoting compactness and cost reduction:

i) The first illustrated application is the fabrication of ultra-thin free-standing membranes of SOI-CMOS RF circuits/functions on Silicon-on-Insulator (SOI) wafers. It will be shown that tremendous performance improvements can be obtained on a range of RF components like integrated inductances and power switches as well as in terms of cross-talk reduction.

ii) The second example describes the packaging of an electro-optical transceiver using a glass electro-optical interposer to connect a silicon photonic chip to a single mode optical fiber.

iii) Finally, the third illustration covers the fabrication of structures integrating mmW waveguides in G and J band [140-220 GHz, 220-320 GHz] with conversion from coplanar to a guided mode in rectangular waveguides (WR5.1 and WR3.1).

References

1. R. Tummala, *Chip Scale Review* 19, 5 (2015)
2. A. Bhaskar et al., *Opt. Laser Technol.* 138, 106866 (2021).