Heterointegration technologies for high frequency modules based on film substrates.

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Modern system technology requires multi-functionality and in many cases energy autarkic systems or very cost-efficient solutions, therefore integrated in plastic or foil substrates. First reason for such a flex-to-flex integration concept is given by the potentially free form factor which allows placing of film based systems on curved surfaces or in housings of very low thickness. Possible application scenarios are **usually** large area electronics in ceilings panels of cars or mobile communication systems.
However foil handling and integration technologies made a large progress just in the last two years. Meanwhile it is possible to integrate GHz micro-striplines in PI and LCP foil technologies showing 3dB bandwidth at 40GHz and compared to commercial available technologies reaching only 15 GHz. Beneath that the group delay in particular in the frequency range up to 15 GHz being considerably smaller too. Such foil technologies may also be used for thinning down compound semiconductor devices aiming much better cooling or co-integration with other technologies on modules.
Modular integration of highly functional film based electronics requires some specific assembly and test techniques to be combined in a technology line. Therefore the manufacture of fine line metal patterns (line /space geometries below 20µm) on film substrates, preferably to be done by cost-effective roll-to-roll technology has been connected with technologies for handling and lamination of film based sub-modules. A technology has been developed for reliable electrical interconnection between vertically stacked film layers including Through-hole via technologies for foil stacks. The manufacture and handling of ultra-thin and flexible integrated circuits has been combined with placement of SMD type passive components by integrated printed passives which do not affect bendability and the overall flat shape. Last not least the test and evaluation of the reliability of the flexible system under mechanical bending and relevant environmental stress has been performed.
A new process sequence “pick&laminate” has been developed in INTERFLEX for vertically stacking of film based sub-modules. This technique allows stacking of foil modules of different size and without restrictions on the target position. An alignment accuracy of 50 µm could be confirmed repeatedly.
Electrical interconnects have been realized by jetting of silver filled adhesives into the laser drilled through film vias which typically show diameters of 500 µm. Reliability tests of double layer film assemblies with electrically active through film vias showed very promising results. A first decrease of the electrical performance has been observed at a bending radius of 5 mm and they changed their resistance by roughly 5 %. In order to be able to integrate specific microelectronic functionalities which are already available as silicon based integrated circuits, such IC devices must be made available at a thickness of 20 – 30 µm which means they are already thinner than a single sheet of plastic film. Also, such thin silicon devices are highly flexible and still show sufficient mechanical robustness for secure handling and assembly. New chip assembly technologies are supposed to play a key-role for film based electronic systems. **Currently handling and assembling of ultra-thin bare dies is limited, soon thin dies will self-assembled on foil substrates will be available in the configuration of a “thin chip foil package” they become mechanically robust and can be handled like other electronic components. Such technologies are also available for compound semiconductor thin devices. In spite of their higher brittleness compared to silicon such thin film handling and flexibility is only a question of the right thickness.**

The contribution will introduce the status of film heterointegration technologies, link these possibilities with the handling of thin semiconductor substrates will introduce the pilot line concept. In the meanwhile it is possible to hetero-integrate full systems in a foil with organic integrated circuits and PV, display, passive components, flexible battery, thin silicon IC, as well as printed sensors and actuators. **The combination of several of these components is demonstrated enabling autarkic multi-functional wireless systems for product application, but also for new semiconductor handling and packaging for heterointegration of different technologies like compound semiconductor with silicon technologies and potential to improve form factor, performance, cooling and cost.**