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SHORT ABSTRACT OF PRESENTATION

To address consumer needs for more ubiquitous mobility, integration has been driving the wireless business to achieve the appropriate cost and form factors. This led to the progressive replacement of historical III-V MMIC technology (such as GaAs) by Si-based ones (RF CMOS, RF-SOI, and BiCMOS). Moving to a more aggressive CMOS technology (in terms of gate length) enabled to either reduce the die size or embed more features for the same size in a system-on-chip. This approach led to current highly integrated 5G RF transceivers, which are now integrated in 12 nm FinFET technologies.

But aggressive gate length scaling is not the only advantage of Si technologies, and derivative Si technologies also play a key role. It is especially true for the RF-SOI technology that has replaced the GaAs technology to achieve RF switches integrated in most RF front-end modules. However, Si-based technologies are still used in a support role in RF front-end, which remains served by an assortment of technologies such as GaAs HBT, acoustic filters, integrated passive devices, surface mount devices, and Si-based technologies (all those technologies being integrated using a system-in-package approach).

Moving to 6G future wireless standard, next-generation RF Front End Module (FEM) will require a breakthrough in terms of performance and integration (while operating on wider band higher in frequency). To do so, cost-effective SiGe BiCMOS technology can once again take advantage of heterogeneous integration with III-V technologies to achieve the best performance/cost tradeoff. In this perspective, compound semiconductors such as GaN High Electron Mobility Transistor (HEMT) and InP Heterojunction bipolar transistor (HBT)/HEMTs are attracting a lot of attention. GaN HEMTs may address

future challenges to integrate efficient power amplifiers and low-loss RF switch at millimeter-wave (mmW). Additionally, InP HBTs and HEMTs exhibit excellent linearity and noise performance up to mmW.

However, GaN and InP technologies have a relatively slow transition from laboratory to qualified process and associated manufacturing cost is way higher than Si-based technologies one. Consequently, the main strategy consists today in limiting the GaN and InP content to small chiplets containing only transistors, while the other features (for example, passive devices) are achieved using lower cost technologies. Dedicating the III-V wafer to transistors enables more efficient area usage, and, thus, yields more than 10,000 chiplets even on a 4” wafer.

This approach requires to disaggregate the circuit into an active compound semiconductor chiplet and a low-cost interposer. This paper will review different integration strategies that can be considered to support proposed heterogeneous integration schemes leveraging existing Si-based or advanced packaging technologies. It will allow us to identify the current technical challenges and limiting factors to be addressed in the coming years to enable proposed disaggregated heterogeneous integration to become a reality.

KEYWORDS

6G mobile communication, heterogeneous integration, SiGe BiCMOS, GaN HEMT, InP HBT, InP HEMT, system in package.

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BIOGRAPHY

Fred Gianesello received the B.S. and M.S. degrees in electronics engineering from Institut National Polytechnique de Grenoble, Grenoble, France, in 2003, and the Ph.D. degree in electrical engineering from the Joseph Fourier University, Grenoble, France, in 2006.

Dr. Gianesello has authored and co-authored more than 200 refereed journals and conference technical articles. He has served the TPC of IEEE International SOI Conference, IEEE International Solid-State Circuits Conference, IEEE International Electron Device Meeting Conference, and IEEE EuMIC Conference and is currently serving the TPC of IEEE RFIC.

Dr. Gianesello has been working for ST on the development of silicon-based RF and mmW technologies for the past 20 years targeting RF and mmW transceivers and front-end module products. He is currently working for STMicroelectronics in Crolles, France, as technical expert providing support to customer and performing business prospection for RF, mmW, and optical products.