Power and Energy TC Completes Integrated Power Electronics Chapter of HIR

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Heterogeneous integration (HI) is not possible without a source of power for the multiple devices and components involved. While it is possible to supply this power externally to one or more devices, it is typically advantageous to integrate the conversion and distribution of this power into the HI system. This makes power delivery one of the most critical elements in an HI system. HI also provides significant advantages for power electronics as it permits wide bandgap power devices, which surpass silicon in power handling capability, efficiency, and operating temperature, to be integrated with silicon control, logic, and memory devices and with lower operating temperature passive devices. Nevertheless, HI of power electronics comes with a raft of challenges for SiP designers, as the power electronics require space, generate heat, and can cause electrical noise in the circuits.

An understanding of the upcoming technology developments in power electronic components (e,g, switching devices, capacitors, inductors), interconnections (e.g. solder joints, wirebonds, sinter attach), and approaches for their integration is critical for the creation of HI systems. It is with this in mind that the Power and Energy Technical Committee has been meeting weekly to develop an Integrated Power Electronics Chapter for the HI Roadmap. In developing this roadmap chapter, the committee has reviewed and referred to other roadmaps [1,2] to make sure to complement these roadmaps by focusing on the issues related to integrating power electronics into HI systems as opposed to discussing development of external power sources.

The roadmap chapter provides a 5 year, 10 year, and 15 year timeline for the development of the power conversion and distribution techniques needed to supply clean, efficient power at a variety of voltages to the wide range of devices in an HI system without significantly increasing system size. Crucial elements of this are reducing the size of the power converters, so that they can be placed in close proximity to the functions they are driving in order to minimize losses. Key developments discussed in the roadmap include the following:

1) Wide bandgap power electronic devices (GaN, SiC, GaO, Diamond) that are thinner in size and can operate at higher frequency, higher efficiency, and higher temperature.
2) Capacitors (discretes, embedded layers, embedded trenches) that combine battery levels of energy storage with the high frequency power transfer rate of capacitors.
3) Novel device interconnection approaches and materials, including stacking sequences, multifunctional (thermal and electrical) vias and busses, and sintered metal attaches.
4) Thermal management, including the development of higher thermal conductivity joining materials and encapsulants, anisotropic conductive joining materials, thermal metamaterials, thermal isolation approaches, and integrated microfluidics.

If you are interested in joining the Power and Energy Technical Committee or contributing to future updates of the power electronics chapter of the HI roadmap, please contact Prof. Patrick McCluskey, Chair of the Power and Energy TC, at mcclupa@umd.edu.

[1] ***International Technology Roadmap on Wide Bandgap Semiconductors***, IEEE Power Electronics Society (PELS), 2018.
[2] ***3D Power Packaging with Focus on Embedded Passive Component and Substrate Technologies***, Power Sources Manufacturer's Association (PSMA), 2018.