

# Mixed Signal Integration in Multi-layered Organic Substrates

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Moore's law has led to the doubling of transistors every 18 months. This trend is continuing and is leading to the integration of a billion transistors onto a single IC. However, Moore's law is beginning to meet its limit for mixed signal integration where multiple domains such as digital, RF/analog, optical, MEMs and nano/bio devices have to be integrated into a single IC. This bottleneck is due to a combination of technical and business reasons.

This bottleneck can be alleviated using the substrate or package for integration. This has led to the integration of multiple functions into the substrate such as digital, RF/analog, optical, MEMs and nano/bio devices along with dies from multiple domains. Both from a technical and business standpoint, this approach is a better alternative to System on a Chip (SoC) approach. Also called System on Package (SoP), this integration is becoming the next Moore's law.

In this presentation, heterogeneous integration in organic substrates will be presented with focus on electronic and nano/bio systems.

## Biography

Madhavan Swaminathan received his B.E. degree in Electronics and Communication from the University of Madras and his M.S. and Ph.D. degrees in Electrical Engineering from Syracuse University. He is currently a Professor in the School of Electrical and Computer Engineering, Georgia Tech and the Deputy Director of the Packaging Research Center, Georgia Tech. He is the founder of Jacket Micro Devices, a company specializing in integrated devices and modules for wireless applications where he serves as the Chief Scientist. He also is the founder of Sangam Design Systems, a company specializing in EDA tools for System in Package (SiP) technologies where he serves as the CTO. Prior to joining Georgia Tech, he was with the Advanced Packaging Laboratory at IBM working on packaging for super computers.

Dr. Swaminathan has over 250 publications in refereed journals and conferences, has co-authored 3 book chapters, has 12 issued patents and has 10 patents pending. While at IBM, he reached the second invention plateau. He served as the Co-Chair for the 1998 and 1999 IEEE Topical Meeting on Electrical Performance of Electronic Packaging (EPEP), served as the Technical and General Chair for the IMAPS Next Generation IC & Package Design Workshop, serves as the Chair of TC-12, the Technical Committee on Electrical Design, Modeling and Simulation within the IEEE CPMT society and was the Co-Chair for the 2001 IEEE Future Directions in IC and Package Design Workshop. He is the co-founder of the IMAPS Next Generation IC & Package Design Workshop and the IEEE Future Directions in IC and Package Design Workshop. He also serves on the technical program committees of EPEP, Signal Propagation on Interconnects workshop, Solid State Devices and Materials Conference (SSDM), Electronic Components and Technology Conference (ECTC), and International Symposium on Quality Electronic Design (ISQED).

Dr. Swaminathan has been a guest editor for the IEEE Transactions on Advanced Packaging and IEEE Transactions on Microwave Theory and Techniques. He was the Associate Editor of the IEEE Transactions on Components and Packaging Technologies. He is a Fellow of IEEE.

Dr. Swaminathan is the recipient of the 2002 Outstanding Graduate Research Advisor Award from the School of Electrical and Computer Engineering, Georgia Tech and the 2003 Outstanding Faculty Leadership Award for the mentoring of graduate research assistants from Georgia Tech. He is also the recipient of the 2003 Presidential Special Recognition Award from IEEE CPMT Society for his leadership of TC-12 and the IBM Faculty Award in 2004 and 2005. He has also served as the co-author and advisor for a number of outstanding student paper awards at EPEP '00, EPEP '02, EPEP '03, EPEP '04, ECTC '98 and the 1997 IMAPS Education Award. Dr. Swaminathan is the recipient of the Shri. Mukhopadhyay best paper award at the International Conference on Electromagnetic Interference and Compatibility (INCEMIC), Chennai, India, 2003, the 2004 best paper award in the IEEE Transactions on Advanced

Packaging, the 2004 commendable paper award in the IEEE Transactions on Advanced Packaging and the best poster paper award at ECTC '04.

Prof. Swaminathan's research interests are in mixed signal microsystems which include digital, RF, optoelectronics and sensors with emphasis on design, modeling, characterization and test.