Thermal-Centric Design Methodologies for Monolithic 3D Integrated Circuits

By

Professor Emre Salman

Department of Electrical and Computer Engineering, Stony Brook University (SUNY), NY, USA,

Abstract: Vertical integration has emerged as a game-changer technology to achieve higher device density, functional heterogeneity, and shorter wirelengths for intra-chip communication. Among 3D technologies, monolithic 3D (M3D) ICs achieve unprecedented device and interconnect density due to sequential fabrication of multiple device tiers and vertical interconnects with diameters in the range of tens of nanometers. A fundamental challenge in dense integration technologies is the effective consideration of thermal constraints during the design process. In the first part of this talk, I will first provide a brief overview of 3D technologies, highlighting the recent advances and challenges related to the fabrication processes. I will then discuss the unique thermal characteristics of M3D ICs, describing the major differences with through silicon via (TSV) based 3D ICs. These results will rely on thermal simulations of M3D systems by leveraging a process design kit and cell library that we developed. I will also present a thermal-centric design optimization methodology for M3D integrated deep neural network (DNN) accelerators and demonstrate how technology-dataflow co-design can achieve an order of magnitude improvement in inference per second per Watt per footprint. In the second part of the talk, I will focus on the thermal crosstalk among the tiers and how such crosstalk can be used by an adversary to establish high bandwidth thermal covert-channels. I will finish the talk by proposing a new technique to dynamically detect such thermal covert-channels in M3D ICs.

Bio: Prof. Emre Salman received the B.S. degree in microelectronics engineering from Sabanci University, Istanbul, Turkey, in 2004, and the M.S. and Ph.D. degrees in electrical engineering from the University of Rochester, NY, USA, in 2006 and 2009, respectively. He was previously with STMicroelectronics, Synopsys, and Freescale Semicondutor (now NXP Semiconductors), where he was involved in research in the fields of custom circuit design, timing, and noise analysis.

Since 2010, he has been with the Department of Electrical and Computer Engineering, Stony Brook University (SUNY), NY, USA, where he is a Professor and the Director of the Nanoscale Circuits and Systems Laboratory. He is the leading author of a comprehensive tutorial book entitled High Performance Integrated Circuit Design (McGraw-Hill, 2012, Chinese translation, 2015). His broad research interests include analysis, modeling, and design methodologies for integrated circuits and VLSI systems with applications to low power and secure computing, Internet of things with energy harvesting, and implantable devices.

Dr. Salman was a recipient of the National Science Foundation Faculty Early Career Development Award in 2013, the Outstanding Young Engineer Award from IEEE Long Island, NY, USA, in 2014, and the Technological Innovation Award from IEEE Region 1 in 2018. He also received multiple outreach initiative awards from the IEEE Circuits and Systems Society. He is a Distinguished Lecturer of the IEEE Circuits and Systems (CAS) Society and previously served as the Chair for the VLSI Systems and Applications Technical Committee (VSA-TC) of the IEEE CAS Society. He also served on the Editorial Board of the IEEE Transactions on Very Large Scale Integration Systems. He currently serves as the Americas Regional Editor for the Journal of Circuits, Systems and Computers, on the Editorial Board of IEEE Transactions on Emerging Topics in Computing, on the organizational/technical committees of various IEEE and ACM conferences.