Duration: 08:30 to 17:50 **Room 252A**

WM04

Millimeter-wave Multilayer MCM/SoP and Heterogeneous Integration Techniques

Organisers

Kamal K. Samanta, Milmega/AMETEK Ltd., UK
Ali A Rezazadeh, School of Elect and Electronic Eng., University of Manchester, UK

Abstract

Owing to several advantages, mm-wave has found an ever-increasing interest for commercial as well as military applications, covering the areas from high speed wireless communication and space science to defense and security. In an mm-wave system, because of interconnecting parasitic, the assembling techniques are more complex and costlier than MMIC/RFICs. The multilayer/3D Multi-Chip-Module (MCM/SoP), with heterogeneous integration, is widely regarded as an excellent solution for realizing compact mm-wave components economically and with ever-greater functionality and reliability. In the past decade, there is enormous advancement in this field, leading to novel component and circuit/system architectures with exceptional miniaturization, performance and reliability, and hence making the challenging applications feasible and cost-effective. This very timely workshop will feature a range of presentations and will provide a comprehensive overview and understanding on recent important progresses in multilayer MCM/SoP technologies: in dielectric substrate, like LTCC, LCP photoimageable thick-film, and IPD/BCB, for embedding high quality passives (up to 100 GHz and beyond); metallization processes, such as Inkjet-printing, Photoimageable and Aerosol-jet printing, for fine and well-defined metal-track geometry; and multilayer substrate and heterogeneous and M3 integration and packaging techniques. Furthermore, will cover the very recent advancement in smart RFICs, 3D/2.5D MMICs, like Si/glass interposer based ICs, and in mixed-technologies (such as ferrites in LTCC), realizing novel components for emerging microwave and mm-wave applications.

Programme

8:30 - 8:40 **Welcome**

8:40 - 9:25 **Aerosol Jet 3D Printing for SOP RF Front Ends**
John Papapolymerou, Georgia Institute of Technology, USA
→ *Abstract*

9:25 - 10:10 **Complete CMOS mm-Wave links for consumer volume and cost structure**
Joy Laskar, SVP QEOS Communications Division, USA
→ *Abstract*

10:10 - 10:50 **Coffee Break**

10:50 - 11:40 **TeraByte/s Data-bandwidth TSV and Interposer Design for 2.5D/3D IC**
Joungho Kim, KAIST, Korea
→ *Abstract*

11:40 - 12:30 **Advanced Multilayer MCM/SoP Techniques: Ceramic High Performance RF Front-Ends at mm-Wave and Beyond**
Kamal K Samanta, Milmega/AMETEK Ltd, Ryde, England
→ *Abstract*

12:30 - 13:50 **Lunch Break**

13:50 - 14:40 **Advances in Tunable Microwave Ferrite-LTCC Components**
Langis Roy, Carleton University, Ottawa, Canada
→ *Abstract*

14:40 - 15:30 **Challenges and constrains in 3D Multilayer MMICs**
Ali A. Rezazadeh, University of Manchester, UK
→ *Abstract*

15:30 - 16:10 **Coffee Break**

16:10 - 16:55 **On the Application of the M3-Approach for Electromagnetic Optimization of Electronic Packaging and System-integration Technologies (EPSiT)**
Ivan Ndip, Fraunhofer-Institut fuer Zuverlaessigkeit und Mikrointegration, Germany
→ *Abstract*

16:55 - 17:40 **Additive Manufacturing Techniques for mm-wave Flexible Platforms**
Manos M. Tentzeris, Georgia Tech, USA

17:40 - 17:50 **Open discussion and concluding remarks**

8:40 - 09:25 Aerosol Jet 3D Printing for SOP RF Front Ends

John Papapolymerou, Georgia Institute of Technology, USA

Abstract

In this presentation we will focus on the fundamentals and applications of Aerosol Jet 3D printing technologies for the development of microwave and mm-wave passive structures and System-on-Package (SOP) RF front ends.

9:25 - 10:10 Complete CMOS mm-Wave links for consumer volume and cost structure

Joy Laskar, SVP QEOS Communications Division, USA

Abstract

Since the first demonstration of 60GHz connectivity in 1895 there has been much interest and promise in the future of mm-wave technology. It has been only recently, with the emergence of mm-wave and sub-THz (up to 300GHz) CMOS based technology and its potential for true monolithic single chip integration that once can envision a new class of systems and applications ranging from ultra-high speed data transmission, video distribution, portable radar, sensing, detection and imaging of all kinds. In this presentation we focus on the primary barrier to the deployment of mm-wave links: high capital cost structure (Capex) and high operational cost structures (Opex). In this paper we present for the first time, all CMOS mm-wave gigabit link solutions (bits to antenna) which solve address the industry's Capex bottleneck and review effective Opex approaches with hybrid beam steering solutions. We will review the market pull and review the convergence of millimeter wave CMOS digital radio, phased array technology, low power multi-gigabit mixed-signal processing and embedded phased array antenna techniques. These solutions offer the most efficient Capex and Opex for mm-wave gigabit wireless links for both battery operated consumer electronic portable devices as well as outdoor point to multi-point solutions from bits to antenna.

10:50 - 11:40 TeraByte/s Data-bandwidth TSV and Interposer Design for 2.5D/3D IC

Joungho Kim, KAIST, Korea

Abstract

Recently, 2.5D/3D IC with TSV and interposer is becoming the most promising semiconductor integration solution to meet electrical performance requirements such as I/O data transmission bandwidth, I/O power consumption, and integration density with an affordable investment and cost.

Especially, it will be highly applicable to mobile platforms and high-performance server platforms.

Moreover, it is expected that more than TeraByte/s I/O bandwidths will be needed between the processor and memory in the near future. In these emerging 2.5D/3D IC systems, thousands of TSVs and interconnections will be integrated in a tiny space to support the required number of interconnections and data transmission bandwidth.

Hence, the design of TSVs and interposer will be the most crucial part of the 2.5D/3D IC systems design to meet the electrical requirements, while special attentions should be paid to design issues such as eye opening, crosstalk, SSN control, I/O power minimization, ISI, equalization, noise coupling, and shielding issues. In this presentation, I will discuss the design methodologies and approaches to solve these design issues. Finally, I will propose future TSV and interposer architectures for the TB/s scale data-bandwidth.

11:40 - 12:30 Advanced Multilayer MCM/SoP Techniques: Ceramic High Performance RF Front-Ends at mm-Wave and Beyond

Kamal K Samanta, Milmega/AMETEK Ltd, Ryde, England

Abstract

Ceramic based Multichip Module (MCM/SoP) is widely accepted as an excellent means for realizing mm-wave systems. However, using conventional thick-film, it is very difficult to achieve either fine conductor geometry to realize passives with high quality as well as high SRF, or trench-filled metal walls for a substrate integrated waveguide (SIW) with applications in high mm-wave frequencies. Whereas, recently developed advanced multilayer photoimageable thick-film (PI-TF) technology is very promising and can comfortably overcomes these shortfalls. The process is straightforward, cost-effective and yet achieves line/gap of 10/15µm and trench-filled via, enabling realization SIW components comfortably to 180 GHz and beyond.

This talk will present the recent important advancements and novel achievements in PI-TF multilayer technology, which have been producing many records in MCM/SoP technologies. This will cover a wide range of high Q and SRF lumped/passive components and circuits (including low loss SIW) up to 200 GHz with remarkably high performance and miniaturization ever reported in MCM technologies, including LTCC, LCP and Organic. Then will present mm-wave systems, realized using an innovative assembling technique, including demonstration of the first highly compact complete V-band receiver integrating MMICs with embedded SIW antenna and filters, L/C components, LPF and other passives on a single substrate.

13:50 - 14:40 Advances in Tunable Microwave Ferrite-LTCC Components

Langis Roy, Carleton University, Ottawa, Canada

Abstract

Ferrite-LTCC system-on-package technology is a promising candidate for achieving the goals of increased functionality, agility and efficiency of miniaturized mm-wave wireless front ends. This presentation will focus on several recently demonstrated components, such as circulators, phase-shifters and antennas, based on a novel 3D circuit approach which requires no external magnets.

Design challenges will be discussed, including the realization of embedded windings to achieve the required magnetization of the ferrite substrate, and the modeling of partially magnetized ferrite so as to be properly handled by EM CAD tools. The proof-of-concept devices exhibit small form factors and can be easily integrated with other electronic components and systems.

14:40 - 15:30 Challenges and constrains in 3D Multilayer MMICs

Ali A. Rezazadeh, University of Manchester, UK

Abstract

The demand for low cost and multifunctional MMICs have seen a great shift from 2D circuit architecture to 3D designs to provide low-loss passive components such as filters, baluns, power divider/combiners and couplers for realisation of compact MMICs.

This paper presents the newly developed transmission-line structures using the great flexibility of three-dimensional multilayer technology. It is shown that MMIC coplanar waveguide transmission lines with a wide range of characteristic impedances can easily be designed using the multilayer technique. Furthermore, this implementation can avoid the well-known current crowding effects on the conductor edges minimizing dissipation loss. Several 3D multilayer MMICs fabricated and characterised at high frequency will be discussed.

16:10 - 16:55 On the Application of the M3-Approach for Electromagnetic Optimization of Electronic Packaging and System-integration Technologies (EPSiT)

Ivan Ndip, Fraunhofer-Institut fuer Zuverlaessigkeit und Mikrointegration, Germany

Abstract

To cope with the ever increasing demand for more bandwidth and faster data processing, chips in RF and high-speed systems today operate at very high-frequencies and high data rates. In this multi-GHz and multi-Gb/s age, parasitic effects of electronic packaging and system integration technologies (EPSiT) that

form signal paths (SPs) and power delivery networks (PDNs) in electronic systems may severely degrade the system performance beyond acceptable limits.

In this work, a holistic and systematic design approach, called the M3-Approach (Methodologies, Models and Measures) is proposed for electromagnetic optimization of EPSiT. It combines the strengths of academia and industry approaches, while simultaneously overcoming their limitations. This unique approach applies just three simple steps and covers the entire design process from modeling to the extraction of reliable design measures for fabrication. The application of the M3-approach for electromagnetic optimization of electronic packaging and system-integration (SoP) technologies.

16:55 - 17:40 Additive Manufacturing Techniques for mm-wave Flexible Platforms

Manos M. Tentzeris, Georgia Tech, USA