

Fabrication of High Density Multichip Modules

JOHN J. H. RECHE, MEMBER, IEEE

Abstract—This paper reviews the fabrication steps necessary to build high density multichip module substrates and covers some of the complex process decisions needed to obtain a system which will eventually be produced in high volumes. Thin-film-based high density multichip modules are necessary to achieve satisfactory performance in new electronic designs. Substrates built with vacuum deposited metal and polymeric insulators have evolved in much more complex structures than traditional thin film hybrids.

I. INTRODUCTION

THE HIGH density multilayer interconnect (HDMI) technology in this paper describes an interconnect fabrication method for microelectronic circuits, based on vacuum thin-film metallization and polymeric insulation between layers, as shown in Fig. 1. HDMI technology allows completion of multichip modules of unprecedented density, complexity, and speed [1].

The multichip modules concept has been with us for two decades as an offshoot of thick-film and ceramic hybrid circuit technology. The term is now used for multilayer thin film circuits, for various miniaturized printed circuit board schemes, as well as for multilayer thick films, and for multilayer ceramics. Confusion arises from this terminology because of the vastly different resulting properties. To distinguish the circuits described in this paper from the ones derived from older, coarser interconnect technologies, the new type of multichip modules will be referred to as high density multichip modules. HDMI refers to the technology used to manufacture the new type of high density MCM's.

Polymeric insulating materials that are useable to fabricate high density interconnect circuits have been available for almost two decades. However, new improved polymers have recently been produced by the chemical industry in response to demands for higher performance. The imperious need to improve packaging and interconnect density, and the availability of new materials, have overwhelmed the reluctance to use polymers in high reliability interconnection circuits. There is a precedent in the use of polymers in complex multilayer electronic circuits. Furthermore, it has been accomplished without the benefit of improved materials which existed then, such as polyimides. Magnetic thin-film heads have been built with polymeric insulation for twenty years in research and development, and ten years in production, using crosslinked novolak layers obtained by overbaking positive photoresists. The

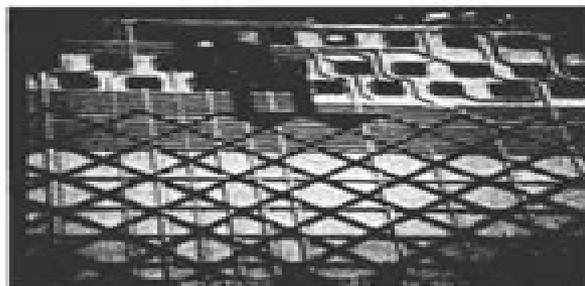


Fig. 1. SEM of a HDMI circuit. The polymer has been removed to expose the four metal layers.

choice of novolak was originally made simply because it was the most convenient material on hand and because inorganic dielectrics could not satisfy the unique circuit fabrication requirements.

The HDMI technology is under intense study for traditionally high reliability military and space applications and has already demonstrated exceptional reliability over functionally equivalent SMT assemblies [2], [3]. Tests on four metallization layers HDMI substrates have demonstrated the ability to withstand repeated large thermal shocks of 400°C, between 320°C and liquid nitrogen (-195°C), without failure. The results of these and other reliability tests, mostly derived from relevant military specifications, will be published later. The most frequent modes of failure of multilayer SMT assemblies in avionics boards, which seems to be cracking in the z-axis of feedthrough holes and solder fatigue, are eliminated. Reliability issues are also investigated for demanding commercial and industrial applications, such as communication equipment, automotive, and large computer systems. The need for extreme reliability is not the exclusive privilege of military and space applications, considering the notoriously hostile environment under a car hood, or the demand for forty years of uncooled operation under any climatic conditions by communication companies.

II. JUSTIFICATION FOR THE HDMI TECHNOLOGY

The need to fabricate large compact systems on a single substrate rapidly followed the invention of the integrated circuit as a natural extension of the monolithic concept. However, the realities of photolithographic fabrication yields have frustrated all practical implementations.

Since the invention of the integrated circuit, the complexity of circuit integration has increased very rapidly. This is the

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provided the necessary external wiring and interconnection capability for transistors and integrated circuits while they have gone through their own spectacular revolution from discrete device to gigascale integration At IBM we are proud to have created the initial simple concept of flip chip with solder bump connections at a time when a better way was needed to boost the reliability and improve the manufacturability of semiconductors The basic design which was chosen for SLT Solid Logic Technology in the 1960s was easily extended to integrated circuits in the 70s and VLSI in the 80s and 90s Three I O bumps have grown to 3000 with even more anticipated for the future The package families have evolved from thick film SLT to thin film metallized ceramic to co fired multi layer ceramic A later family of ceramics with matching expansivity to silicon and copper internal wiring was developed as a predecessor of the chip interconnection revolution in copper multilevel submicron wiring Powerful server packages have been developed in which the combined chip and package copper wiring exceeds a kilometer All of this was achieved with the constant objective of minimizing circuit delays through short efficient interconnects

Proceedings of the ... International Symposium on Microelectronics ,2001 International Symposium on Electronic Materials and Packaging ,2000 Topics covered by this title include flip chip running solder joint reliability emerging technologies solder materials delimitation polymers for packaging design and process modelling and testing material characterization and package reliability Materials, Integration and Packaging Issues for High-frequency Devices ,2003 Proceedings ,1999 *Flip Chip, Hybrid Bonding, Fan-In, and Fan-Out Technology* John H. Lau,2024-05-23 This book focuses on the design materials process fabrication and reliability of flip chip hybrid bonding fan in and fan out technology Both principles and engineering practice have been addressed with more weight placed on engineering practice This is achieved by providing in depth study on a number of major topics such as wafer bumping flip chip assembly underfill and reliability chip to wafer wafer to wafer Cu Cu hybrid bonding WLCSP 6 side molded WLCSP FOWLP such as hybrid substrates with PID ABF and ultra large organic interposer the communications between chiplets and heterogeneous integration packaging and on board optics near package optics and co packaged optics The book benefits researchers engineers and graduate students in the fields of electrical engineering mechanical engineering materials sciences industry engineering etc *The International Journal of Microcircuits and Electronic Packaging* ,2001 *Thermo-mechanical Characterization of Evolving Packaging Materials and Structures* Sheng Liu,Zhengfang Qian,Chao-pin Yeh,1998 Fluidic Self-assembly of Microfabricated Parts to Substrates Using Capillary Forces Uthara Srinivasan,2001 **Silicon-on-silicon System Packaging** Mihaela Ana Balseanu,2003 2002 International Symposium on Microelectronics ,2002 Electronic Packaging and Interconnection Handbook 4/E Charles A. Harper,2005 Whether you re designing an electronic system from scratch or engineering the project from someone else s design the Handbook gives you the tools you need to get the job done faster cheaper and more reliably than ever We guarantee it From development and design to manufacturing and testing the Handbook has you covered It s the one resource to turn to first Why not put it to the test and see for yourself

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