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FROM DISPLAY AND PWB TO MCMs: LARGE PANEL MANUFACTURING

by

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ABSTRACT

Considerable manufacturing development is currently aimed at reducing high density Multichip Module (MCM) cost through the use of large panels (>40 cm x 40 cm) to fabricate many interconnection substrates in parallel. This drive for low cost MCM manufacturing is aided by the growing base of similar panel technology for the Printed Wiring Board (PWB) and Flat Panel display industries. It is toward this experience that the infant large panel MCM efforts are looking. In particular, the MCM Consortium formed by the Electronic Industry Association (EIA) and funded under the federal TRP effort is charged with developing a line of equipment optimized for large panel, fine line manufacture.

PWB line definition research into large panels of glass and smooth non-woven laminate at 2-4 mil lines and spaces reveals that present equipment and processes are extendible well beyond commercial PWB product. In contrast, the ultra-cleanliness and spin coating of the silicon integrated circuit technology prove too expensive when scaled from 150mm diameter wafers to 560mm panels. Thus low waste photoresist (and other polymer dielectrics) application methods are needed for large panel manufacture. Similarly, PWB contact photomasking is nearing limits at 2-4 mil feature size, and projection or maskless direct write processes may be needed.

Even small hand-held flat panel displays are manufactured from large panels to reduce the cost per display for conductive and dielectric layer deposition and patterning. In addition, as low cost flat displays become larger and improve in resolution, the line pitch and density approach that needed in high density MCMs.

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One question facing large panel processing (PWB, displays, or MCMs) is when to singulate the units from the panel. For example, should interconnection test, component population, and functional testing be performed in the large format with many identical steps taken in parallel? That is, should all 64 MCM networks in a panel be tested for shorts and opens simultaneously with 2 flying heads each carrying 64 probes?

PANEL ROADMAP (Simplifications used to make chart tractable)

	size (inches)	metal dep	etch	dielectric dep, PR & insulator	photolith	resolution/ conductor thickness
IC Fab	6" wafers	Al alloy sputtering	plasma	spin PR CVD insul.	stepper	1 / 1 μ
goal IC fab	8-10" wafers	sputtering, Al, Cu, or W	plasma	low waste PR coat, CVD insul.	x-ray or phase masks	0.1 / 1 μ
PWB today	18 x 24" panels	Cu cladding, electro plating	spray, FeCl	lamine solid resist or dip small. Layer boards for 2 conductor.	contact mask	3 / 1.2 mil (75 / 30)
goal PWB	18 x 24" panels	Cu cladding, electro plating	spray, FeCl	large panel dipping or roller coat. layer boards	projection and laser direct write	1 / 1 mil (25/25)
Display today	18 x 24" panels	sputtered Cr/Cu	wet and dry etches	lamine solid or dip liquid PR	contact mask	3 / 0.5 mil (75 / 12)
Goal display	35 x 20"	sputtered seed layer, selective plating up	quick etch (only seed layer)	low waste thin coater: roller, curtain....	projection and laser direct write	12 / 2 μ
proposed MCM panel manufacture	>16 x 16" or use display standards.	sputtered seed layer, selective plating up.	quick etch (only seed layer)	low waste thick coater: curtain, roller, spray.	projection and laser direct write	12 / 12 μ

EQUIPMENT FOR LARGE AREA SUBSTRATES

Large area patterns on flat panel substrates have common developmental needs whether for printed wiring boards, flat panel displays (such as for direct view HDTV applications), and

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multichip module arrays. To manufacture these products in a cost effective way, production tools are required to perform the following operations on large panels.

1. Cleaning
2. Metalization
3. Photoresist application
4. Photoresist exposure
5. Thick film screening and firing
6. Electroplating
7. Etching and stripping
8. Pick and place
9. Device bonding
10. Inspection and repair
11. Testing

Many of these tools exist for 18" x 24" printed wiring boards. However, for multichip modules and flat panel displays the requirements on patterning are usually more demanding. For example, the goal for flat panel displays is a manufacturable product for direct view color displays intended for HDTV. The commonly quoted requirements for HDTV call for 2 million full color pixels on a 40" diagonal viewing area having an aspect ratio of 9:16. This calls for substrates which are approximately 20" x 35" (500mm x 890mm). The patterns needed on this panel require line widths down to one mil (25 microns). In addition to fabricating the metal interconnections on these HDTV glass panels, many large displays incorporate the driver chips on the glass periphery. Thus equipment and processes for IC assembly on the large panels is under development including pick and place, wire bond/ TAB/ and flip chip, repair, and encapsulation.

LARGE PANEL MCM CONSORTIUM

The Electronic Industrial Association subsidiary, EIF, initiated the "MCM Consortium" to address common challenges in producing low cost, high density MCMs. As of this writing EIF, Sandia, SEMI, and 6 MCM foundry companies are striving to forge an effective organization to meet the challenges of the large panel MCM manufacturing TRP government contract. The member companies of this endeavor represent about 80% of the U.S. MCM business spanning the communications, workstation, military, automotive, and space applications.

The motivation for large MCM panels is to lower unit cost. For example, a 16" panel would hold 64 MCMs of 2 x 2" size. Thus all metalization, dielectric deposition, photo-definition, and etching will be performed on 64 units at once. This concept is already utilized in PWB and IC fabs. During the first year of this team effort, the basic equipment needed to perform these process steps will be specified. These specifications will be compatible so that an integrated MCM manufacturing line can be formed. It will leverage off the panel equipment development already achieved by the PWB and display industries. The initial estimate is that the MCM line/process will resemble displays more than PWB or ICs because of the need for 0.5-1.0 mil lines. A cost savings of at least a factor of 10 is expected for substrate definition.

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Existing metalization equipment to handle these large substrates is based on sputtering or e-gun evaporation technologies. Such large panel metalizers have not traditionally been clean enough for subsequent half mil patterning. Contamination free handling and processing equipment will be critical for MCMs as for ICs and displays because of the miles of fine lines. In addition to vacuum processes, electroplating can be used to increase the thickness of the conductors for some applications. Selective plating to a seed layer through patterns in thick (0.5 mil) photoresist may prove the best process for the first conductor layer on the MCM panel by eliminating an etch step. The critical parameters for metalization include conductor thickness uniformity and substrate adherence.

New methods of applying dielectric layers on large panels may be necessary to produce thick uniform films with minimal material waste. For example, if polymer layers are satisfactory for the product, standard IC photoresist spinning methods would prove too wasteful since typically only 5% of the material ends up on the wafer. Many processes that result in 99% of the polymer being used are being evaluated including curtain coating, directed spray, roller coating, extrusion [1], and capillary plate applicators [2]. Inorganic dielectrics may be applied locally at conductor line cross overs to avoid the stress of a blanket film over the entire panel.

To quickly define precision patterns having line widths as small as 0.5 mil on large area substrates will demand refinement of existing tools. Liquid photoresist rather than solid laminate will be needed for this fine line patterning. Given the high cost of photoresist, a low waste application system will be needed. Photolithography tools will also need improvement. Contact masks as used today will not give the uniformity and yield on large panels at 0.5 mils. The current practical photolithographic limit on large PWB panels is due both to the local roughness of the panel material and the high cost of large fine resolution masks. The history of improvement of alumina surface finish demonstrates that improvement in panel materials should be expected. Non-contact projection exposure (stepped small mask) with several mils depth of focus [3] or higher speed direct write systems using a laser [4] will be needed.

In addition, considerable expense in MCMs exist in substrate network testing, assembly of components, and functional testing. To date the mainstream PWB and IC manufacturers have not performed these steps in parallel. For example, only one IC is functionally tested at a time at wafer probe, not all chips on the wafer at once. The display industry has had to face the challenge of chip assembly to large panels with drivers on the edge of the glass. Whether assembly internal to a panel can be achieved with slightly modified equipment, or whether assembling all 64 MCMs concurrently can bring a factor of 10 savings are not known yet. The TRP effort includes resources to develop one assembly and one test process/equipment aimed at increasing line capacity and lowering costs. The choices have not yet been made.

The only two panel materials that have been tested by the 'fire' of fine line manufacture are glass (Corning 7059) and nonwoven (smooth) PWB laminate. Part of this effort will be to test other materials available in panels such as polysilicon, insulated metal sheet, and ceramic sheet if available in large sheets with needed flatness. For substrates that can not yet be manufactured in large format (diamond, alumina, alumina nitride, or silicon carbide) a carrier panel standard will be developed.

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SUMMARY

The tools required to manufacture large area printed wiring boards, flat panel displays, and MCM arrays are similar for many fabrication steps in each of these technologies. Many of these tools have been developed initially for the PWBs. As the requirements become more demanding to meet the needs for future application, the development of advanced tools will benefit all three manufacturing technologies. This program will define and establish the next generation of these tools and processes.

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