Current Status of Semiconductor and Microelectronic Packaging Technology Development in Korea

Yong-Bin Sun
Graduate School of Industrial Technology and Information, Kyonggi University
San 94-6, Yiui-dong, Paldal-gu, Suwon-si, Kyonggi-do, 442-760 Korea

Abstract

It is very important to foresee the main stream of technology development in the future. Packaging related manufacturers in equipment and materials focused their strength on products sharing big portion of world markets. As a result, domestic supply sources for packaging materials and equipment has been increased, but the manufacturer's capital and manpower is so limited to develop high technology machinery and high functional materials. The current status of packaging infrastructures in Korea is reviewed statistically. The hot issues in packaging arena are now in wafer level packaging, 3D packaging, and ultra-thin packaging. In addition, the recent advancement in microelectronics packaging technology is also covered.

Introduction

It was inevitable for Korea economy to undergo the epoch of change. IMF gave a momentum for redistribution of highly educated engineers as well as for restructuring of business model. These two factors accelerated a birth of daughter companies leading towards the increasing needs in domestic portion of supply. However, the way to increase the domestic portion of supply faces with big obstacles, which are lack of technology infrastructure. In order to overcome these hurdles, government prepared a long-term plan for industries to develop key items intensively. Key items are PCB (printed circuit board), lead-frame (L/F), EMC (epoxy molding compound), Au wire in the material field, and bonder, molding machine, singulation machine, inspection machine in the equipment field. But high value added products are still from foreign countries. On the other hand, packaging process development in Samsung, Hynix, Anam, and ChipPAC Korea is quite competitive. They now concentrate on wafer level, chip scale, 3D packaging processes in semiconductor business.
In microelectronics business, LTCC (low temperature co-fired ceramic) module, optoelectronic packaging, MEMS packaging are the hot topics. In close connection, design and bumping foundry are building their firm basis. Special attention may be given to the beginning of small fab research activities supporting micron design rule technology, which will be a new paradigm shift.

Packaging companies

In Korea, two big semiconductor companies, Samsung and Hynix, have their own packaging line for memory devices but only pilot line for the rest devices. SEC outsources small pin count surface mounting devices (SMD) from STS Semiconductor Co., LTD., and quad flat packages (QFP) from Hana Microelectronics Co. Hynix outsources non-memory packages from ChipPAC Korea Ltd. (Table 1)

Table 1 Packaging outsourcing companies [1]

Device manufacturer	Outsourcing	items
SEC	STS Semiconductor Hana Semiconductor	SMD QFP
Hynix	ChipPAC Korea	Non-Memory
Fairchild Korea	SP Semiconductor WooSeok S. Tech	TO, DIP, D2 TO
Anam	ATK	QFP, BGA
Dongbu	ChipPAC Korea	QFP, BGA

Equipments

Global market for assembly equipments are composed of 38% wire bonder, 22% molding machine, 20% die bonder, 14% sawing machine in amount base. (Table 2)

Table 2 Global Markets for Assembly Equipments

(Unit: M$)

Equipments	'99	'00	'01(E)
Sawing M/C	234	363	430
Die Bonder	333	550	634
Wire Bonder	667	990	1,185
TAB Bonder	47	88	106
Molding M/C	386	579	685
Marking M/C	93	104	121
Total	1760	2674	3161
Korea market (Domestic supply%)	173 (36)	284 (35)	111 (34)

Source: (1) 2000 Semiconductor Equipment Databook
(2) April 2001 KSIA Periodic statistical data

In the second half of 90's, a government project was pursued by equipment manufacturers to increase domestic supply portion up to 50% for assembly equipments, which are flip-chip die bonder, LOC die bonder, wire bonder, auto molding system, and inspection equipments. As a result, it was raised up to 40%, but assembly technology has been changed rapidly. (Table 3)

Table 3 Government Projects sponsored by COSAR

Equipment	Company	Years
LOC Die Bonder	Top Engineering	95-96
Auto Molding System	Towa Korea	95-96
T/F Loader Module	S.J. Engineering	96-97
Wire Bonder System	TaeSuk Machinery	95-97
Laser Marking System	LG Industrial System	95-97
Backend Inline System	Towa Korea	97-99
Flip Chip M/C	Samsung Techwin	01-now

In the field of high technology wire bonding, K&S ATX series, ESEC WB3088 series, and ASM AB339 place a stress on fine pad pitch (35-50㎛) with high speed, and Shinkawa UTC-1000 put a stress on least vibration design with linear motor. They are basically capable of doing 100KHz operation and low temperature bonding for COB and COF. In February this year, Samsung Techwin's SWB-800 came on to the market, which has capability of bonding speed 80ms, pad pitch 50㎛, and unique loop control especially for multi-chip package. Samsung Techwin has a plan to produce 50 bonders per month and sales revenue will be $40M in 2003.

There are many manufacturers for molding die but only 4 companies for molding system, which are Towa Korea (a subsidiary company of SEC), Hanmi, Sunyangtech, and Anam Instruments. They all produce auto mold system and back-end-of-assembly line equipments. However, big semiconductor companies in Korea purchase Towa Korea's product for memory line.

Equipment supply in dependence on foreign manufacturers weakens competitiveness of domestic company in development of new technologies. SEC jumped into the development business for principal semiconductor equipments. The company has a master plan to transfer core technology to small companies after development. (Table 4)

Table 4 Equipment Development Strategy of Samsung

Company	Kinds of Equipment
Samsung Techwin	W/B, D/B, T/F/S, BGA/CSP
SEC	Mechatronics
Towa Korea	Y-series, Auto-Inline System for BEOL

Materials

The domestic supply portion has been steadily increased. In advanced packaging process, however, most of high functional materials are imported and its dependency is going to be increased. For example, solder ball and polyimide film for µBGA are entirely imported at relatively high prices. (Table 5)

Table 5 Assembly material markets in Korea[2]

(Unit: M$)

Items	1998	1999	2000	2001(E)
L/F	368(71)	295(75)	304(76)	283(76)
BGA substrate	207(41)	244(45)	266(43)	320(46)
Bonding wire	142(89)	137(84)	125(91)	123(90)
EMC	109(28)	99(35)	91(29)	90(29)

Source: KSIA 2001. 4 (Domestic portion in parenthesis)

Lead-frame (L/F)

As compared to Shinko's 138μminner lead pitch (ILP), Acqutek S&T produces 150μm ILP etched lead frame (ELF) and has a plan to produce 135μm ILP in 2003. Acqutek S&T has overcome the weak points of ELF turn-around time and quantity: first order in 7 days and repeated order in 2 days for quick turn. In order to eliminate the solder plating and Ag plating steps, Samsung Techwin developed μ-PPF (palladium pre-plated frame), which passed the SEC's acceptance test. Even though the μ-PPF has Pd thickness of 0.1mil, it still needs to be improved since Pd price is 5 times Au price. Acqutek developed its own proprietary plating method at lower cost compared to the Pd pre-plated. (Fig.1) As shown in Table 5, domestic portion is about 75%. One thing that has to be solved is the production of raw materials, which is imported mostly from Japan.

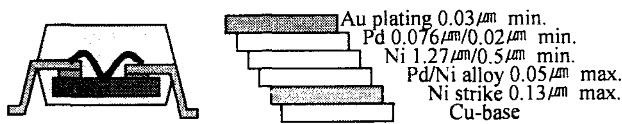

Fig.1 Coated LOC(60 30 μm) and μPPF

Substrate

LG Electronics contracted with North Co. for using NMBI (Neo Manhattan Bump Interconnection) process, which utilizes Cu bumps to make interconnection without the hole processing. Compared to the laser drill and copper plating interconnection, electrical resistance of the NMBI is reduced down to 10% and substrate area is also half-reduced due to easy routing. Daeduck is a leading company in Microvia board manufacturing.

Bonding wire

MK Electronics produces Au wires and Cu wires. Depending on the impurity addition, the heat-affected zone is changed in grain size and hardness.

Epoxy molding compound (EMC)

In amount base, almost 70% of total consumption is imported. The reasons for this low percentage of domestic supply are; 1) the cost for EMC is less than 5%, *i.e.* cheap, 2) it is too wasteful to develop all over again.

Kumgang Korea Chemical Co. has produced Pb-free EMC and Green Compound with new substitutes for Sb and Br. Cheil Industries developed low stress and low α type for TSOP. SEC has evaluated several kinds of resin systems such as OCN, Biphenyl, DCPD, and Kylok, to prevent the popcorn cracking.

Because of sticking problems, DCPD is controlled in usage. For the environmental protection purpose, lead is inhibited from solder joining process. In case of lead-free solder joining, reflow temperature is generally increased by about 40 degrees, which makes pre-conditioning test result worse due to increased inside vapor pressure.

Packaging Technology

Wafer level packaging

Wafer level packaging is almost realized. The correlation of electrical test data between die and final package has been underway to verify the reliability level. SEC offers three different kinds of wafer level packages, Tiles, MOST, Ultra CSP (chip scale package).

3D packaging

Samsung offers two types of 3D package; stacked package (package stacking with the same foot print) and dual die package (DDP: die stacking within the same dimensional package). The DDP was applied to 512Mb SDRAM by stacking 256Mb chips.

Amkor offers 3D packages such as stacked CSP (S-CSP), stacked etCSP, Stacked MCM, System-in-Package (SiP) (dissimilar die on top of another, like a piggyback type). (Fig.2)

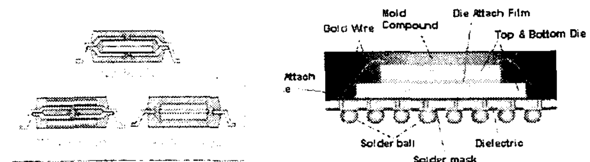

Fig.2 SEC's DDP and ATK's S-CSP Profiles

They make it a rule of thumb to use existing line-up of equipments.

Ultra thin packaging

Amkor has a target to make wafer thickness thinner, 50 μm for 200mm wafer and 100μm for 300mm wafer in this year. Amkor used 50μm thick chip to make the etCSP (extremely thin CSP, 0.5mm total height), which enables Toshiba to squeeze 2Gb into PCMCIA Type II HDD. ChipPAC has the capability to make it 100μm thick for both 200 and 300 mm wafers.

Since the ultra-thinned wafer is easy to damaged during transportation, packaging companies usually do the thinning job. Plasma polishing technology evolved recently is quite promising.

Bumping service

Although the demand for flip chip has been increased by 40% every year, domestic bumping service was not available.

Microscale Co. has offered bumping service with the TiW/Cu UBM (under bump metallurgy) structure. The reasons why use this UBM structure are less expensive than evaporation, good adhesion to pad metals and passivation materials, good diffusion barrier, and good wettability. The company has the capability to cover various substrate materials. The company also produce Au-bumped chip for LCD driver IC. Au stud bump and solder bump services are also available. (fig.3)

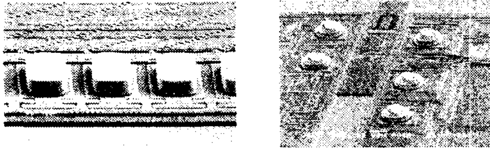

Fig.3 Au bump and Au stud bump

The CST Co. offers gold bumped flip chip and Samsung Techwin is also planning to open electroless plated bumping services late this year.

Optoelectronic packaging

Request for Proposal issued by the Ministry of Commerce, Industry and Energy was about packaging technology development for optoelectronics. The project focused on high-speed laser module, optical devices and fiber alignment, photosensitive adhesive, butterfly package, and laser welder. The 2.5Gbps and 10Gbps laser modules developed were passed the Bellcore test and 25 years reliability test.

High frequency packaging

As devices are operating over giga-hertz frequencies, material for the circuit board need to be changed from FR4 to ceramics. In order to minimize the parasitic effects, LTCC is compatible with Au thick film. This is one of the big challenges in mobile telecommunication era.

Conclusion

The packaging technology development is active in both semiconductor area and microelectronics area. Even though government urged packaging technology development onward, level up of all the infrastructures needs more time.

The importance of packaging process is still not recognized well by the top management in semiconductor business. They used to be aware of the low salary standard for packaging (actually assembling) manpower and, If possible, they want to use outsourcing.

Korea government and companies need to invest the research funds in packaging technology development. The small-scale companies in microelectronics area ought to help each other strategically to protect themselves from big company's pressure. The IMAPS-Korea will support this budding flower to grow fruitfully.

References

(1) Korea Semiconductor Industry Association, "The Present State of Korea Semiconductor Industry," Periodic Statistical Data, September 2001.

(2) The Korea Development Bank, "Semiconductor Industry Market Trends," Annual Report, April 2001.