Trends of Printed Circuit Board Design for IC Industry

Dr. Yu-Charn Chen
San Francisco State University, USA, http://www.sfsu.edu
Phone (415)338-1171, Fax (415)338 -7770, e-mail: ycchen@sfsu.edu

Abstract: Printed circuit boards (PCBs) replaced conventional wiring in most electronic equipment after World War II, reducing the size and weight of electronic equipment while improving reliability, uniformity, precision and performance. PCBs are used in all kinds of electronic products because they can be mass-produced with very high circuit density and also enable easier trouble-shooting.

As semiconductor Integrated Circuit (IC) device circuit densities increase, the role of Computer Aided Design (CAD) in advanced PCB design and manufacturing technology becomes more critical. Computer Aided Design (CAD) is very important for teaching engineering students in the field of PCB layout design. However, a PCB layout design for IC industry is still new to many college students and educators.

The objective of the study is to examine trends of PCB design and technology in order to enhance technology curriculum development in the new millennium.

Keyword: PCB, CAD, IC design, curriculum.

1. Introduction

Of all the changes and advances that have taken place in the electronics industry in the past century, the impact of PCB must be one of the most significant. It is not so many years ago that the components used in electronic equipment were bulky and heavy and had to be mounted on metal chassis. Followed by the introduction of and rapid expansion in the use of semiconductors and integrated circuits, this inevitably led to the increased use of the PCB. Today, from the cars we drive to the lamps, calculators, computers and entertainment equipment familiar to all, we take for granted the advances that PCBs have brought.

PCBs have greatly reduced the size and weight of the equipment while improving reliability and uniformity over the hand-soldered circuits formerly used. They can also be mass-produced efficiently. Furthermore, a board can have different printed circuitry on both sides or in many layers, allowing for increased compactness. Harris & Lall found common multilayer configuration consists of a five -layer circuit board . . . but up to 42 layers have been used" [1]. Reis (1989) stated that PCBs offered many advantages such as ess room for error, quicker assembly time, greater circuit density, ease in troubleshooting, less skill required, use of automatic assembly equipment, less prone to vibration problems, fewer gremlins" [2]. Because of these advantages, PCBs are now used in all kinds of electrical and electronics products.

2. CAD and PCB Design

For the past decade, computers have been used to help design everything from space shuttles to kids' toys.
A related benefit of a computer-aided design system is the ability to edit quickly, easily and accurately. Ginsberg indicated here are three key reasons to use computer-aided design (CAD) tools to design printed circuit boards. First is increased productivity . . . Second reason is increased design complexity . . . Third reason is increased integration requirement" (p.195). It is clear that the advantages of using CAD as a tool are more accurate than a hand-made tape-up artwork; improved stability over the hand tape-up, and speed.

Actually in today IC industry it is impossible to design the IC chips and the chipset carriers without using CAD tools.

3. Trends of PCB Technology for IC Industry in the New Millennium

The rapid growth of low-cost personal computers, digital cameras, smart cellular phones, wireless communications now requires chip-scale electronics to meet the form and functions of the next generation electronics. Chip-scale packaging (CSP) in the past has been memory and microprocessor ICs. Analog ICs are now joining these categories.

The demand for array packages -- Ball Grid Arrays (BGAs), CSPs and new versions of Pin Grid Arrays (PGAs) -is growing rapidly. A distinguishing feature of array packages is the use of a substrate rather than a leadframe for the internal interconnection. Package substrates are made from a number of materials such as Bismaleimide Triazine (BT) Resin, Flex Tape, Deposition, Flame Retardant type 4 (FR-4), ceramic, etc. Over the past five years, PGAs have largely moved from ceramic substrates to BT resin. Berry and Winkler indicate his trend will continue in the coming years. Substrates for full-sized BGAs are overwhelmingly made from BT resin. Flex tape and FR-4 will only make small inroads into this market in the future" [4]. Table 1 shows the summary of IC substrates used in 1998 and 1999. Table 2 is a comparison of the size of typical BGA I/O Pitch in 1998 and 1999.

Table 1. Summary of IC substrates in 1998 and 1999

	Summary of IC Substrates 1998-99 (Unit= M)			
IC Substrates	1998	%	1999	%
Flex Tape	271	13.24	626	18.80
FR-4	37	1.81	73	2.19
BT Resin	1649	80.56	2510	75.40
Ceramic	77	3.76	93	2.79
Deposition	5	0.24	14	0.42
Others	8	0.39	13	0.39
Total	2047	100.00	3329	100

Source: Berry, S. & Winkler, S . [4].

Table 2. A comparison of the size of typical BGA I/O Pitch in 1998 and 1999

	I/O Pitch of BGAs		(Unit: Million)	
I/O Pitch	1998	%	1999	%
1.27 mm	1170	81.02	1602	73.02
1.00 mm	173	11.98	373	17.00
0.80 --0.65 mm	101	6.99	219	9.98
Total	1444	100.00	2194	100.00

Source: Berry, S. & Winkler, S . [5].

Wire bonding, accounting for more than 90 percent of all leads assembled to packages in 1999, continues to dominate semiconductor interconnection. Levine pointed out that the worldwide lead count for integrated circuit interconnection is expected to double to more than 9 trillion by 2003. New technologies, such as copper wire and wafer metallization, are under development to allow manufacturers to continue achieving milestones in cost per lead, pad pitch and electrical performance [6].

4. The PCB Marketing in the New Millennium

Semiconductor revenues, according to Dataquest [7], the industry market intelligence firm, exceeded $160 billion in the year 1999, an increase of 17.6 percent over 1998. A key factor for industry growth was the firming up of the DRAM (Dynamic Random Access Memory) market. Intel continued to dominate the market with 1999 revenue of $16 billion more than its nearest competitor, NEC, as shown in Table 3.

Table 3. Top 10 Worldwide Semiconductor Vendors by Revenue Estimates (millions of dollars)

Name of Company	1998 Revenue	1999 revenue	1998 Rank	1999 Rank	1998-99 Growth (%)
Intel	22,784	26,806	1	1	17.7
NEC	7,947	9,210	2	2	15.9
Toshiba	5,913	7,618	4	3	28.8
Samsung	4,743	7,125	6	4	50.2
Texas Instrument	5,820	7,120	5	5	22.3
Motorola	7,088	6,394	3	6	-9.8
Hitachi	4,668	5,554	7	7	19.0
Infineon	3,909	5,223	10	8	33.6
ST Microelectronics	4,199	5,077	9	9	20.9
Philips	4,448	5,074	8	10	14.1
Others	67,167	83,378	--	--	24.1
Total	138,686	168,579	--	--	21.6

Source: Dataquest, 2000 [7]

The Semiconductor Industry Association (SIA) has announced a four-year p cycle" with worldwide chip sales increasing 63% between 1999-2004. This forecast means that chip sales will reach $234 billion by 2004 [8]. Selven also indicated y the end of 2004, our industry will take on an entirely new look. This will be driven by the accelerating demand for the uel' of the new millennium -- the IC -- as both die size and package continue to shrink and to reach new levels of performance" (ibid).

5. Engineering Education with the Challenge of the New Technology

Rapid changes in science and industrial technology are not only affecting the industry, but are posing a challenge to the technology and engineering educators. For example, printed circuits have been used in all kinds of electronic products for a long time; however, a PCB layout design is still new to many college students and educators.

A critical shortage of engineers has developed over the last decade. The number of U.S. electrical engineering graduates, a traditional source of engineers for the semiconductor industry, has declined more than 40 percent in the past ten years [9].

In the fall of 1999, a semiconductor industry association survey of over 400 recent engineering hires by semiconductor and supplier companies cited lack of interest in math, science and engineering as the primary cause of the BSEE decline. Most frequently cited as barriers to studying math, science and engineering were academic difficulty, poor high school academic preparation, and lack of information about career opportunities in math, science and engineering (ibid).

6. Conclusion

To survive in this ink or swim" milieu, we need to change our instructional content to provide students with the new and updated knowledge and skills for the new century. The access to knowledge and intellect will expand and it will be the technology instructor task to take a lead in the instruction and delivery of these technologies. Qualified engineering and technology education teachers will play very important roles in the 21st century.

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