VLSI Design and Test – A Keynote by Vishwani Agrawal (See attached slides)

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As you know, VLSI stands for very large scale integration circuit. Before that, came the integrated circuit or IC. The story of IC begins in 1958. Jack Kilby, a young engineer, fresh out of college, had just joined Texas Instruments at Dallas, Texas in the United States. Few years earlier, Texas instruments had perfected the technique of making Silicon transistors.

Let us examine the state of electronics at that time.

**SLIDE 2 (First General Purpose Digital Computer)**

So in the late 1950s, transistors were replacing vacuum tubes. Some of the large electronic systems, such as digital computers that filled a full room, would now occupy only a part of the room.

Coming back to Jack Kilby, he observed that transistors and passive components such as resistors and capacitors, and sometimes inductors as well, were all discrete components that were tied up by discreet wires. This led to tremendous costs of components and assembly, besides posing reliability problems. That summer, while many of his colleagues were out on vacation, he being a new employee had to sit alone in the office. That is when the idea came to him. Why not treat components and interconnects alike and fabricate the entire circuit at once rather than first make the components and then assemble them. He constructed a rather crude looking circuit that worked. Thus, the integrated circuit or IC was born.

**SLIDE 3 (Jack Kilby and . . .)**

There were major issues about this invention. Technologists were skeptical. The manufacturing yield of discrete transistors was as low as 10%. Then, how could you expect a single IC with many transistors and interconnects to be free from faults. There was no repair mechanism for an IC. Nevertheless, Jack’s company immediately filed a patent.

However, Jack Kilby was not the only one doing this. In California at another company, named Fairchild Semiconductors, Robert Noyce had a similar idea. Having heard of Kilby’s patent filing, Noyce wrote up a very detailed patent application of his invention. Being a clearer description, this was understood by the patent office and he was granted a patent in 1961.

**SLIDE 4 (Robert Noyce)**

Kilby’s application took longer to understand and a patent was granted in 1964. The two companies went to court but eventually settled with a joint ownership agreement. There is footnote to this story. In 2000, Jack Kilby received the Nobel Prize for the invention of the integrated circuit. Robert Noyce, who could have shared it, had died in 1990. The scientific community treats them as co-inventors.

What followed were larger systems and smaller component dimensions, leading to LSI and VLSI. The mobile phone in your pocket has microprocessor and memory chips, each of which would be a circuit of the size of a football field in the old vacuum tube technology. Obviously, what we have today or what we do today are greatly influenced by the VLSI technology.

The tremendous advances of VLSI are summarized in the well-known Moore’s Law, which predicts that the number of components on a single chip will double every 18 months. The basic influence is the dropping cost of a chip that can include an entire system. As a result, we can now walk around with a computer, rather than walking up to a computer. Let’s take a look.

**SLIDE 5 – 16 (Gordon Moore)**

Design and test: The VLSI technology provided tremendous scope for advances in circuits and systems. It was as if we learned how to make paper and now had tremendous scope for writing. But, what were we going to write?

Today, we have analog and digital circuits implemented on VLSI chips. Analog circuits range from DC to radio frequency. Among digital, we have logic and memory. At this point we could build anything that we could design.

Let us step back and talk about logic design. All of you have heard about Boolean algebra. Its origins are in pure mathematics of almost two centuries ago.

**SLIDES 17 – 21 (Boole)**

Because of the VLSI capability, computer-Aided Design or CAD got tremendous boost. Various kind of tools were developed as computers became available. Computer scientists and mathematicians joined electrical engineers in this effort. CAD programs for logic synthesis, physical design, Standard cells, ASICs, also for simulation, verification and test were produced. Design styles such as FPGA, SoC and 3D-stacked IC evolved as well.

But as Bernard Shaw once said: Science is always wrong. It never solves a problem without creating ten more.

**SLIDE 22-23 (2018)**

Future of VLSI may require research on device technologies, architectures and algorithms.

**SLIDES 24-27 (CNT)**

**SLIDE 28 (Von Neumann)**

**SLIDES 29-30 (Quantum computing)**

**SLIDE 31-32: Final thoughts.** This is the 22nd symposium. Most of you are aware of another conference, the 32nd International Conference on VLSI Design that will be held in the Delhi/NCR area in January 2019. That conference started in 1985 in Chennai. Although VLSI technology was there in 1985, many things were yet to come. Email and mobile phone were yet to come. TV had no flat panel. Cameras still needed film. All those have changed but could we have predicted? You can trace the presence of VLSI as the backbone of these changes.

Today, we have things that were quite unthinkable 30 years ago, such as, the internet of things (IoT), cloud computing, drones and robots, autonomous cars. There will also be things that we cannot imagine now. Whether MOSFETs are replaced by CNFETs or by some other devices, or whether quantum computers replace digital computers, I am sure VLSI will continue to revolutionize our life in an unpredictable way, I hope for the better.