Tuesday Afternoon, October 26, 1999

Vacuum Technology Division
Room 610 - Session VT-TuA

Vacuum Contributions to the Semiconductor Industry (1950-1975)

Moderator: R.E. Ellefson, Leybold Inficon, Inc.

2:00pm **VT-TuA1 Vacuum Systems, Deposition Sources, Measurement and Control Tools for the Semiconductor Industry (1950-1975)***, **D.E. Meyer**,* Consultant **INVITED**

The purpose of this presentation is to relate and discuss how VS&T (vacuum science and technology) impacted the semiconductor industry prior to 1976. The major portion of the talk will feature research, development, production, and quality and reliability experience at Texas Instruments. But company interactions with the rest of the SC industry and the military and space agencies also provide noteworthy examples of VS&T's contributions. Initially, military requirements for performance and reliability were the driving force. Device stability and manufacturability (read yield) were key to industry growth as well. All of these it turns out were highly dependent upon equipment, processes, and control of various thin film depositions in device manufacture and vacuum techniques in package assembly. A progression of improved technology and equipment will be described including the change from filament to eb-gun deposition, from oil pumped to high vacuum dry pumped systems, process control and reliability assurance using RGA, scanning electron microscopy, and current-temperature stressing. Both early bipolar and MOS processing will be addressed. The data presented and discussed will show how significant VS&T was to the growth of the SC industry and will consist of both a review of published and unpublished information.

2:40pm **VT-TuA3 Evolution of Integrated Circuit Vacuum Processes: 1962-1975***, **R.K. Waits**,* Technical Marketing Programs **INVITED**

The quarter-century from 1950 to 1975 witnessed the introduction of an extraordinary sequence of revolutionary semiconductor products: the silicon transistor, the integrated circuit (IC), the semiconductor memory, and the microprocessor. This ever-increasing complexity was made possible by many small breakthroughs in manufacturing technology involving new fabrication processes and measurement methods. Often an innovation involving vacuum technology appeared at just the right time to make possible the next technological leap. The metallization process is a good example. The components in the first practical IC were interconnected with a patterned layer of vacuum-evaporated aluminum. When the MOS field-effect transistor was perfected, it required a sodium-free evaporation process and the magnetically-focused electron-beam evaporation source propitiously arrived to save the day. As metal connections got narrower, strange failures began to occur. The scanning electron microscope (operating under vacuum, of course) was a new tool that let us examine the surface of an IC as if we were standing on its surface and gazing around. The failures were seen to be caused by microcracks in the metal lines as they crossed over steps in the circuit topography. Geometrical analysis showed that gaps were caused by shadowing during vacuum deposition. Methods were devised increase the mobility of the depositing aluminum atoms so that they would fill in the gaps during film growth. Metallization failures due to electromigration, and the shorting of shallow junctions by silicon diffusion into the aluminum, had to be cured by adding small amounts of copper and silicon to the aluminum. New magnetron sputter sources came to the rescue. During these years, ion implantation, plasma etching, and low-pressure and plasma-enhanced chemical vapor deposition, all became manufacturing processes, and, without which, today's (and tomorrow's) ICs would not be possible

3:20pm **VT-TuA5 History of Plasma Ashing and Plasma Etching in the Semiconductor Industry from 1950 to 1975***, **R.L. Bersin**,* Ulvac Technologies, Inc.

This paper will focus on the introduction of plasma etching and photoresist ashing from the late 1960's to 1975 as seen by International Plasma Corporation (IPC), the first company dedicated exclusively to the manufacture of "barrel" plasma ashers for the semiconductor industry [subsequently to be named Dionex Gas Plasma Systems, Branson IPC, and finally to disappear into Gasonics International]. The history from 1-inch wafers through 6-inch wafer development will be discussed in terms of equipment design features and process technology for both resist stripping and plasma etching. Limitations of isotropic etching and uniformity problems with barrel chambers are discussed; the introduction of the first multi-step automatic plasma ashing equipment is described. Early etching of oxide, nitride, and metals as well as stripping will be illustrated with SEM examples of the then current process technology and photographs of the equipment at that time.

3:40pm **VT-TuA6 History of Commercial Ion Implantation***, **C.B. Yarling**,* EEESPEC/Ion Beam Press

In today's semiconductor manufacturing industry, doping of sub-micron junctions is impossible without the use of an ion implanter. Indeed, most process flows of advanced microprocessors and 256kb DRAMS being manufactured in modern class-10 wafer fabs contain more than 15 separate implant steps. And if one examines the National Technology Roadmap for Semiconductors (NTRS), it is clearly seen that the implanter continues to play a key role in an industry that has been richly filled with people and equipment. A historical perspective of ion implantation begins with its development in 1906, when Rutherford bombarded aluminum foil with an alpha particle, and ends in 1978, when it is generally considered that ion implanters came of age! Sandwiched between these two events are several key process and equipment developments: Schockley's patent on ion implantation (1954); delivery of the first industrial implanter (1960); the first doping implant in semiconductor manufacturing (1962); shipment of the first US commercial implanter (1967); and the first semiconductor wafer fab to use implantation on all devices (1970). This paper reviews the history of ion implantation, the genealogy of commercial implanter manufacturing companies, and visits some of the colorful people who have helped to make the industry what it is today. We see that a certain amount of incestuousness has enabled this industry to grow since its inception. Yet in today's business climate where acquisitions and mergers are the norm rather than the exception, we find only three remaining major US suppliers of ion implanters. Although new shallow doping technologies which may eventually replace some implant steps are being developed, it is clear that the ion implanter has enabled semiconductor technology to travel the NTRS roadmap, where microns of junction depths in the mid-1960's are now in the sub-micron regime at the start of the new millennium.

4:00pm **VT-TuA7 Application of Sub-atmospheric Plasmas to Semiconductor Device Processing***, **D.M. Mattox**,* Management Plus Inc.

Sub-atmospheric pressure plasmas play a critical role in semiconductor device processing. Plasmas provide the ions used to sputter surfaces, modify film properties and affect the surface coverage by deposited films. Plasmas also 3activate2 reactive species to enhance chemical reactivity for reactive cleaning, deposition and etching processes. This paper reviews the history of using plasmas for surface preparation, PVD and PECVD film deposition, modification of film properties, reactive deposition and plasma etching to create film structures.

4:20pm **VT-TuA8 Refining Old Vacuum Knowledge for Today's Semiconductor Manufacturing Processes***, **J.F. O'Hanlon**,* University of Arizona **INVITED**

In today's competitive manufacturing environment, it is necessary to use vacuum system processes which are reliable, repeatable and cost efficient. This knowledge which constitutes our understanding of vacuum science is vast, and has on occasion been forgotten or misused. This talk will review some important concepts which have been re-invented, or re-applied or misunderstood in the course of designing modern vacuum-based processing systems.

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