INVESTIGATIONS OF 300mm WAFER TOOL SET PROGRESS AND PERFORMANCE

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Introduction

The semiconductor industry is now in the process of converting to 300mm wafer size factories, and this will be the most important transition to occur in its history. Although the first production factories are only recently operating, the industry has been preparing for this event during the last seven years. Key specifications and standards for 300mm wafers, wafer carriers, wafer delivery systems, processing and metrology tools, and their equipment interfaces are being tested and modified in the 300mm pilot lines. The 300mm wafer size conversion is being accomplished with 0.13µ device technology introduction, with volume manufacturing being planned for the 0.10µ node. The challenges and opportunities for future 300mm factories will be affected by the technical and economic requirements of both the 300mm wafer and ≤0.13µ conversions. This paper will detail the semiconductor industry's progress in the 300mm wafer conversion, focusing on the results from SEMICONDUCTOR**300** (SC300 - a joint venture between Motorola and Infineon Technologies through September 2000).

Experimental

The equipment expectations for 300mm process equipment and metrology hardware in comparison to the current 200mm tool set are: 1) increase the wafer throughput, 2) minimize the cleanroom tool footprint, 3) improve the tool reliability metrics and uptime, 4) standardize components, modules, consumables, and facility requirements, 5) automate wafer delivery systems, and 6) accomplish these challenges without significantly increasing tool and factory costs.

Results and Discussion

300mm factories will differ from 200mm factories in: 1) pervasive use of FOUPs (front opening unified pod) and mini-environments on tools, 2) very high levels of individual tool automation, 3) highly integrated factory CIM (computer integrated manufacturing) systems, 4) automated intra-bay material handling systems, 5) factory layout optimized for automation, and 6) a significantly reduced level of operators. To demonstrate the initial capabilities of 300mm plasma etch and other process tools, SC300 began building testable wafers in the 3rd quarter 1998 and compared these data against process and device metrics from the 200mm manufacturing line located in the same module using a similar DRAM process flow. Equipment development for 300mm plasma etch tools will require improved process non-uniformity (film removal and CDs) and film selectivity over the wafer surface. Other critical process factors investigated include: 1) resist loss, 2) base layer loss, 3) CD control, 4) micro-loading, and 5) profile control. Other performance aspects include defectivity and contamination reduction, longer time between chamber wet clean procedures, and reduction of plasma damage or charging on wafers.

Process characterizations were done after the tool hardware was determined to be stable, and design of experiments (DoE) were run to improve each etch process for the required specific process outputs. As a result of these efforts, many of the etch processes actually exceed the 200mm equivalent process outputs due to recipe optimization or hardware improvement. Some etch chamber configurations have been improved upon in comparison to 200mm, including 300mm chamber scale-ups or 300mm-specific redesigns. These improvements include process gas flow dynamics (better mixing and distribution), pressure control (reduced control range and response time), and rf power delivery system upgrades that have resulted in increased process stability. In comparing critical factory metrics of 300mm to 200mm etch tools, a significant distribution exists reflecting the maturity range of the SC300 tool set. Each tool set was assessed at various times during the project for process and equipment performance and manufacturing readiness. These metrics were used to report progress to the suppliers and focus development priorities.

Each functional group had significant issues identified that were largely resolved prior to the project's conclusion. For the Etch tools, non-uniformity was not as much of a challenge as predicted. The primary challenges were the lifetime and stability of the electrostatic chucks, excessive footprint size-with possible reduction from gas box arrangement and relocation of support equipment below the factory floor, particles and chamber cleanliness, and tool software flexibility and reliability. There were recipe programming functions that were not readily available on 300mm tools that exist on the 200mm equivalent tool. This includes endpoint data analysis and recipe parameter database sorting and analysis. For high throughput tools such as Ash, wafer handling and multiple FOUP stocking for continuous running is a continuing problem. This is due to hardware and software issues, including communication protocol limitations. Matching of duplicate chambers on the same mainframe or on separate tools was not difficult. The mainframe platforms for most etch tools will likely change one additional time before the production tool version is released. Each process tool functional group had 3-5 significant challenges to demonstrate robust manufacturing processes and cost-effectiveness.

Conclusion

The industry in actively demonstrating 300mm tool set capability, testing various types and levels of automation, and processing impacts. While most tool groups had significant challenges, these were not immense or insurmountable.

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