SEPTEMBER 2008

Solid State TECHNOLOGY®

THE INTERNATIONAL MAGAZINE FOR SEMICONDUCTOR MANUFACTURING

Powerchip's Darkfield Inspection Strategy p. 20

- 45 nm Mask Verification p. 26
- Substrate Centering Robotics p. 30
- A Modular Approach to Tool Hookups p. 36

PennWell®

www.solid-state.com

Tool hookup: a paradigm shift to modularization

EXECUTIVE OVERVIEW As semiconductor manufacturers continue to address cost, speed, and safety as key components of capital equipment tool installations in the last several years, few solutions exist to address the need to reduce installation cost without sacrificing installation quality and safety. The cost of tool hookup as a component of a factory start-up has come under increased scrutiny, as have all aspects of the start-up, as well as operational costs in bringing a $3.5B or larger mega fab online. The large shift to Asia-based foundries away from IDM wafer fabs has reduced the overall labor cost/hour as a component of factory cost, but labor efficiency has not always realized a corresponding reduction in real cost for tool hookup.

The shift to locations with less expensive labor has also shifted the future burden of lowering tool hookup cost toward material selection, which increases the risk of quality and safety. Original equipment manufacturers (OEMs) and mechanical contract companies alike are beginning to look at new methodologies to address areas of tool hookup, which remain under pressure (speed, quality, and safety), while also attempting to reduce tool hookup cost based on return-on-investment modeling. This paradigm shift in tool hookup methodology is addressed in this article.

OEMs' demonstration labs and wafer fabs have successfully taken advantage of space-saving modules for toxic and inert gases, de-ionized and process cooling waters, and cleaning chemicals and slurries in an effort to meet cost- and space-saving requirements [1].

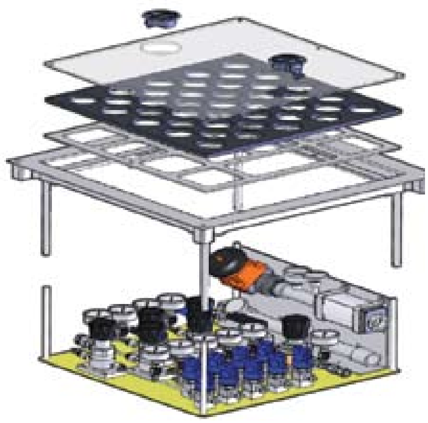

Figure 1. A cutaway example of an integrated floor module.

Increasing tool hookup efficiency

NEHP modules and racks are used at the fab process level and in the sub-fab levels where space has become a premium, as toolsets have more chambers and support equipment than ever before. An example of this can be seen in the etch area of wafer fabs, where gas panel requirements per chamber have expanded from an average of five gases/chamber just a few short years ago, to greater than or equal to eight gases/chamber in the 65nm and below current generation of etch equipment.

Previously, an etch chamber was required to etch a specific material type (oxide, polysilicon, or metal layer). Now, however, etch equipment manufacturers are required to trim photoresist, etch through top and bottom antireflective coating (ARC) layers and hardmasks, as well as etch the primary material with higher aspect ratios and achieve ever greater control of CD. Furthermore, all these etch processes must be accomplished while supplying far superior selectivity to underlying thin layers of films [2,3].

Multi-chamber etchers have increased from two to three chambers/system of a single type, to as many as six chambers/system in the current generation, with only a slight increase in overall tool footprint. In addition, as CD dimensions shrink to 45nm and beyond, there will be a need to meet requirements such as dual-patterning and chamber matching constraints for dual etch solutions for critical layers (e.g., gate, shallow trench isolation [STI], and contact). These requirements mean process level and sub-fab level footprints and layouts, and quality installations, are far more critical. Furthermore, with individual chambers having two or three RF generators, an associated cathode and chamber wall, as well as source power heating and cooling temperature control systems, there is an ever-larger requirement for process waters needed for each tool and specific to each chamber process. This is just one element driving the cost and complexity of facilities to each tool to a new level. Modularizing common items, cost, and complexity, as well as standardized layout per module, improves safety response in the event of a chamber or tool incident.

Once considered a luxury in the sub-fab, pump garages are now considered a requirement to maintain control over space limitations. Particle specification requirements for a given tool and process will continue to require OEMs to demand even more control over tool installation and installation component quality and specifications. Tool crowding concerns and minimum safety standards exist at the process level to maximize precious fab floor space utilization and achieve capacity requirements with more etch steps per layer and

Andrew J. Beers, ABM Consulting LLC, Liberty Hill, TX USA; **Daniel Williams, Adam Tarr,** NEHP, Williston, VT USA

more layers per device. Space constraints, along with additional complex etch sequences, have forced the space just below the raised floor to be a premium. Previously, floor view tiles and traditional stick built installations had been an acceptable solution. Modularization of these facility interconnects solves the space, standardization for safety response, cost, and schedule needs for these complex tools, creating a lowest-cost and highest-quality solution, and enabling tool hookup to the module to be completed prior to tool arrival. Using components that are fully compatible with the tool maintains the OEM's quality requirements as well.

Modular hookup savings

Tool	OEM	Chamber configuration	Overall module savings	Toxics module savings	Inerts module savings	PCW module savings	DI water module savings	PCW subfab rack savings
Etch	A	4	51%	57%	39%	27%	21%	10%
Deposition	B	4	49%	7%	49%	36%	24%	62%

Space management and tool hookup schedule

Space management techniques in 3D now require complex planning, design, and construction to avoid a maze of inefficient space utilization, increased total cost-per-tool installation, as well as raising safety response concerns while avoiding poor quality installations. OEMs are being forced to lower tool costs amid cost-of-ownership (CoO) pressure, which is also forcing more responsibility and cost onto the facility infrastructure for tool hookup.

In addition to the cost-savings and ease-of-installation of modular approaches, because they are built off-site and can be shipped prior to tool arrival, they arrive on-site before the tool modules and create a final hookup point for constructors. This allows construction process installation activities to move forward seamlessly in conjunction with bay fit-up construction activities after the process tool arrives. For critical path tools, schedule compression has been demonstrated in excess of 50% from dock to tool signoff. On-site trades labor hours are also significantly reduced by eliminating many of the welds and cost associated with the attendant risk of rework, thereby significantly improving the tool hookup schedule [4]. Work space utilization is also less crowded using the modular approach resulting from point-to-point hookup of the tools utilities and consistent same tool hookup locations, eliminating the maze of below-floor construction done on-site when a detailed layout plan often doesn't exist, as seen previous to the use of modules.

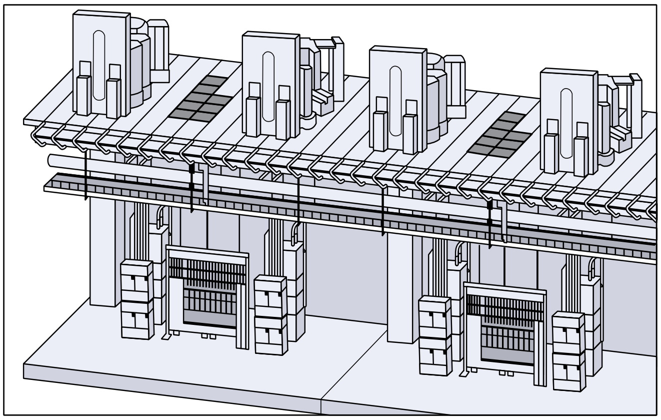

Figure 2. Conceptual design of how floor modules and subfab utility racks can be used to standardize on-tool installations independent of the tool type, and reduce space requirements at the fab and subfab level.

Conclusion

The paradigm shift in tool hookup methodology to using pre-built installation modules brings a number of cost-savings, schedule, and space-savings benefits. Other benefits of the modular approach to tool hookup include having clear, consistent, and safe layouts for valves, gases, and filters, which take the guesswork out of safety shutdown procedures and valve locations during a lockdown event. Also, utilization of modules for more than one tool at a time allows for maximization of hookup savings seen from a single tool (**Table**), which can be anywhere from 14% and up to 51%, depending on tool complexity. Modules for multiple tool installations allow for increased input sizing and optimization of the breakouts to a single or multiple tools of like kind. In addition, modules can be tied to individual tools on a futures basis, or can be moved with tools during relocation to avoid material waste during tool upgrade or move cycles. ■

References

1. A. Tarr, G. Chabot, "Method for Installation of Semiconductor Fabrication Tools," NEHP US Patent 7,039,999 B2, May 9, 2006.
2. B. Brown, T. Shrock, K. Poolla, M. Welch, P. MacDonald, "Rapid Diagnostics of Etch Processes in High-Volume Manufacturing Using Temperature Metrology," *Semiconductor Manufacturing*, October 2003.
3. T. Dao, "Multi-Gate Transistors for 22nm Technology," IEEE-EDC Austin, TX, March 2008.
4. K. Collier, D. Yeamen, N. deVries, A. Canales, Dr. Allan Chasey, "Rapid Tool Installation: A Process for All Concerned," *Semiconductor Fabtech*, 29th Edition, March 2006.

Andrew J. Beers received his BSEE from the U. of Illinois and is president at *ABM Consulting LLC, P.O. Box 835, Liberty Hill, TX USA 78642; ph 512/775-9920; e-mail andy_beers@mac.com.*

Daniel Williams received his BS in mathematics and concentration in civil engineering from the US Military Academy and is director of business development at *NEHP, 340 Avenue D, Suite #40, Williston, VT 05495 USA; ph 802/652-1444 ext 257; e-mail dan@nehp.com.*

Adam Tarr received his mechanical instructor degree from Washington College and Michigan State and is CEO/owner at NEHP.