

APPLIED MATERIALS

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Applied Materials Announces Technology and Productivity Breakthrough with New PRODUCER™ System

Innovative Dielectric Deposition System Sets a New Benchmark in Cost-Efficient Manufacturing

SANTA CLARA, Calif., July 1, 1998 — Applied Materials, Inc., the world's leading supplier of wafer fabrication equipment to the semiconductor industry, introduces **Producer™**, an ultra-high productivity system for depositing blanket dielectric films on sub-0.18 micron devices. Using a revolutionary new platform architecture, Producer combines the throughput benefits of twin wafer handling with the advantages of single-wafer process technology in a simple and exceptionally reliable system design.

"The Producer system addresses a new era in device manufacturing which demands higher yields, lowest cost and maximum asset utilization," said Sass Somekh, senior vice president of Applied Materials. "Its innovative architecture sets a new standard in cost-efficient, advanced-technology wafer processing that can be applied to many future applications. Built to support multiple device generations as well, Producer is uniquely capable of processing both 200mm and 300mm wafers using the same platform."

Compared to currently available systems, the Producer's new platform offers a major improvement in productivity as well as reduced facilities cost and a smaller system footprint. Featuring a central transfer chamber mounted with up to three Twin Chamber™ CVD modules, the wafers are transferred in pairs to each module. Up to six wafers can be processed simultaneously, achieving throughputs of more than 110 wafers per hour. To simplify system design without sacrificing the flexibility and control of single-wafer processing, each Twin Chamber set uses the same pumps, mass flow controllers and gas delivery components.

"Simplicity was the focus of our hardware design and high output was our performance goal," noted Kevin Fairbairn, general manager of Applied Materials' PECVD Product Division. "For exceptional production reliability, Producer incorporates many of Applied Materials' time-tested components including its magnetically-coupled VHP wafer transfer robot. The Producer's Twin Chambers are also extensions of the production-proven hardware and process technology found in Applied Materials' industry-leading plasma CVD products."

—more—

"This combination of simplicity and industry-proven design also result in very high system uptime and easy serviceability," adds Fairbairn. "Extensive marathon testing has confirmed the superior uniformity and repeatability of the Twin Chamber design. In addition, process parameters such as deposition rate and particle performance are virtually identical to, or better than, those demonstrated by the advanced chambers found on our other platforms."

Producer is currently offered for PECVD applications including blanket oxides (TEOS or silane-based), silicon nitrides and dielectric anti-reflective coatings (DARC™). Several of these films will be needed to form copper interconnect damascene structures.

Each Twin Chamber module uses Applied Materials' remote clean technology to remove deposited byproducts while minimizing damage to system hardware and reducing cost of ownership. This unique "soft" clean process creates virtually no global-warming perfluorocompounds (PFC) and enables significant reduction in chamber clean frequency for very high equipment uptime and availability.

The market for dielectric CVD equipment is one of the largest of the semiconductor equipment markets. Dataquest estimates the 1997 dielectric CVD market to be \$1.50 billion, and forecasts it to grow to \$2.92 billion by 2001. Applied Materials is the global market leader in CVD, including both dielectric and metal applications.

Advance commitments for Producer totaling more than \$28 million have been received from customers in North America, Europe, Taiwan and Japan. Both 200mm and 300mm Producer systems have already been shipped to customers, with production ramping for the 200mm systems expected to begin in the third calendar quarter of 1998.

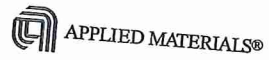
Applied Materials, Inc. is a Fortune 500 global growth company and the world's largest supplier of wafer fabrication systems and services to the global semiconductor industry. Applied Materials is traded on the Nasdaq National Market System under the symbol "AMAT." Applied Materials' web site is <http://www.AppliedMaterials.com>.

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P r o d u c e r
Dielectric CVD System
June 1998

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Applied Materials Boosts 300mm CVD Productivity With New Producer System

New Addition to Proven Producer® Product Line Sets Benchmark for 300mm Processing

SANTA CLARA, Calif.—June 19, 2001-- Applied Materials, Inc., the leading supplier of CVD (chemical vapor deposition) equipment to the global semiconductor industry, announces the **Producer® SE** system. Based on Applied Materials' highly successful single-wafer Producer CVD design, Producer SE provides the industry's highest level of productivity for the widest range of dielectric CVD applications, making it the most technologically advanced and flexible CVD system in the semiconductor industry.

"In the past three years the Producer has become one of the semiconductor industry's most successful CVD systems," said Dr. Farhad Moghadam, vice president and general manager of Applied Materials' Dielectric Systems and Modules product business group. "The Producer SE builds on the innovative Producer platform to help customers seamlessly transition to 300mm production with advanced deposition technology for sub-100nm geometries. This new system sets the industry standard for throughput, productivity, reliability and overall high-output production capability for all blanket dielectric film applications."

Throughput of the new Producer SE system has been increased up to 45 percent over the original groundbreaking Producer system, depending on configuration and film application. A new loadlock pre-heating design allows the large 300mm wafers to stabilize their thermal expansion before transfer to the process chambers, saving time over methods that heat the wafer while in the process chamber. The system can process up to 130 wafers per hour for thin film applications and up to 100 wafers per hour for thick films.

The Producer SE also offers a new low-flow Remote Clean™ system that reduces NF₃ gas usage by up to 40 percent over the company's original Remote Clean technology. Distinguished by the U.S. Environmental Protection Agency as an exemplary product for global climate preservation, Applied Materials' Remote Clean technology virtually eliminates the emission of global-warming perfluorocompound (PFC) gases from the system.

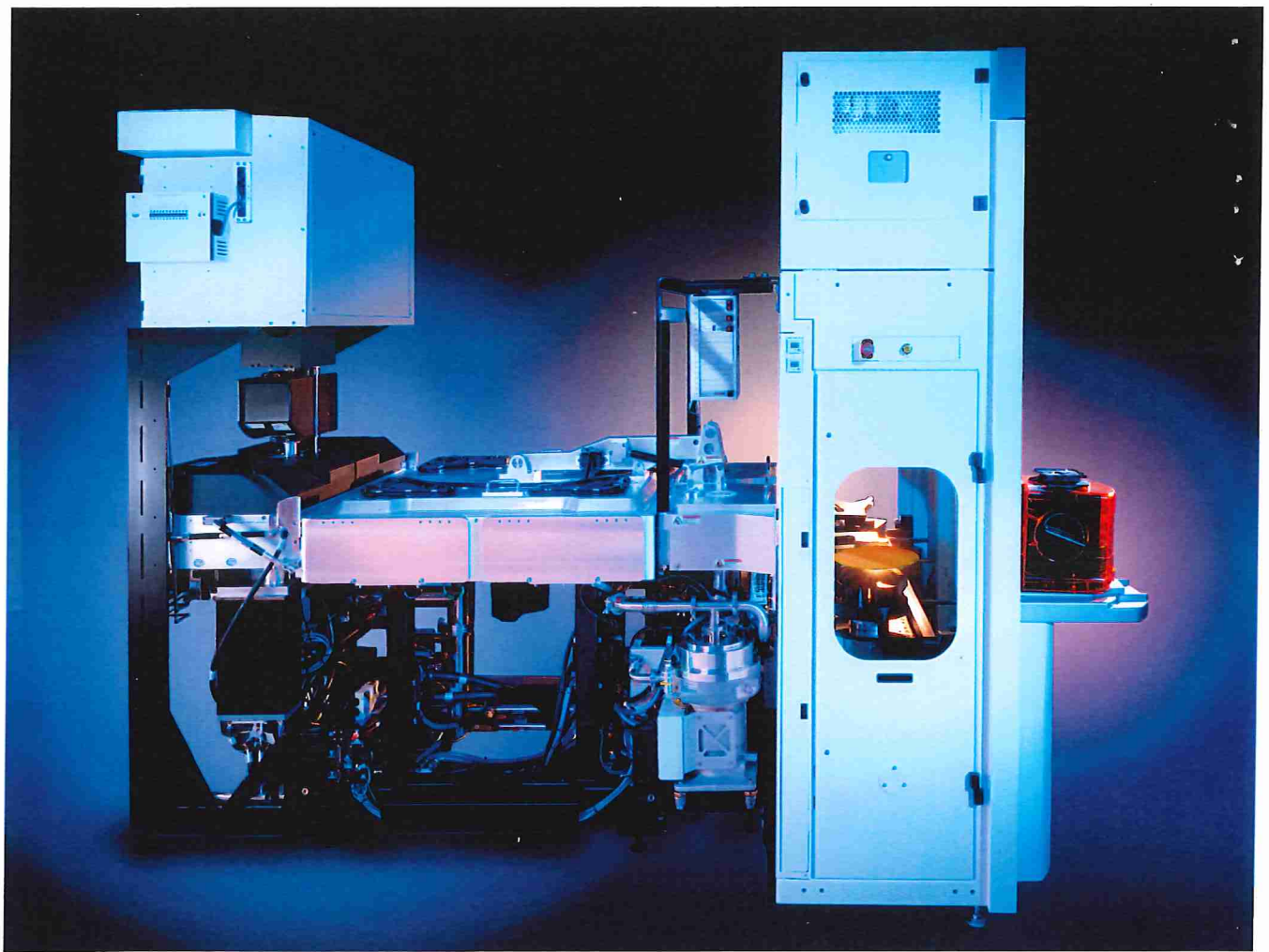
The system's optional integrated inspection and metrology tools provide the capability for automated process control in 300mm wafer fabs without impacting the system's high throughput. Located within the system's factory interface module, an integrated particle monitor offers high-speed particle detection and the capability to reduce the number of costly test wafers. An integrated metrology unit enables customers to run their processes at very high throughput rates while closely monitoring thickness, uniformity and refractive index of films deposited on product wafers as they enter and/or exit the system. The combination of inspection and metrology technologies maximizes uptime and system availability so customers can operate the systems longer between service or maintenance intervals.

The Producer single-wafer family of products has a unique platform architecture that features a central transfer chamber mounted with up to three Twin Chamber™ CVD modules. Wafers are transferred in pairs to each chamber module, allowing up to six wafers to be processed simultaneously. In addition to handling the full range of conventional dielectric CVD applications, the Producer system deposits several leading-edge dielectric CVD materials, including DARC™, damascene nitride and low k films such as TEOS FSG, Black Diamond™ and BLOk™ (Barrier Low k). More than 350 Producer systems have been shipped to chipmakers around the globe.


Dielectric CVD makes up one of the largest semiconductor equipment markets. VLSI Research, a market research firm, estimates that the dielectric CVD system sales totaled \$3.7 billion in 2000, with growth projected to \$6.2 billion by 2005. Applied Materials is the global market leader in CVD, including dielectric and metal applications.

Applied Materials (Nasdaq: AMAT), the largest supplier of products and services to the global semiconductor industry, is one of the world's leading information infrastructure providers. Applied Materials enables Information for Everyone™ by helping semiconductor manufacturers produce more powerful, portable and affordable chips. Applied Materials' Web site is <http://www.appliedmaterials.com>.

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 APPLIED MATERIALS®
Producer® SE CVD System
June 19, 2001

Producer SACVD™ USG 200mm and 300mm

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OUR CHALLENGE

The challenges of PMD (pre-metal dielectric) and STI (shallow trench isolation) applications are to provide repeatable and reliable void-free fill of gaps for sub-100 nm devices while maintaining superior contamination levels and no charging damage. The goal is to enable the production of future logic, flash and DRAM devices using SACVD TEOS/O₃ technology.

THE SOLUTION

Producer SACVD builds on Applied Materials' Giga-Fill™ Sub-Atmospheric CVD chamber technology, currently in production for BPSG, USG, and PSG films. Producer HT-USG is the industry's only single-wafer TEOS/O₃ USG system to achieve very high aspect ratio gap fill while demonstrating superior uptime and mean-wafer-between-clean (MWBC) performance.

Producer SACVD is capable of processing HT-USG films with the same stable, repeatable performance and gap-fill capability as the Giga-Fill SACVD Centura system, with an overall improvement in film quality and productivity. This new addition to the Producer product family is targeted for next-generation advanced STI and PMD gap-fill applications. The SACVD HT-USG process demonstrates greater than 6:1 AR gap fill providing extendibility to $\leq 0.08 \mu\text{m}$ geometry.

Because of its high productivity and process flexibility, the Producer SACVD HT-USG is gaining market acceptance. As devices continue to shrink, Producer

SACVD HT-USG will rapidly replace other technologies as the STI solution of choice.

An unprecedented combination of productivity, gap fill capability, and film quality make Producer SACVD HT-USG the industry choice for $\leq 0.10 \mu\text{m}$ process applications.

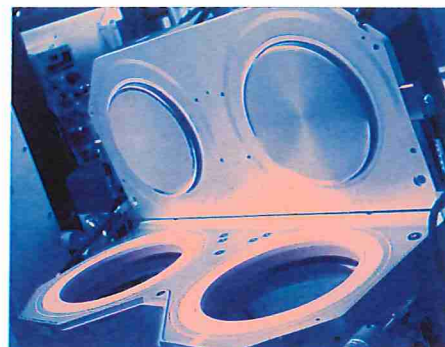
With ongoing technology innovations, the production-proven Producer SACVD HT-USG will extend TEOS/O₃ for several device generations to meet customers' most aggressive front-end gap fill needs.

APPLICATIONS

- Shallow Trench Isolation
- Zero Thermal Budget Pre Metal Dielectric
- Gate Liner Stack for Advanced Logic
- Deep Trench Mask for Advanced Logic
- Sacrificial oxide for Implant Mask

FEATURES

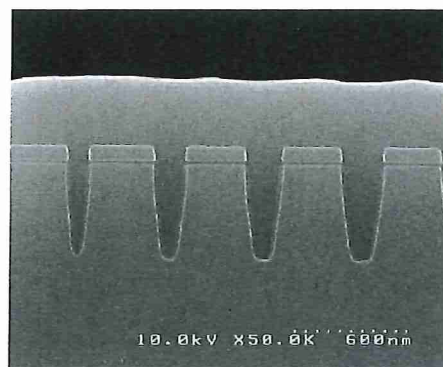
- 200mm and 300mm common platform
- Unique Twin-wafer handling with six(6) processing stations
- Advanced single-wafer deposition technology with independent, tunable process parameters.
- Ceramic heater for high-temperature processing
- Remote Clean™ technology
- Parallel Precision Liquid Injection System™ and high concentration ozonator
- Thickness Range from 200Å - 1μm



300mm Twin Chamber

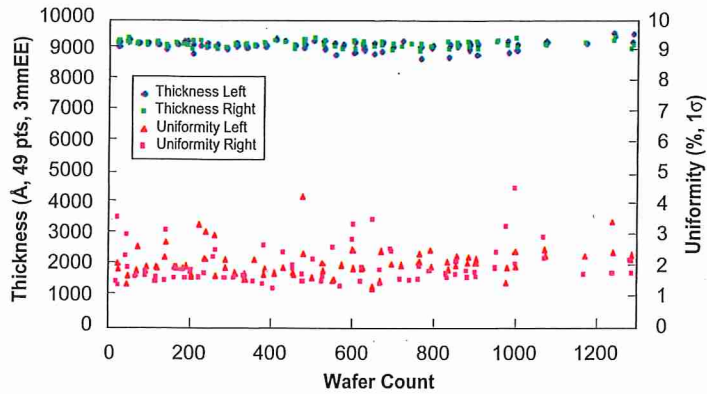
BENEFITS

- Superior thickness uniformity, ultra low metallic contamination and particle performance, excellent process control and repeatability
- Void-free, high aspect ratio gap fill without plasma damage
- High throughput capability, 30 wafers per hour (3-Twin)
- Up to 6,000 wafers per twin chamber wet clean frequency with no intermediate hardware maintenance.

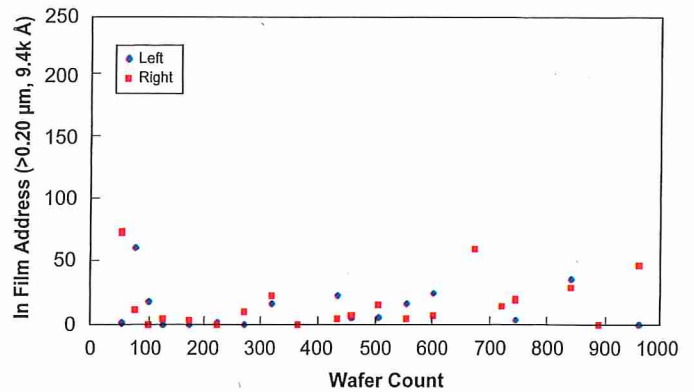


Void-free gap fill
0.08 μm spacing, 6:1 AR

300mm USG Marathon



300mm USG Marathon



TYPICAL PROCESS PERFORMANCE

Uniformity (49 pts, 3mm edge exclusion)

Within wafer

<2.0%, 1 σ

Wafer-to-wafer

<1.5%, 1 σ

Particulates (>0.2 μ m)

≤ 0.1 pcs/cm² at 0.2 μ m or larger

Metal Contamination

Al, K, Na, Ni, Fe, Cr, Ni, Zn, Ti, Mg

<5E10 at/cm²

Film stability

<48 hours. 40% R.H.

Film stress (as deposited)

<2.0E9 dynes/cm², tensile

Stress hysteresis (after 800°C anneal)

<0.5E9 dynes/cm² (>1E9 deposited films)

Wet etch rate (6:1 BOE) (as deposited)

<5:1 relative to thermally grown oxide

Wet etch rate (6:1 BOE) (post anneal)

<1.5:1 relative to thermally grown oxide

Step coverage

>90%, 0.5 μ m isolated space (0.5 μ m film)

Throughput (6k 3-Twin)

30 wph

[continuous mode with manual cassette interface]

Gap fill capability (post 1050° C densification)

0.08 μ m spacing, >6:1 Aspect Ratio

MWBC (per twin chamber)

>2,000 μ m

System availability

>90%



Producer SACVD™ BPSG 200mm and 300mm

OUR CHALLENGE

The challenge of pre-metal dielectric deposition is to provide repeatable and reliable void-free fill of gaps as small as $0.05\text{ }\mu\text{m}$ wide at 200mm and 300mm wafer sizes while maintaining technological superiority and competitive cost of ownership.

THE SOLUTION

Producer SACVD builds on Applied Materials' Giga-Fill™ sub-atmospheric CVD chamber technology, currently in production for BPSG, USG, and PSG films. Producer BPSG is the industry's only single-wafer TEOS/O₃ BPSG system to achieve very high aspect ratio gap fill while demonstrating superior uptime and mean-wafer-between-clean (MWBC) performance.

Producer SACVD is capable of processing BPSG films with the same stable, repeatable performance and gap fill capability as the Giga-Fill SACVD Centura system, with an overall improvement in throughput. Highly efficient in situ cleaning enables greater than 36,000 wafers of BPSG deposition per system without preventative maintenance and throughputs up to 90 wafers per hour. The SACVD BPSG process demonstrates greater than 10:1 AR gap fill providing extendibility to $0.13\text{ }\mu\text{m}$ geometries and compatibility with CMP and RTP processes. Because of its high productivity and process flexibility, the Producer SACVD BPSG has gained rapid market acceptance and proven production worthiness all over the world.

An unprecedented combination of productivity, gap-fill capability, and film quality make Producer SACVD BPSG the industry choice for $<0.13\text{ }\mu\text{m}$ process applications. Producer BPSG has not only demonstrated low defect density and excellent process control at 300mm, but has also proven to be the only production viable Ozone/TEOS 300mm solution available.

With ongoing technology innovations, the Producer SACVD BPSG is prepared to meet the stringent reduced thermal budget constraints required to extend SACVD technology to the $0.10\text{ }\mu\text{m}$ generation.

APPLICATIONS

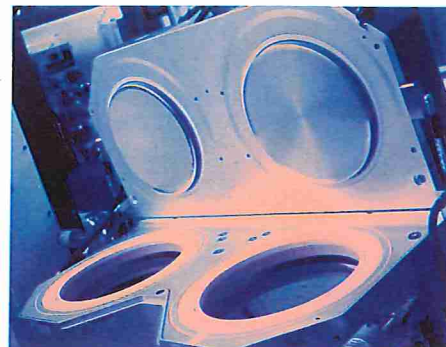
- Pre-metal Dielectric
- Cladding (Optoelectronics)

FEATURES

- Advanced single-wafer deposition technology with independent, tunable process parameters.
- Ceramic heater for high-temperature processing
- Remote Clean™ technology
- 200mm and 300mm common platform
- Unique Twin-wafer handling with six (6) process stations
- Parallel Precision Liquid Injection System™ and high concentration ozonator

LOWEST COST OF OWNERSHIP

Thanks to excellent product maturity and superior equipment reliability, the Producer SACVD BPSG has the lowest cost of ownership of any Ozone/TEOS solution currently available in the market.



300mm Twin Chamber

BENEFITS

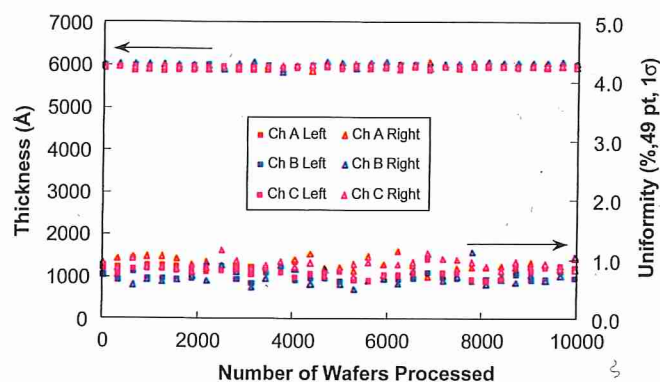
- Superior thickness, and dopant uniformity and particle performance; excellent process control and repeatability for thin and thick films
- Void-free, high aspect ratio gap-fill
- High throughput capability, 90 wafers per hour (3-Twin)
- Up to 12,000 wafers per twin chamber wet clean frequency with no intermediate hardware maintenance.



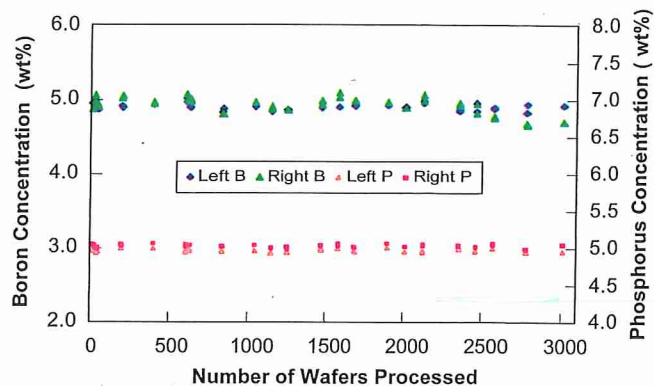
This gap-fill process has been developed with the IBM/Infineon DRAM Development Alliance which also provided the gap-fill test structures

*Void-free gap fill
 $0.03\text{ }\mu\text{m}$ spacing, $>8:1$ AR*

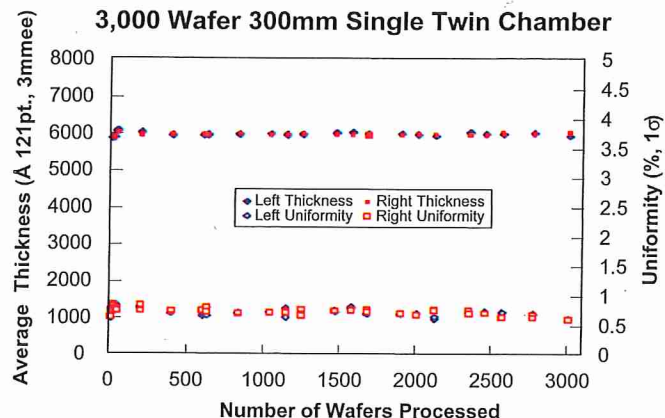
10,000 Wafer 200mm 3-Twin Chambers



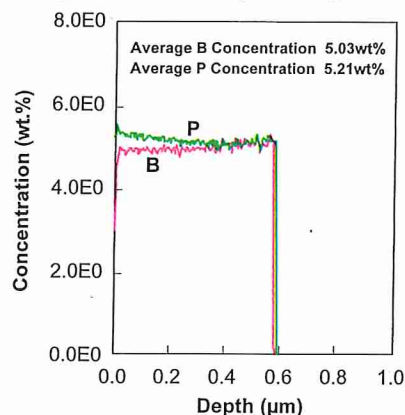
300mm Marathon Dopant Concentration



3,000 Wafer 300mm Single Twin Chamber



Dopant Uniformity through the Wafer



TYPICAL PROCESS PERFORMANCE

Uniformity (49 pts, 3mm edge exclusion)

Within wafer

Wafer-to-wafer

Deposition rate (dopant wt% dependent)

Dopant Capability

Dopant uniformity (within wafer and wafer-to-wafer)

Particulates ($>0.2 \mu\text{m}$)

Metal Contamination

K, Na, Ni, Fe, Cr, Ni, Zn, Ti, Mg

Al

Film stress (as deposited)

Stress hysteresis (after 800°C anneal)

Wet etch rate (6:1 BOE) (as deposited)

Step coverage

Throughput (3-Twin) [5k Å films, 5 wt.% (B), 5 wt.% (P)]
[continuous mode with manual cassette interface]

Gap-fill capability (post 800°C anneal)

MWBC (5k Å) (per twin chamber)

$<1.5\%$, 1σ

$<1.5\%$, 1σ

4,500 Å/min (5 wt.% B x 5 wt.% P)

2-6 wt.% B, 2-9 wt.% P (≤ 10.0 wt.% total dopants)

$< \pm 0.15$ wt. %

$\leq 0.1\text{d}/\text{cm}^2$

$< 5\text{E}10$ at/ cm^2

$< 1\text{E}11$ at/ cm^2

$< 1.5\text{E}9$ dynes/ cm^2 , tensile

$< 0.5\text{E}9$ dynes/ cm^2 ($> 1\text{E}9$ deposited films)

$< 2:1$ relative to thermally grown oxide

$> 90\%$, $0.5 \mu\text{m}$ isolated space ($0.5 \mu\text{m}$ film)

90 wph (78 wph at 300mm)

$0.05 \mu\text{m}$ spacing, $> 8:1$ AR

$> 12,000$ (6,000 μm)