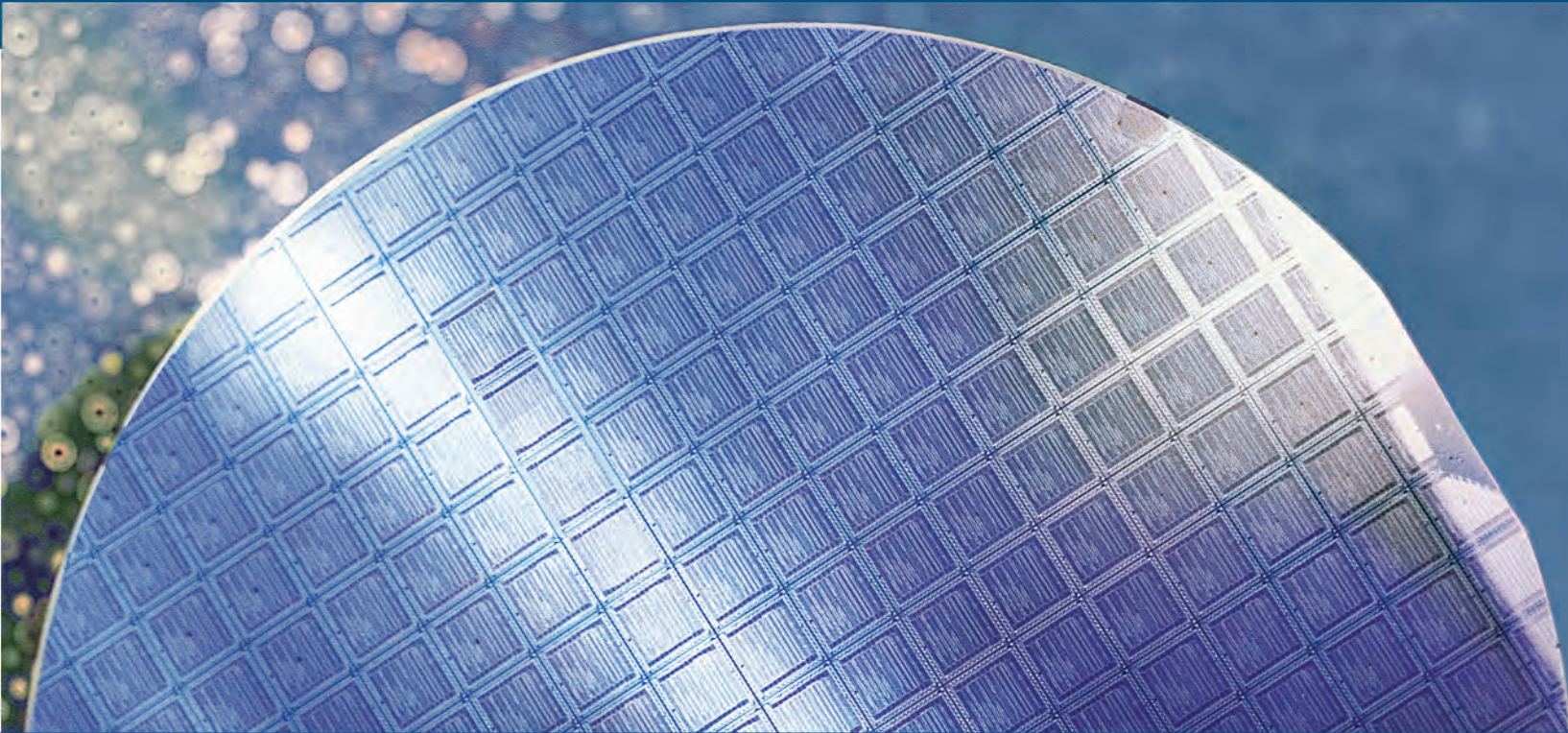
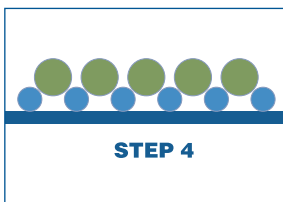
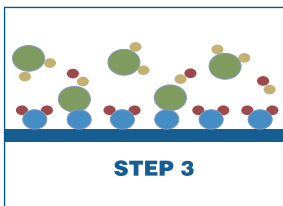
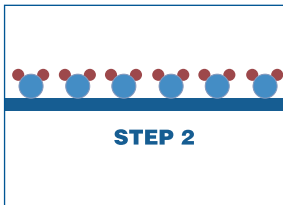
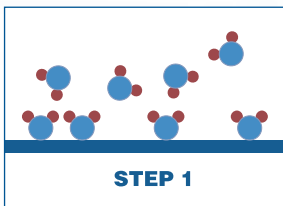


# Atomic Layer Deposition



## CHALLENGES OF ALD



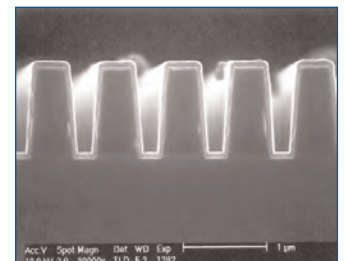
ALD deposits thin films on a substrate with monolayer precision, critical for leading edge deposition. This self-limiting, “pulsed” process sequentially introduces reactants into the process chamber in the gas phase to build successive monolayers of film on the wafer. These reactions often require the use of extremely precise doses of precursor materials.

Effective precursor delivery and control, process and tool monitoring and the appropriate selection of precursor materials positively influence parameters such as growth rate, reaction temperature, impurity levels, and crystallinity of the deposited films. MKS has the product portfolio and experience to help you achieve success in ALD processing.

Achieving the film qualities essential for ALD is no trivial matter. Maintaining uniform, angstrom-level film thickness requires critical control of precursor gas composition and delivery. A typical ALD run consists of many, short cycle-time steps using multiple precursor chemicals. Each step involves delivering extremely small doses of these materials and each material may vary widely in its chemical properties.

The small temperature and vapor pressure process windows of many precursors necessitates strict process control. In addition, precursor chemicals are often very expensive and highly toxic and must be monitored and controlled carefully to minimize costs and potential hazards. MKS works closely with industry experts and ALD OEMs that develop ALD precursor chemicals and process equipment. This collaboration allows us to better understand the evolving challenges and requirements of ALD.

As with all semiconductor processes, tool performance, reliability, process yields, fast install and longer times between maintenance cycles are critical to ALD. MKS has a history of providing leading-edge solutions and world class service to the semiconductor industry.



Cross-sectional FESEM micrograph of a 50nm ALD film grown on 20nm TiN. (Image courtesy of the Electro-chemical Society, Inc.)

*LEFT: An illustration of a typical four step process making up an ALD cycle. Steps 1 and 2 depict the creation of the initial film generated from the reaction between the primary precursor and the substrate material. Steps 3 and 4 depict the generation of the desired final film created by the reaction between the initial film and a reactant precursor material.*

# Atomic Layer Deposition



**P-SERIES DIGITAL MFCs**  
Real-time mass flow control and delivery of precursors, reactants and process purge gases

- Accurate and reliable flow control for exceptional step change repeatability and higher yields
- High tolerance to system pressure disturbances ensures precise gas delivery for every cycle
- 500ms response for precise pressure control



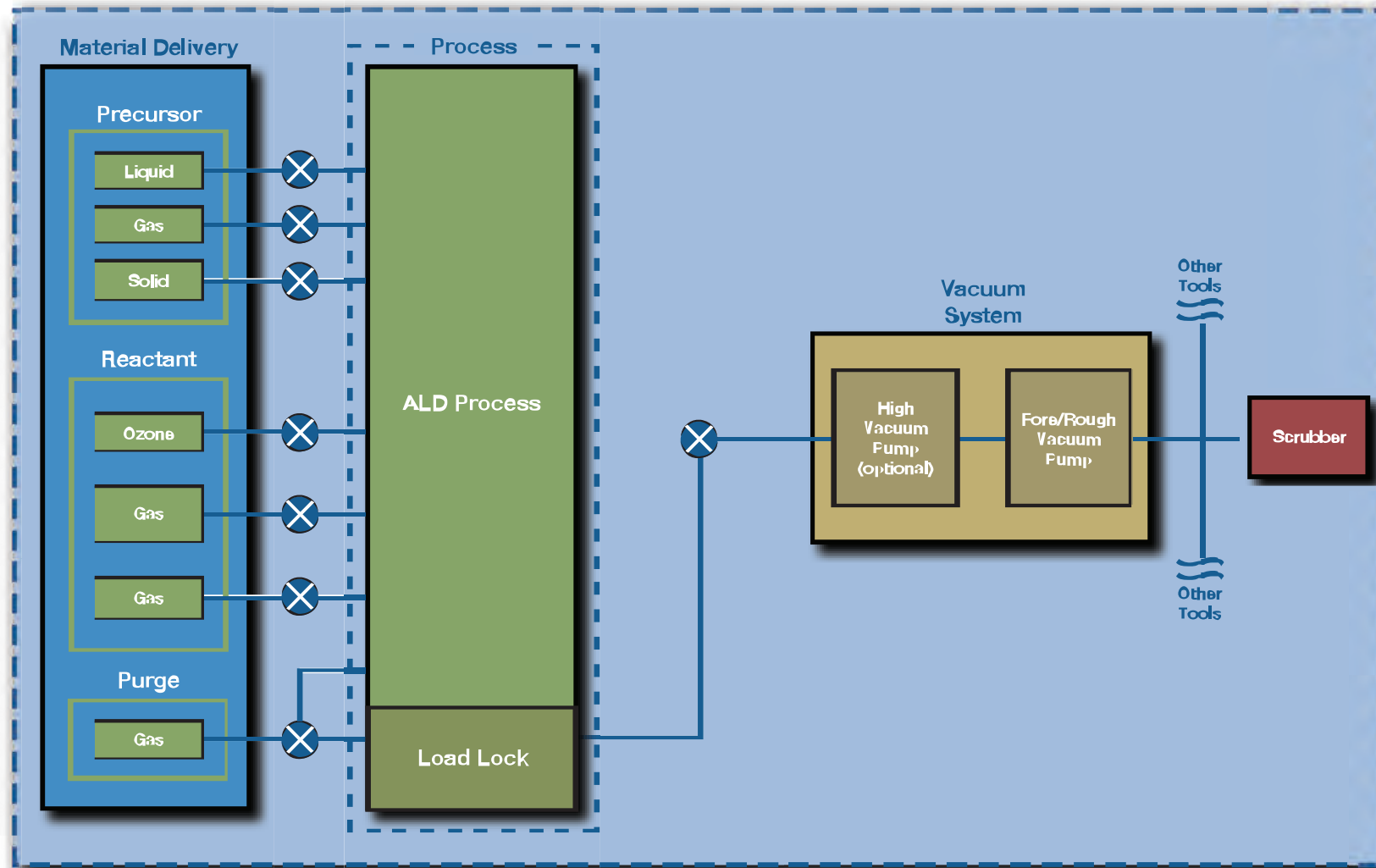
**O3MEGA<sup>®</sup> COMPACT OZONE DELIVERY SYSTEM**  
Fully integrated ozone generation and delivery system

- High concentration ozone production enables faster reactor rates at lower temperatures
- Ultra clear ozone for improved film quality and higher purity oxide growth in every ALD cycle



**VoDM WATER VAPOR DELIVERY SYSTEM**  
Fully integrated DI water vaporizer and vapor mass flow control

- Reliable and precise source of H<sub>2</sub>O vapor for ALL reactant precursor applications
- Limited connection to DI water system eliminates refilling of source vessel for reduced downtime and greater throughput



**631C BARATRON<sup>®</sup> CAPACITANCE MANOMETER**  
Accurate measurement of ALD precursor and process chamber pressures

- High measurement accuracy ensures superior process control and repeatability
- High temperature tolerance of up to 200°C compatible with advanced precursor properties



**R\*EVOLUTION<sup>®</sup> II REMOTE PLASMA SOURCE**  
Ultra clean source of reactive gas species for on-wafer processing

- Exceptional plasma power results in highly efficient water pre-clean for excellent film adhesion
- Quartz plasma body ensures high purity, active gas species for effective filtration of high-k films and improved electrical properties



**T3Bi INTELLIGENT EXHAUST THROTTLE VALVE**  
Fast and reliable downstream pressure control

- Faster recovery from flow and pressure perturbations provides increased throughput, better process control and higher yield
- Robust, high torque valve motor provides extended uptime under adverse conditions and reduces preventative maintenance cycles



**FabStat REAL-TIME MONITORING, PREDICTION AND FAULT DETECTION**  
Real-time fault detection and classification (FDG) in semiconductor manufacturing

- Start-up application designed to seamlessly integrate into your existing fab data management system
- Reduces downtime by quickly identifying faults, their cause, and their solution



**VISION 2000-C™ MASS SPEC-BASED GAS COMPOSITION MONITOR**  
Application-specific RGA designed for continuous in situ monitoring of advanced vapor deposition processes

- Superior trace gas detection limits and high speed response rapidly identifies process problems ensuring optimum film quality and maximum yield
- Continuous in situ monitoring during chamber clean, passivation, and deposition increases system uptime and yield for many advanced ALD processes

## PROVEN TECHNOLOGY LEADERSHIP

MKS Instruments is the world's leading supplier of process control solutions that improve productivity in semiconductor and related advanced manufacturing. Our extensive range of instruments, components and integrated subsystems control and manage critical parameters of the process environment.

### CORE COMPETENCIES

- pressure measurement and control
- materials delivery
- vacuum technology
- gas composition monitoring
- power and reactive gas generation
- control and information management



*O<sub>2</sub>MEGA® Ozone Subsystem, an oxidizer source for ALD gate-oxides and high k processes*

Unlike companies that may have only one or two application-specific technologies, MKS' technological breadth and years of process applications experience give us the ability to identify process challenges and provide value-added process control solutions. Our technology set is fundamental to meeting the requirements of advanced and leading-edge technologies like ALD. With extensive process knowledge and proven technology leadership, MKS is well suited to provide OEM's and end-users with high value ALD solutions that will optimize process performance, reduce costs and provide greater ROI.

### GLOBAL SUPPORT

As a worldwide leader in the development and manufacture of advanced instruments and controls for the semiconductor industry, we can support your MKS products. Our service engineers average 7-10 years of industry experience. Service plans include extended warranty, contracts, calibration, 24/7 telephone support and state-of-the-art training. With 17 calibration and service centers in 13 countries around the globe, we are where you are.

### ENHANCED PRODUCT PORTFOLIO FROM MKS



#### 628D Baratron® Capacitance Manometer

*In situ process pressure measurement*



#### 870/872 Micro-Baratron® Capacitance Manometers

*Pressure measurement of purge gas delivery systems*



#### 901P MicroPirani™ / Piezo Loadlock Transducer

*Loadlock pressure measurement and control*



#### Jalapeño Series Heated Vacuum Valves

*Isolation of process chamber and vacuum system while eliminating turbulent pumpdowns*



#### Heater Jackets, Traps and Effluent Management Solutions

*Eliminate condensation and reduce system contamination*



#### MicroNode I/O™ Module

*Monitor and control precursor delivery valves*



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