

# Enable IC breakthroughs

with MKS Instruments surrounding chambers

万机仪器助力中国**IC**产业做强做大



*Mar, 2017*

# Outline



China IC  
Policy &  
Roadmap



Critical  
Subsystem -  
MKS at  
a Glance



Global  
presence

# China IC Development

Roadmap issued on Jun 24, 2014

	2015	2020
<i>Revenue</i>	>RMB 350B	>RMB 870B (CAGR>20%)
<i>Manufacturing Node</i>	32/28nm mass production	16/14nm mass production
<i>Design</i>	Advanced or closer technology in focused technical areas (such as mobile handheld, network and communication)	WW Cutting Edge technology in focused technical areas (such as mobile handheld, network and communication, IoT, Cloud and Big Data etc.)
<i>Packaging and Test</i>	>30% revenue from Mid to High end application	WW Cutting Edge technology
<i>Materials</i>	12" Silicon Wafer mass production	Qualified in International IC manufacturing supply chain
<i>Equipment</i>	65~45nm Critical equipment in mass production	Qualified in International IC manufacturing supply chain

Fast growth

- More than 20 semiconductor fabs in construction plan since 2016!
- Merge and Acquisitions – hunting world wide!

Challenge

- Technology barriers
- Lack of talents
- Components, Materials, Basic Science...

# China IC Development

Roadmap issued on Jun 24, 2014

	2015	B\$ 10x10	2020
<b>Revenue</b>	>RMB 350B		>RMB 870B (CAGR>20%)
<b>Manufacturing Node</b>	32/28nm mass product	60%	16/14nm mass production
<b>Design</b>	Advanced or closer technology in focused technical areas (such as mobile handheld, network and communication)	27%	WW Cutting Edge technology in focused technical areas (such as mobile handheld, network and communication, IoT, Cloud and Big Data etc.)
<b>Packaging and Test</b>	>30% revenue from Mid-end application	8%	WW Cutting Edge technology
<b>Materials</b>	12" Silicon Wafer mass production	2%	Qualified in International IC manufacturing supply chain
<b>Equipment</b>	65~45nm Critical equipment in mass production	3%	Qualified in International IC manufacturing supply chain





# 50 Years of Technology

## MKS and the Electronics Industry





# MKS Business Units



## Power Solutions

RF Power Generators

Match Network

DC Power Generators



## Plasma & Reactive Gas Solutions

Microwave Plasma Source

Remote Plasma Source

Ozone Generator & Delivery



## Analytical & Control Solutions

Automation Platforms

I/O Modules

Multivariate Analysis

Fault Detection & Classification

Residual Gas Analyzers



## Pressure/Vacuum Measurement & Integrated Process Solutions

Vacuum Gauges

Pressure/Vacuum Measurement

Traps & Effluent Management

Integrated Solutions



## Flow & Valve Solutions

Mass Flow Controls

Flow Ratio Controls

Mass Flow Verifiers

Pressure Control

Isolation Valves



## Process & Environmental Solutions

Optical Gas Analyzers

# Product Portfolio



- Automation and Control
- Data Analytics
- Flow and Gas Delivery
- Gas Analyzers (Optical & MS)
- Custom Effluent Management
- Lasers and Light Sources
- Light Analysis
- Microwave Systems
- Motion Control
- Optics
- Plasma Sources
- Power Systems
- Pressure and Vacuum Instruments
- Reactive Gas Generators
- Vibration Isolation Tables & Systems
- Custom Vacuum Solutions
- Valves

# Pressure and Vacuum Measurement Solutions

## TRANSDUCERS & GAUGE CONTROLLERS



- $10^{-11}$  to 1000 Torr
- Pirani, Convection, Piezo
- Hot & cold cathode
- MEMS based Pirani

## PRESSURE MEASUREMENT SUBSYSTEMS



- Transducer, isolation valve & controller
- Single-chamber connection point
- Simplifies pressure management

## BARATRON® CAPACITANCE MANOMETERS



- Accuracy in harsh environments
- High res. digital output with analog equivalent
- Ranges from 0.02  $\mu$ 1000T
- Temperatures to 200°C

## ISSUES IMPACTING FABRS

- Process control & yield
- Faster processes
- Higher temperatures
- Lower pressure
- Larger substrates
- Better control

## SOLUTIONS FROM MKS

### DIRECT & INDIRECT GAUGES

- Higher temperatures
- Increased accuracy, precision & speed
- Lower pressure
- Embedded diagnostics
- RF immunity (digital comms)
- High reliability



# MKS Flow Solutions

## FLOW RATIO CONTROL



- Fast, accurate flow ratio control
- 2, 3, & 4-zone solutions
- Wide dynamic range
- Web-enabled diagnostics

## PRESSURE CONTROL



- Baratron Capacitance Manometer
- 1 Torr to 100 psia Full Scale
- Integral flow measurement option
- Dual channel assembly for backside wafer cooling application

## MASS FLOW CONTROL



- Multi-gas/multi-range capability
- 5 sccm  $\pi$  1000 slm Full Scale
- Insensitive to pressure disturbances
- Pulsed gas / molar delivery options

## FLOW VERIFICATION



- In situ mass flow verification enables chamber-to-chamber and tool-to-tool matching
- External volume insensitive
- -0 ne device for multiple chambers
- Exceptional repeatability and reproducibility

## ISSUES IMPACTING CUSTOMERS

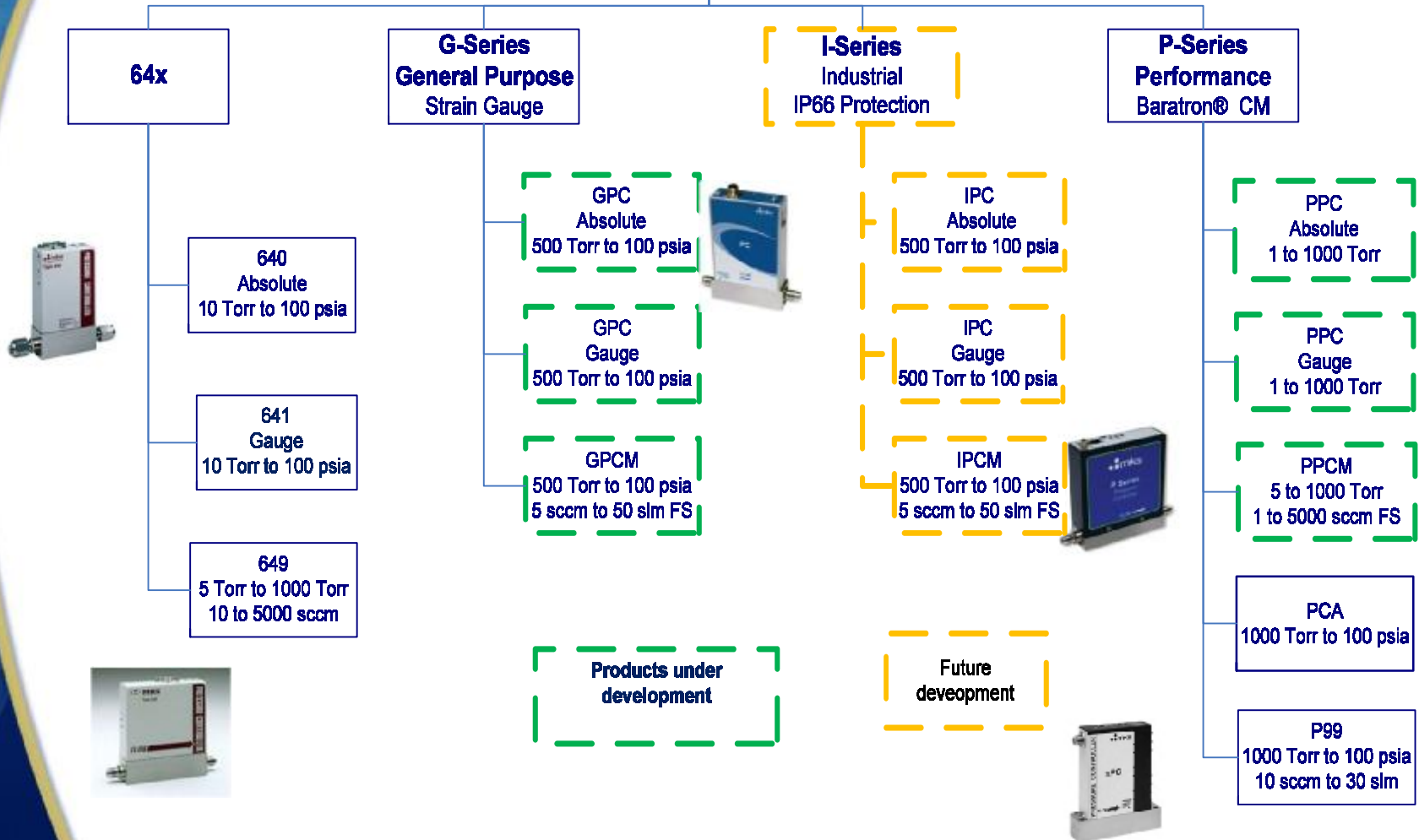
- Chamber Matching
- Process Uniformity
- Faster Processes
- Tool Utilization / Uptime
- Diagnostics and Ease of Use

## SOLUTIONS FROM MKS

### FLOW CONTROL

- High Accuracy, repeatability & reproducibility
- Faster process control response
- High reliability
- Embedded user interface
- In-situ verification

# Pressure Controllers 5 Torr to 100 psia



# Valve Solutions

## ISOLATION VALVES



- Stainless steel & aluminum
- Two stage with integrated soft pump
- Heated & unheated
- High cycle (10M+ cycles)
- Corrosion resistant

## DOWNSTREAM VALVES & PRESSURE CONTROL



- High speed, high torque, <200 ms open to close
- Heatable to 150°C
- Advanced model-based control
- Robust for processes with exhaust deposits

## Gate Valves



- Cost Effective Solution for Roughing Pump Isolation
- Soft Pump Bypass for reduced particle generation during pump down
- Uniform Heating to prevent condensation of corrosives

## ISSUES IMPACTING OEMs

- Process control & yield
- Faster processes
- Higher temperatures
- Larger substrates
- Better control
- Preventative maintenance due to exhaust deposits

## SOLUTIONS FROM MKS

### PRESSURE CONTROL

- Higher temperatures
- Increased accuracy & precision
- Extended PM intervals
- Better Control Performance
- Embedded diagnostics
- Digital communications
- High reliability

# Integrated Process Solutions

## VACUUM FITTINGS



- Fittings, flanges & components
- Stainless steel, aluminum, brass
- ISO-KF, ISO-Universal, CF, welded
- State-of-the-art, complies with latest fab specifications

## HEATED PUMP LINES



- Form fitting for tight control
- Selfregulating (no external temp controller)
- Options for high temp fiberglass heaters up to 260°C
- FM certified

## CUSTOM SOLUTIONS



- Process traps
- Nitrogen barrier devices to prevent byproduct build up
- Virtual wall to reduce particulates
- Complete turnkey vacuum foreline solutions

## ISSUES IMPACTING FABRS

- Tighter particle specs
- Lower COO
- Higher yields
- Higher throughput

## SOLUTIONS FROM MKS

### EFFLUENT MANAGEMENT USING HEATERS, VIRTUAL WALL, TRAPS

- Increase uptime of tool
- Increase pump lifetime
- Reduce particulates
- Reduce energy consumption

# MKS Solutions In Gas Analysis & Leak Detection

## HIGH PRESSURE PUMP-FREE PROCESS RGAs



- Compact control module for limited space applications such as clean room areas
- Monitoring of degas, pre-clean, buffer & transfer chambers

## VACUUM QUALITY MONITORING



- System gas load analysis
- Leak detection (real or virtual)
- Analyse out-gassing issues
- Differentiate different gas species
- Compact, fast and easy-to-use

## IN-SITU PROCESS MONITORING & LEAK DETECTION



- Low ppb, trace level detection
- Component process RGA
- Fully integrated, application-specific packages
- FAB-level software solutions

## ATMOSPHERIC GAS ANALYSIS



- Low ppb, trace level detection
- Compact, fast response
- Characterization of simple and complex mixtures
- Multipoint calibration for quantification

## ISSUES IMPACTING FABs

- Need to confirm vacuum quality and integrity
- Identify contamination which causes:
  - π Process variability
  - π Increased PMs
  - π Reduced yield

## SOLUTIONS FROM MKS

### GAS ANALYSIS & LEAK DETECTION

- In situ monitoring
- Improved uptime
- Increased yield
- Protects tools from contamination
- Monitors vacuum quality
- Monitors for leaks

# Process & Environmental Analysis (P&EA) Group

## Optical Gas Analysis

**MultiGas™ FTIR**



- Bulk gas im purity analysis
- Cham bercharacterization
- Analysis of fluorinated green house gas em issions
- 30+ m ulti-com ponent analysis

**AIRGARD® Ambient Air Monitor**



- Am bientairm onitoring
- Detection of a broad range of toxic gases
- Self-contained , ultra-sensitive ppb
- Adaptable library

**Process Sense™ NDIR Analyzer**



- Cham ber clean end point
- Single gas analyzer
- Sm all fo tprint, sim ple design
- Low -cost process m onitor

**Precise® TFS™ Gas Analyzer**



- W afer process end point
- Cham ber clean end point
- Precursor gas analysis
- M ulti-com ponent analysis
- Low -cost process m onitor

- ISSUES IMPACTING CUSTOMERS**
- Cham ber M atching
  - Process Uniform ity
  - Faster Processes
  - Tool U tilization / U ptim e
  - D iagnostics and Ease of Use

**SOLUTIONS FROM MKS**

- PROCESS & ENVIRONMENTAL ANALYSIS**
- Cham ber clean end point
  - Bulk gas im purity analysis
  - W afer process end point
  - CVD tool abatem ent analysis
  - Am bientairm onitoring

# MKS Solutions In RF Power

## 13.56 MHz RF PULSED POWER



- Industry leading pulsing
  - Multiple setpoint
  - Closed loop pulse shaping control
- Dynamic Frequency tuning
- Integrated VI sensor
- On-board diagnostics

## 2MHz RF PULSED POWER



- Industry leading pulsing
  - Multiple setpoint
  - Closed loop pulse shaping control
- Integrated VI sensor
  - Power accuracy & digital control for fast response

## RF MATCH



- Fully digital controlled system
- Fast, converging algorithms
- Automatic, manual & preset modes
- Adjustable matching trajectories

## ISSUES IMPACTING FABS

- High aspect ratio etch
- Sidewall roughness
- Reflected power
- Cleaning and surface preparation
- Process repeatability

## MKS SOLUTIONS PROVIDE

- Quick impedance adaptation for etching through different material layers
- 50  $\mu$ sec dynamic frequency tuning minimizing reflected power
- Consistent high output power delivery
- Power accuracy of  $< \pm 0.1\%$  setpoint

# Power Solutions EDGE Platform

- New MKS Branding
  - 400KHz to 60MHz
- Common Modules
- Scalable & Fast Product Development
  - 30% Faster
  - Multiple Frequencies & Power Levels
- Leading Technology





# Solutions In Remote Plasmas & Reactive Gas

## OZONE GENERATORS & DELIVERY SYSTEMS



- Gas & dissolved ozone
- High flow, purity & concentration
- ALD, CVD, cleaning, prep, oxide growth
- Recirculation of ozonated water

## ON-WAFER PLASMA PROCESS



- Remote plasma wafer processing
- Significantly reduces overall investment & tool operating costs
- Photoresist removal, wafer pre-clean, nitridation, oxidation

## CHAMBER CLEAN



- Remote plasma chamber clean
- High reactive species output, self-contained unit
- High power & higher gas flows enable reduced clean times

## ISSUES IMPACTING OEMs

- New materials & processes
- Tighter process control
- Larger substrates
- Short process times
- Contamination
- Cost: water, power & chemical consumption

## SOLUTIONS FROM MKS

### ATOMIC SPECIES & REACTIVE GAS FOR PROCESSING & CLEANING

- Precise
- Clean
- Reliable
- Cost effective
- Environmentally friendly

# MKS Torroidal Remote Plasma Sources

- MKS ASTRON and Paragon torroidal plasma sources are used to generate reactive radicals for chamber clean, PR strip and on-wafer processing



1997

ASTRON 2L



2002 - 2003

ASTRONi  
R\*evolution I



2004 - 2008

ASTRON hf-s  
ASTRON hf+  
ASTRON G7



2010-2015

Paragon  
Paragon H\*  
R\*evolution III



2017-2018

Paragon II  
Paragon hf-s  
R\*evolution V

# Product Roadmap - OZONE Products

Technical Drivers:

- New Materials
- New Processes
- Tighter Process Control
- Short Process Times
- Low Contamination

Higher Concentration Ozone  
Higher Flow Rates



AX8410

2015



LIQUOZON  
Stream



AX8585

2016



AX8415



AX8585

2017



LIQUOZON  
Vari03

Ultra-clean Ozone Generation  
and Subsystem Development

MKS Roadmap:

- Increased Concentration
- Increased Flow Rates
- Ultra-Clean Ozone
- Lower CoO
- General
- Form
- Reliability

# MKS Automation & Control Solutions

## INTELLIGENT & PROGRAMMABLE AUTOMATION PLATFORMS



- C-program m able, Linux logic controllers.
- Integrated and modular PLCs and PACs .
- Control tem plates and plug -ins for sem iconductor fab instrum entation

## EtherCAT ,ETHERNET, DEVICENET & PROFIBUS I/O DEVICES



- Analog, digital & com bo m odules for com m on instrum entation
- Quick connect m odule configurations
- Turn -key signal distribution and packages
- Configurations include 2 to 2000 I/O points

## SYSTEM CONTROL SOLUTIONS



- Precision tem perature controller
- M VA -based control packages
- Safety system

## COMPACT PCI CARDS & CAGES



- Unique, rear I/O & com m unication cards
- Power supply cards
- 3U developm ent kit

## ISSUES IMPACTING FABs

- Precision processing requires better control, repeatability & reliability
- Cham ber m atching requires tight synchronization betw een subsystem s
- M ore devices to control
- H igher data volum e

## SOLUTIONS FROM MKS

### AUTOMATION PLATFORM AND TOOLS

- Enables precise control and superior process repeatability .
- Extended product lifecycle to m atch capital equipm ent tim eline
- Lower cost
- Faster tim e to m arket than in house design

# Global Presence Supports Technical Localization Strategy



**Localized technical expertise across the globe**

# In Closing

## Strong Supplier

- ▶ Recognized leader
  - Market leader with broad technology portfolio
  - Supporting Sem i industry for >50 years
- ▶ Financially stable
- ▶ Investing in technology & development

## Critical, Enabling Technologies

- ▶ Proven technology for leading edge processes enabling technology infections
- ▶ Core capabilities
  - Precise control of pressure, flow and composition
  - Generation and delivery of power & reactive gases
  - Integrated solutions for process modules & systems
  - Precise control of position, motion and stability
  - Generation & delivery of laser power
  - Integrated solutions for inspection & lithography modules & systems

## Global Presence

- ▶ Global footprint
- ▶ Local support
  - π China
  - π Japan
  - π Singapore
  - π Israel
  - π UK
  - π France
  - π Germany
  - π Korea
  - π Taiwan
  - π USA