Future Manufacturing

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GLOBALFOUNDRIES Fab 1, Dresden

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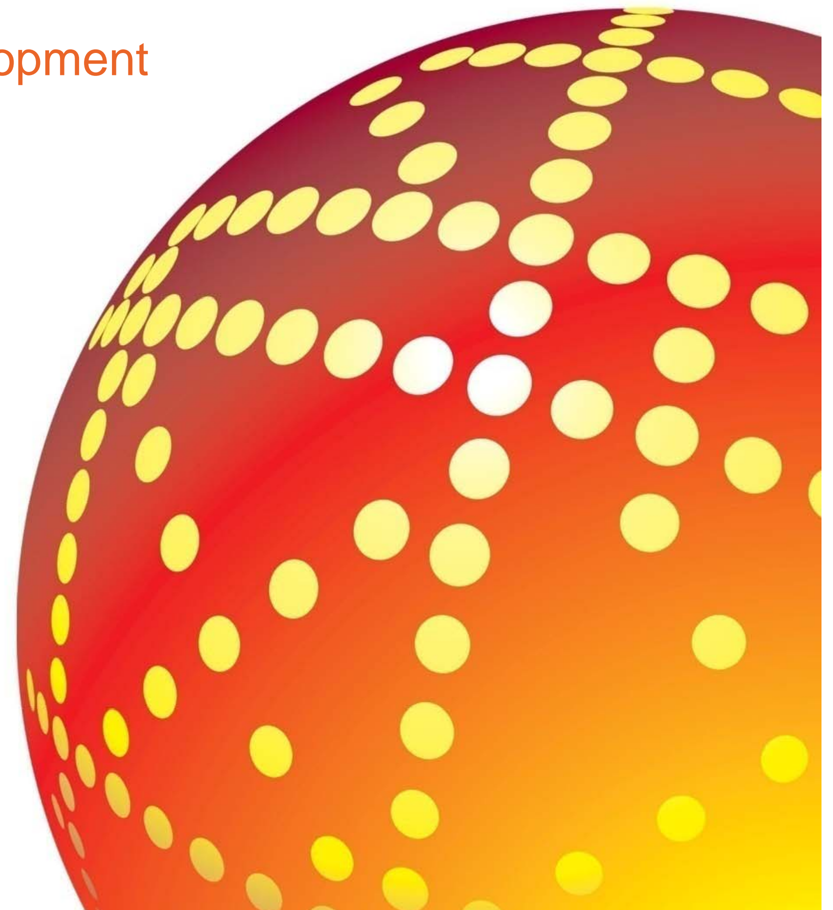


When Physics and Finance conspire…

IDMs going fablite/fabless

Fabless % of overall semi revenue continues to increase

Chip Demand

- **130NM**: Altis Semiconductor, Dongbu HiTek, SMIC, UMC, TSMC, GLOBALFOUNDRIES, Seiko Epson, Freescale, Infineon, Sony, Texas Instruments, Renesas (NEC), IBM, Fujitsu, Toshiba, ST Microelectronics, Intel, Samsung
- **90NM**: Dongbu HiTek, SMIC, UMC, TSMC, GLOBALFOUNDRIES, Seiko Epson, Freescale, Infineon, Sony, Texas Instruments, Renesas (NEC), IBM, Fujitsu, Toshiba, ST Microelectronics, Intel, Samsung
- **65NM**: SMIC, UMC, TSMC, GLOBALFOUNDRIES, Infineon, Sony, Texas Instruments, Renesas (NEC), IBM, Fujitsu, Toshiba, ST Microelectronics, Intel, Samsung
- **45/40NM**: SMIC, UMC, TSMC, GLOBALFOUNDRIES, Renesas (NEC), IBM, Fujitsu, Toshiba, ST Microelectronics, Intel, Samsung
- **32/28NM**: UMC, TSMC, GLOBALFOUNDRIES, ST Microelectronics, Intel, Samsung
- **22/20NM**: TSMC, GLOBALFOUNDRIES, ST Microelectronics, Intel, Samsung
- **14NM**: ?, GLOBALFOUNDRIES
- **< 14NM**: ?

Advanced CMOS Logic Manufacturing Technology Capability*

Source: iSuppli, GLOBALFOUNDRIES

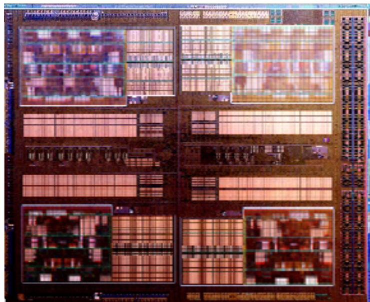
Manufacturing Technology Vision

Inside the Fab | Outside the Fab

	Yesterday	Today	Tomorrow
RUN	Operator Required	Operator Assisted	Lights-Out Operation
Measure /Control	CIM	Remote Operations	Lights-Out Operation
Improve	Integrated Yield Management	Automated Yield Management	Design Optimization / DEM

What does it take?

Innovation



Technologies

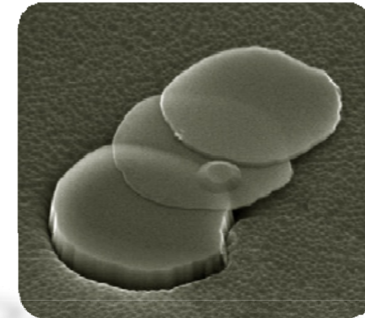
Comparing the options

	2D-SoC	3D-SiP	3D-TSV
Cost			
Performance			
Power			
Functionality			
Time to market			

STRENGTH WEAKNESS

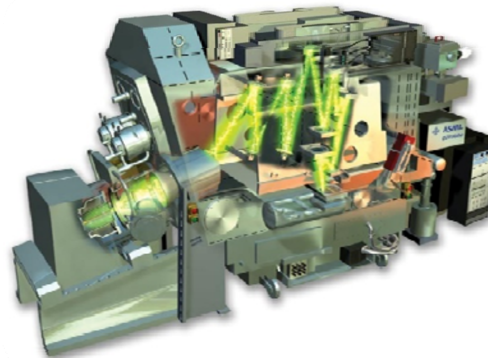
3D TSVs offer a cost-effective way to achieve high density and performance while also being able to integrate non-CMOS products with CMOS. The SEMATECH project is based on cost modeling to assure products will be manufacturable and affordable.

Materials & Processes



People

Advanced Tools & Methods



Automation

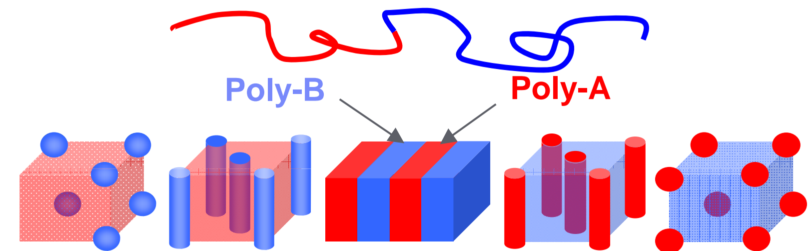
New Materials & Processes in ‘Fab & Lab’

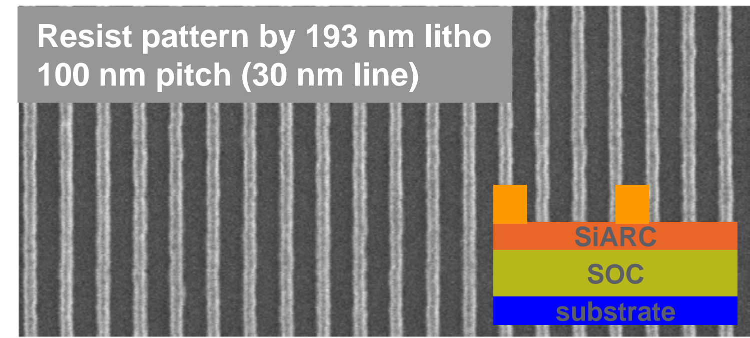
	20nm	14nm	10nm	7nm	5nm	Beyond 5nm
Stage	Fab-stage	Fab-stage	Lab-stage	Lab-stage	Lab-stage	Lab-stage

- **Planar**
- **FinFET**
- **FinFET (bulk)**
- **SiGe PMOS FinFET**
- **III-V /Ge FinFET/trigate**
- **Nanowire/All-around gates**
- **Super-steep subthreshold device**
- **Carbon-based structures**

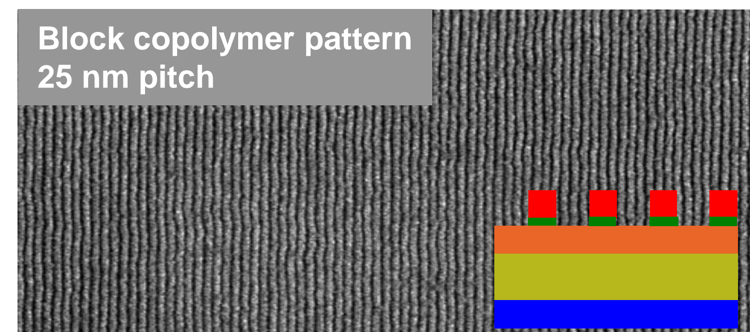
Block Copolymer Directed Self Assembly (DSA)

- **Based on phase separation in block copolymer thin films**
  - Resolution controlled by block sizes
  - Feature size largely determined by polymer film
- **Benefits**
  - Very high ultimate resolution << 10 nm
  - Can be implemented existing exposure tooling
  - Large multiples of frequency multiplication
- **Drawbacks**
  - New materials & processes
  - CD control, defectivity need work
  - Requires ultra-regular design



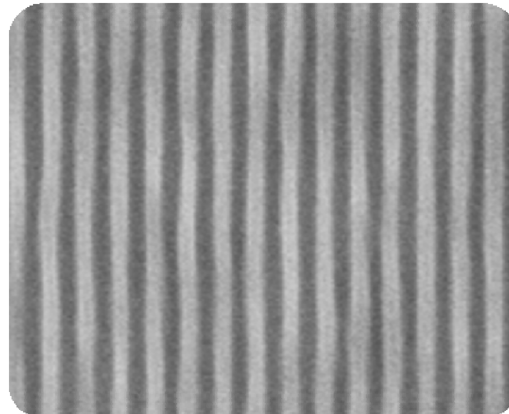
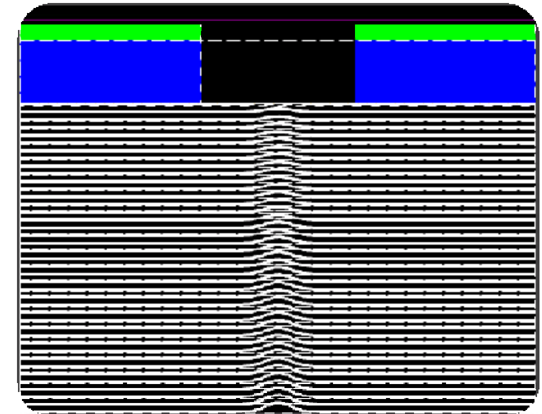


1. Apply neutral surface
2. Apply block copolymer
3. Etch



Source: IBM

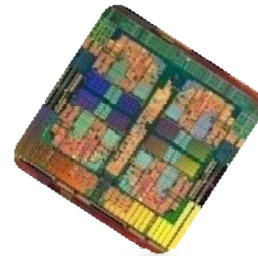
EUV Technology: Comprehensive Solution

Scanner Technology	Imaging Materials & Process Optimization	Mask Technology
		
▪ *Scalable Source Power*	▪ *Sensitivity / Resolution / LER*	▪ *Inspection Infrastructure*
▪ *Reliability & Availability*	▪ *Integration of Thin Resists*	▪ *Mask Blank Supply Chain*

- **Collaborative development and integration of these technology elements are required to bring EUV Lithography to maturation**

Source: IBM

Manufacturing Evolution to Next Generation Factory



APM 1.5	APM 2.0	APM 3.0	NGF	Future Fab
150mm Wafers	200mm Wafers	300mm "Classic"	300mm Prime	450 mm Prime
Late 80's-1995	1995 - 2002	2002 - 2009	2009 and still going strong	> 2017/18
Line Yield Improvements	**Sort Yield Improvements**	**Sort Yield Optimization**	**Manufacturing Optimization**	**Light-Out-Fab**
• Tool recipe verification • Process monitoring • Tool automation	• Tool recipe optimization • Tool performance monitoring • Process automation	• Holistic, automated, integrated decision making • Fab-wide control • Tool-to-tool nonlinear material movement • Process optimization • Wafer/die level control	• Lean manufacturing • Small Lot Manufacturing • Rapid Cycle Time • Rapid product development • Maximized ASP's • Supply-chain automation • On-demand manufacturing	• Extreme Clean Dry Air • Inert Conditions Clean Room (N2)

Next Generation Factory

Advanced Material Controls

- Next Generation Material Handling Systems
- Advanced WIP management – dispatching & scheduling

On-Demand Manufacturing

- Optimized cycle time
- Quick cycles of learning
- Rapid yield enhancement

Predictable Equipment and Factory

- Improved equipment utilization
- Proactive factory responses

Coordinated Command and Control

- Unified factory setup and control
- Enterprise-wide data accessibility and visibility
- Supply chain automation

Next Generation Factory

- Turning orders into cash
- Turning ideas into solutions
- Rate of transitioning to new technologies
- Rate of transitioning to different product mix
- Mitigating risk of forecast error
- Mitigating risk of ASP declines
- Finding an excursion
- Mitigating the impact of an excursion
- Offsetting the effect of more masking layers in advanced technologies

Sustainable Profitability

Summary

- Manufacturing in the electronics industry will evolve significantly moving forward as we are forced to deal with increase in cost as well as complexity.
- Mega-Fabs (> 1 million wafers/year) will leverage the scale of the investment required.
- “Lights-Out” Manufacturing will push system integration and automation to levels never before considered.

THANK YOU

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