Semiconductor Industry Strategic Trends

great opportunities handcuffed by policy

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Chip Innovation Engine  Relentlessly Drives Opportunity

Macroeconomics
- AI-everywhere
- AR/VR
- Auto\SDV\ADAS
- IoT
- SSD
- Computational Medicine
- COVID
- MMT
- National Security
- PowerGrid
- Zooming
- Lifestyle
- Data Security
- Data Economy
- Data Center as a Profit Center
- Cloud
- 3D Printing\Etching
- China
- Factory 4.0
- Quantum Computing

Semiconductors
- Law of PPACt
- Heterogeneous Integration
- GAA
- GaN
- CNT
- 2D Nanosheets
- Al-in-design
- DCTO
- Compound Semi
- DRAM
- 3DNAND
- 3DLogic
- PCRAM
- RRAM
- CrossPoint
- RF
- FPGA
- Chiplets

Equipment & Materials
- Multi-beam litho/inspection
- EUV revolution
- Optical DW
- Hi-NA-EUV
- Al-in-fab
- HAR
- hyper-NA-EUV
- Advanced Assembly
- EPE\LER
- Hi/LoK
- Curvilinear Masks
- ALD
- DSA
- Dry Resist
- NGinterconnect
- Materials System Engineering
- Materials Enabled Scaling
- Selective-dep/etch

28 Sep 2021
Semiconductor Technology Opportunities

**DRAM**
- DDR\textsubscript{N+1}
- 3D DRAM\textsubscript{GAA}enabled
- Copper
- Low R Metal

**HAR Gap Fill Co capping**

**Selectively-dep/etch NGMs**

**Hi-Mobility Channel TSV**

**LoK Dielectric NGM-Hard Mask**

**Advanced Doping**

**Advanced Interface Engineering**

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**NAND**
- V-Limit: H-Scaling
- Low-Dishing CMP
- Hybrid W2W Bonding
- NPU xPU
- Hi-Modulus ON
- Advanced Interface Engineering
- CMOS Over/Under Array
- Zig-Zag Staircase
- HAR Gap Fill
- Optimized Implant/Anneal

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**LAP**
- Logic, Analog & Power
- EUV Hi-NA-EUV
- GaN
- Curvilinear Masks
- Dry Resist
- Chiplets
- CNT 2D

**GAA NGMs**

**hyper-NA-EUV**

**3DLogic**

**GAA\textsubscript{enabled} eDRAM**

**NGM-Hard Mask**

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28 Sep 2021
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<th>Qtr or Week</th>
<th>Overall</th>
<th>DRAM</th>
<th>NAND</th>
<th>IDM</th>
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Range: Shortage | Tight | Balanced | Loose | Saturated | Glut
Long-term Impact

United States has Lost Semiconductor Manufacturing Share for six decades

Semiconductor Manufacturing Share by Region
(CMA of production share in wafer area)
Wafer Fabs are Natural Monopolies

- They are “Technology Treadmills”
  - Cochrane’s Theorem

- $20B: Cost of a new 3nm gigafab
  - $7B: Cost to upgrade it to 2nm
    - Thus, existing players have substantial cost advantage over new entrants.
  - $11M: Loss from a single day of construction delay
    - A myriad of factors from poor access to capital to simple things like sales tax & slow local permitting are what drove manufacturing offshore
How we got here

- EDA broke Design-Fab coupling
- Silicon Shield incentives shifted manufacturing to Asia
- US CapEx phobia favored fabless
- US Industrial Policy phobia favored Silicon Shield regions
- Foreign STEM students’ financial advantage at US Universities
Investors voting against US Chip Co’s

Threat of higher corporate taxes is hurting the value of America’s Semiconductor Industry
Policies to strengthen US Chip Manufacturing

Business Infrastructure

- Single federal construction permitting process
- Bolster Public-Private Partnerships with proven structures
- Link American leadership in Universities and Semiconductor technology
- Keep corporate taxes low for America’s Semiconductor sector
  - Incentivize strategic investment in private production capacity

Human Infrastructure

- Drive STEM and require Computer Science in the K-12 curricula
- Provide financial incentives for STEM college degrees in STEM
- Make STEM College Loan payments tax deductible
- Provide tax incentives for those who work in Semiconductor related fields.
- Foreign students getting an advanced degree in STEM automatically get a green card upon graduation
  - Provided they stay and go to work in America’s semiconductor industry
Thank You

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CTO
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- Preserving the history of semiconductors for future generations
- Virtual history museum
- Based on industry donations
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