


Manufacturing Equipment Innovations Enabling 3D Architecture

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Lam RESEARCH

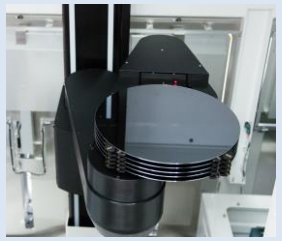
Strategic Partner of Choice for Today's and Tomorrow's Memory Technologies

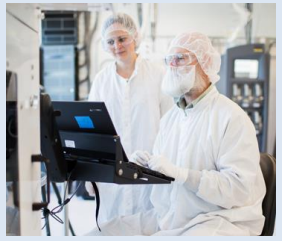
Lam Research


Plasma Processing


Wet Processing

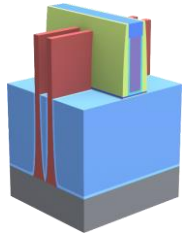

Atomic-Layer Processing

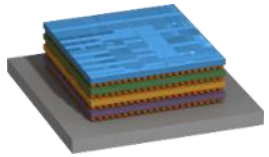

Mechatronics

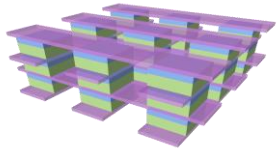

Software

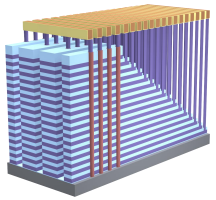

Services

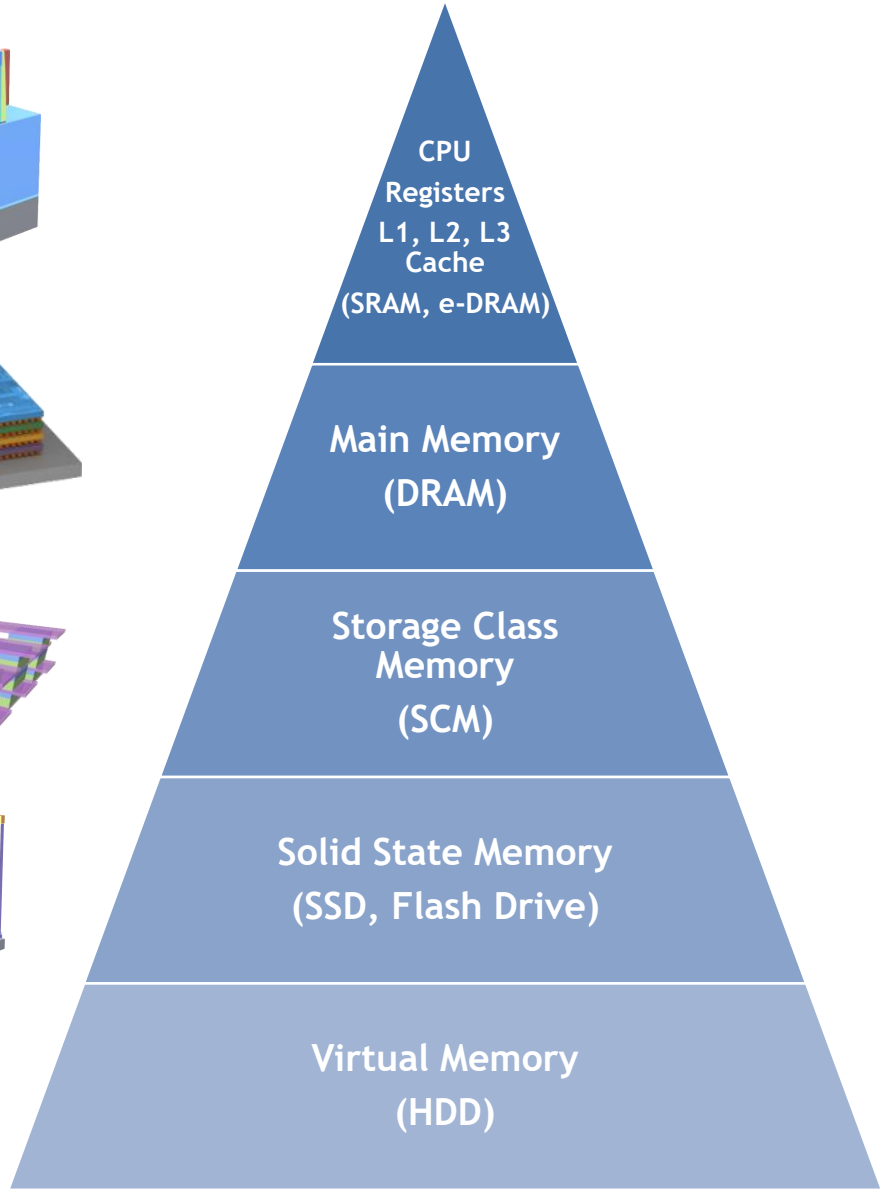
Enabling 3D Architecture







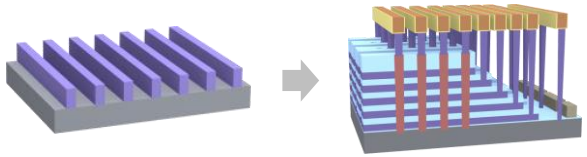




Today's and Tomorrow's Scaling Is Enabled by 3D Architecture

The Vertical Reality

2D → 3D NAND



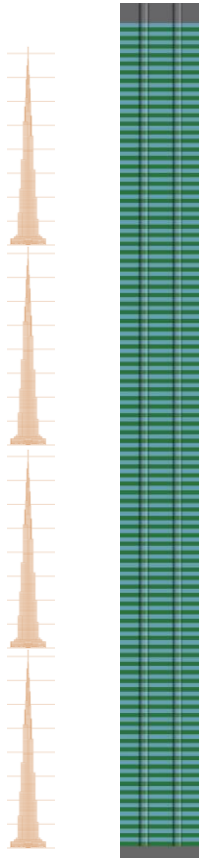
Planar → FinFET

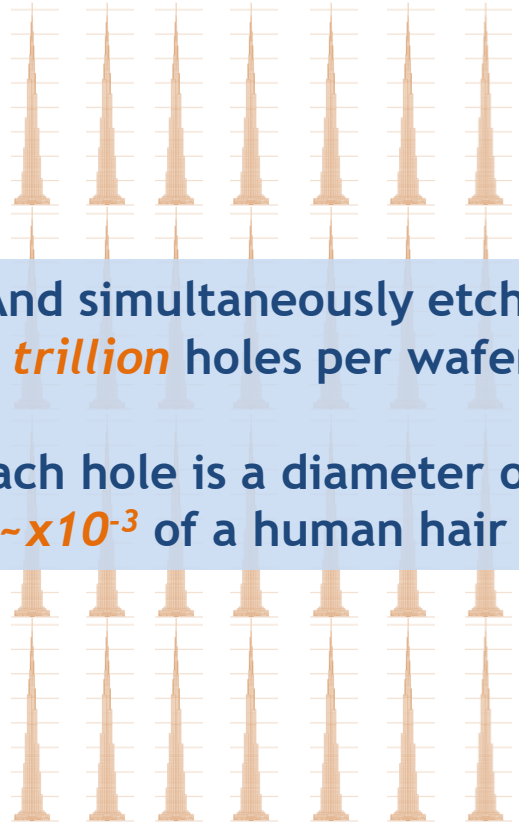
Chip → Stacked Chip

Aspect Ratio ~9:1

The Burj Khalifa, tallest structure in the world

Aspect Ratio >40:1



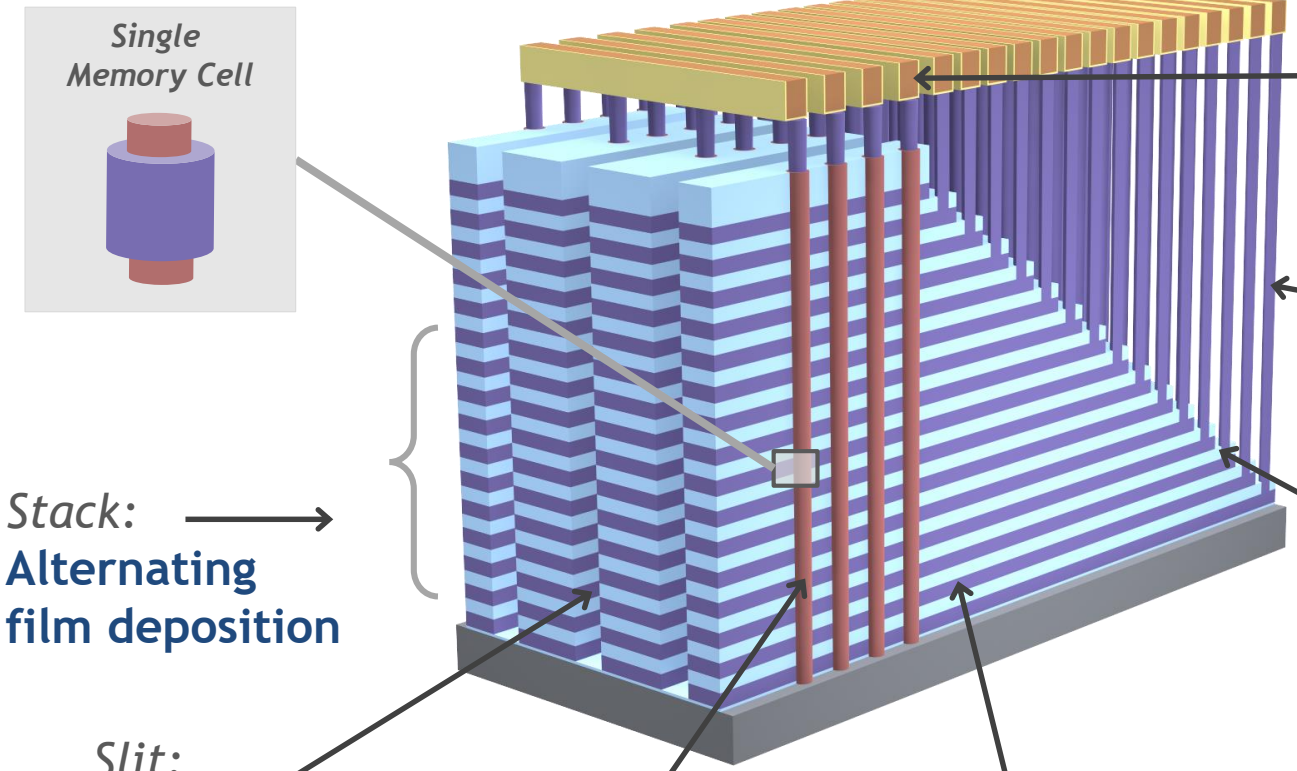


And simultaneously etch *a trillion* holes per wafer

Each hole is a diameter of *~x10^{-3}* of a human hair

Channel hole etched for 90+ layer 3D NAND

Deposition and Etch Processes Define 3D NAND Memory Array



Bitline:
Metal fill SABRE® copper plating

Contact:
Metal fill ALTUS® CVD/ALD deposition

Stack:
Alternating film deposition
VECTOR® Strata™ deposition

Stair:
Staircase etch Kiyo® conductor etch

Slit:
High aspect ratio etch
Flex™ HAR etch

Channel:
High aspect ratio etch
Flex™ HAR etch

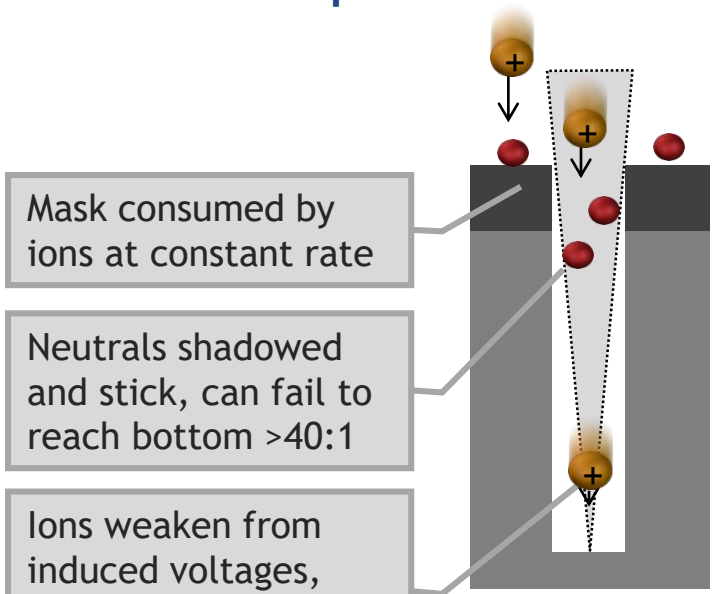
Wordline:
Metal fill ALTUS® CVD/ALD deposition

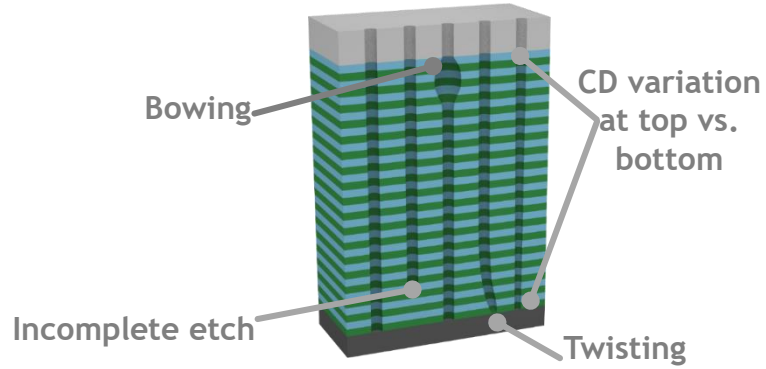
Lam is a leading equipment supplier in 3D NAND deposition and etch applications

Breaking Fundamental Tradeoff with Equipment Innovation

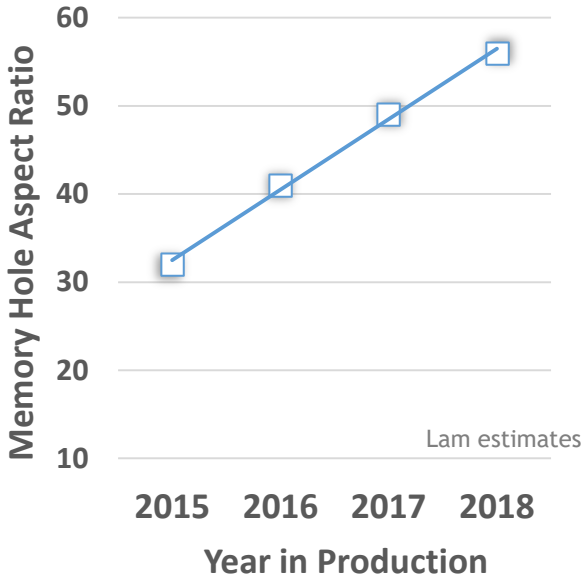
Example: Memory Hole Etch – the Most Critical and Difficult Step in 3D NAND Manufacturing

High aspect ratio etch challenges due to transport limitation





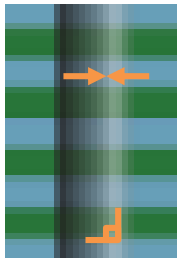
Increasing engineering difficulty for high aspect ratio etches



Equipment innovation required to break the fundamental tradeoff
(AR, profile, mask selectivity)

Flex™ Channel Hole Etch

Atomic-scale process control is required in addition to micron-scale etched depths

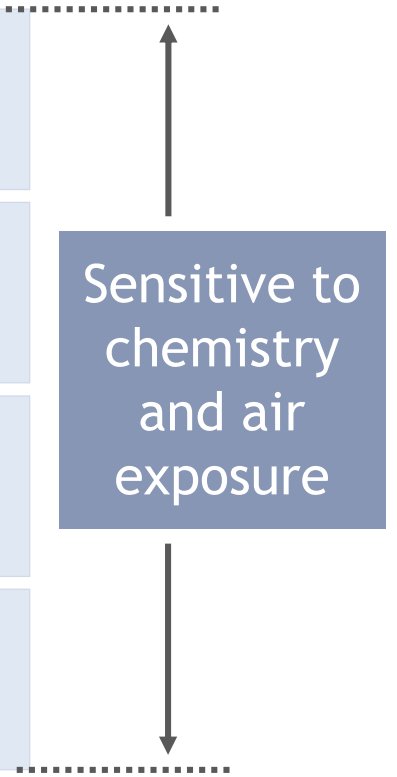


Etched profile control precision:
Angstroms

Etch depth capability:
Microns

New Class of Materials and New Manufacturing Challenges

MRAM	▪ Electrode: Ru, Ta, TiN ▪ Magnetic: CoFe, NiFe, CoFeB, PtMn, IrMn, Ru ▪ Dielectric: Al_2O_3, MgO, NiO
RRAM/CBRAM	▪ Electrode: W/Ag/Cu/Co/Mo/TaSN ▪ Electrolyte: (Ag-Ge-S/Cu-Ge-S) ▪ Dielectric: Perovskite ($CaTiO_3$), $PrCAMnO_3$, transition metal Ox
FeRAM	▪ Electrode: Pt/Ir ▪ Dielectric: PZT (PbZr1-xTixO3): Y1 ($(SrBiTa)O_3$), doped HfO_2
Phase Change Memory (PCM)	▪ Chalcogenide (Ge_2Sb_2Te, InSbTe)
3D NAND	▪ Traditional materials
DRAM	▪ Traditional materials ▪ Dielectric fill: ZrO/AlO/SrTiO



Innovative **Technology**

Trusted **Productivity**

Fast **Solutions**

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