ECSE 425 Lecture 3: Trends in IC Cost

H&P, Chapter 1

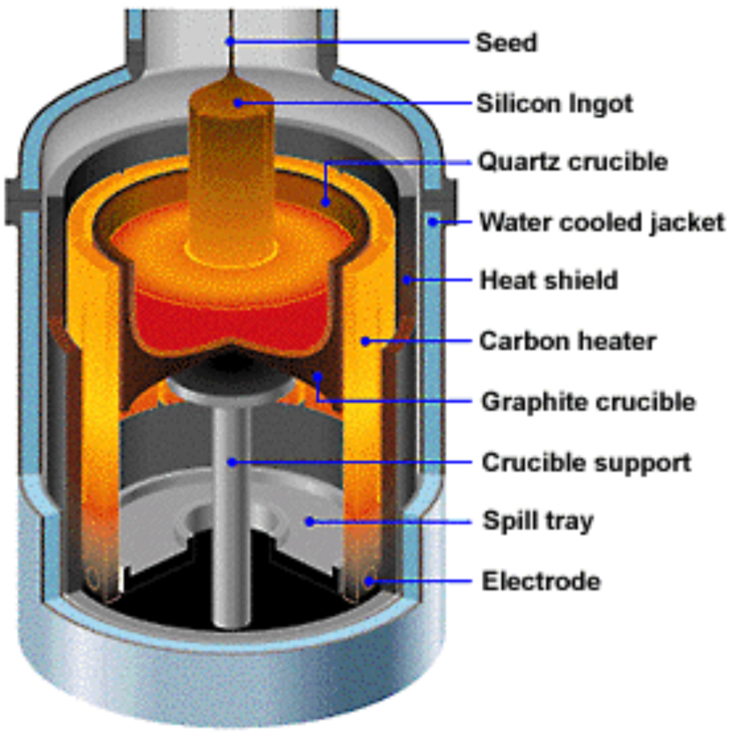
Last Time

- Computer architecture
- Trends so far
  - Performance
  - Bandwidth vs. latency
  - Power

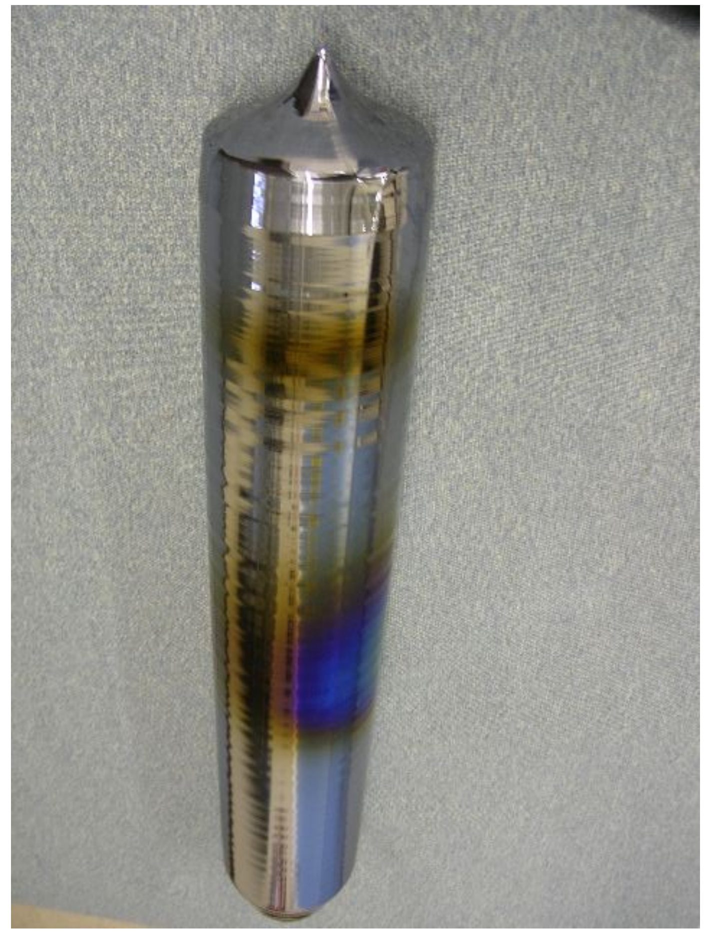
Today

- Integrated Circuit (IC) Cost

Silicon: It All Starts Here

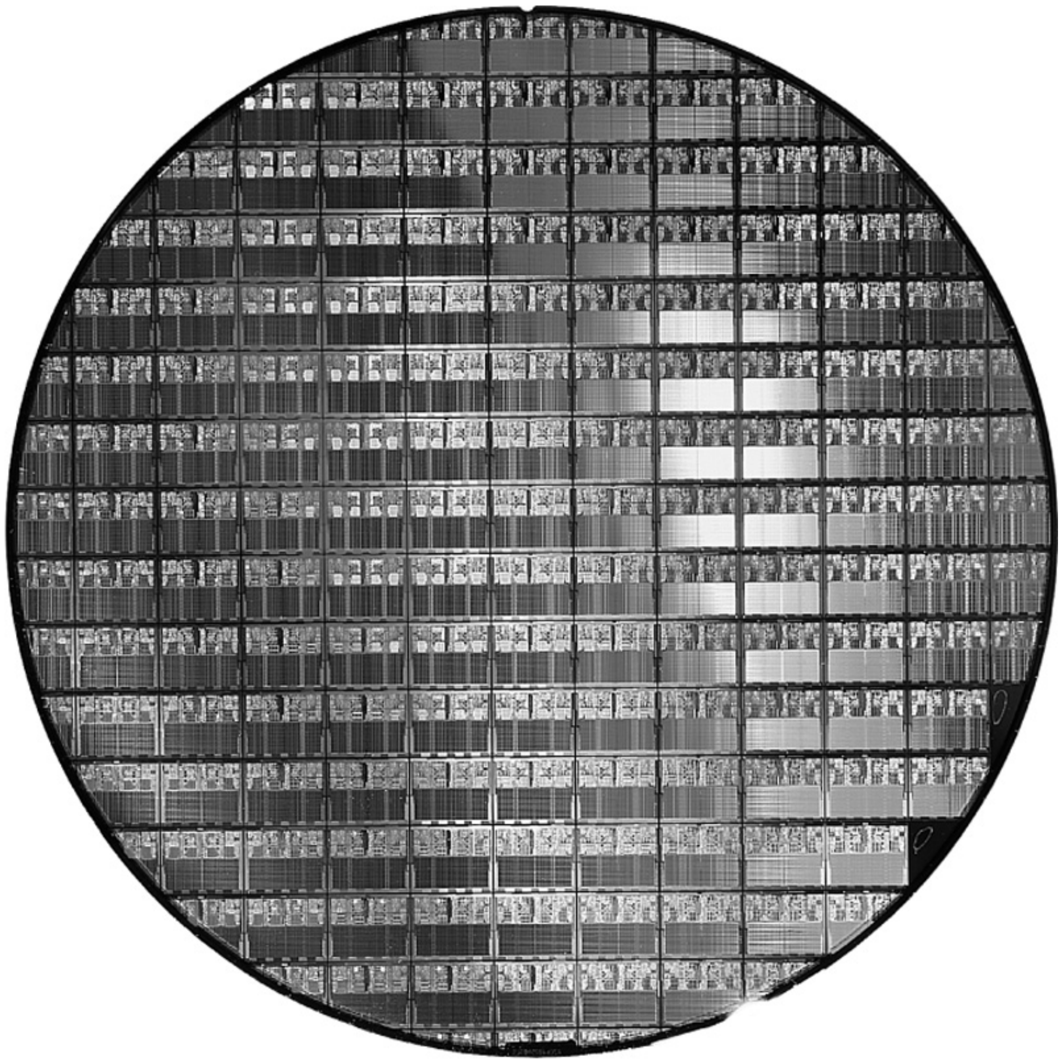


Cz crystal pulling furnace



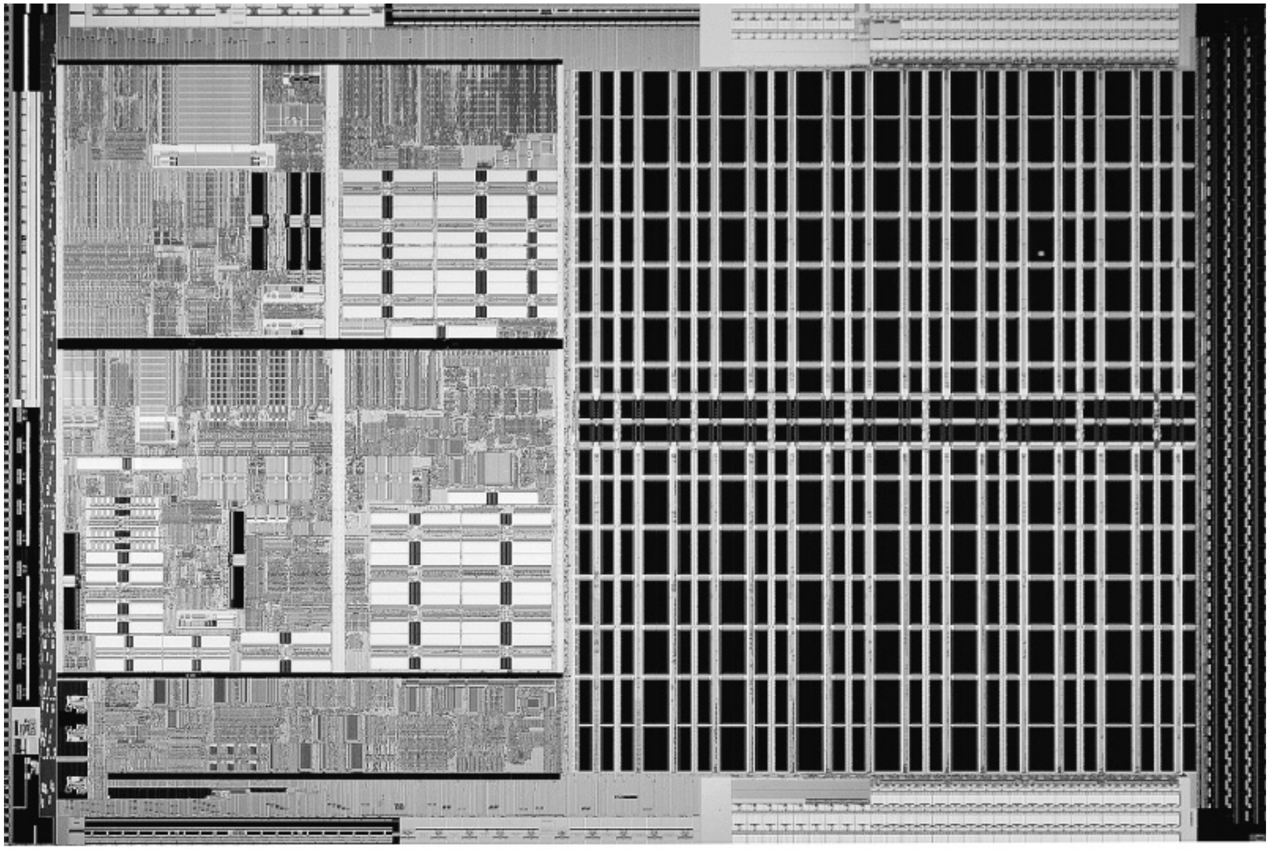
[Credit: Mission Silicon, Inc]

Processed Silicon Wafer



300 mm AMD Opteron WAFER in 90nm process (117 processors)

Single Die



AMD Opteron die

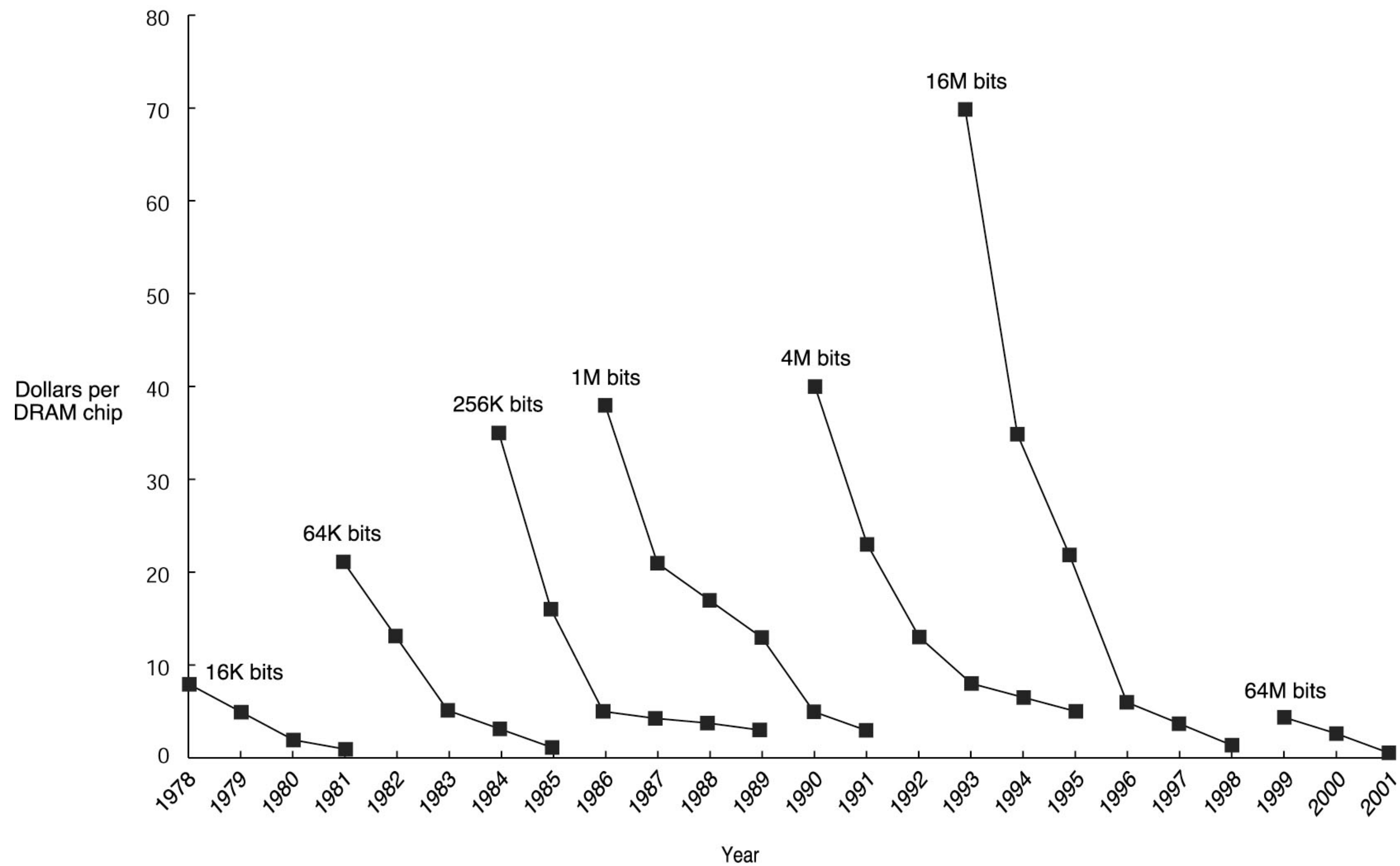
The Cost of IC Manufacturing

- Non-recurring expenses
  - IC mask set
- Recurring expenses
  - Cost of manufacturing, including raw materials
  - Cost of die testing
  - Cost of die packaging
  - Cost of manufacturing losses

Reducing the Cost of Computers

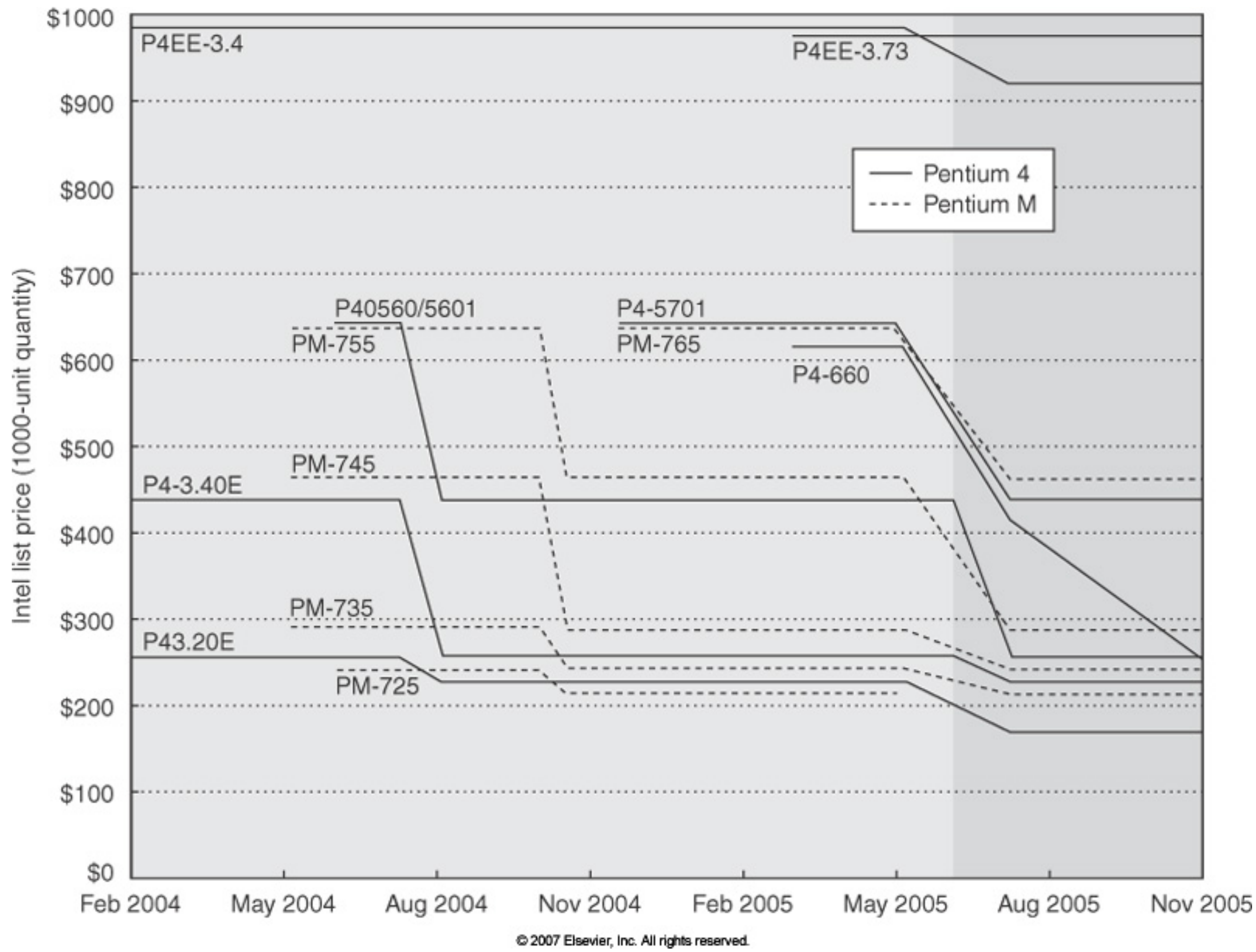
- Time: yield learning
  - Better yield
  - Lower manufacturing cost
- Manufacturing volume
  - As yield improves, increase volume
  - 10% cost decrease for doubling volume
- Commoditization
  - When all processors in a particular market are basically the same, costs are driven down
  - Low end computers (desktop, laptop)

DRAM Cost Trends



Prices of six generations of DRAMs over time since 1977 in dollars

Processor Cost Trends



Price of Pentium 4 and Pentium M at a given frequency decreases over time as yield enhancements decrease the cost of a good die and competition forces price reductions.

Quantifying IC Cost

$$ICCost = \frac{DieCost + DieTestCost + PackagingAndTestCost}{FinalYield}$$

$$DieCost = \frac{WaferCost}{DiesPerWafer \times DieYield}$$

$$DiesPerWafer = \frac{\pi \times WaferRadius^2}{DieArea} - \frac{\pi \times WaferDiameter}{\sqrt{2 \times DieArea}}$$

$$DieYield = WaferYield \times \left(1 + \frac{DefectDensity \times DieArea}{\alpha}\right)^{-\alpha}$$

IC Cost Examples (1)

- Find the number of dies per 300 mm wafer for a die 1.5 cm on a side

IC Yield Examples (2): Case Study 1.1

Chip	Die Size (mm^2)	Defect Density (cm^{-2})	Technology (nm)	Transistors (millions)
Sun Niagara	380	0.75	90	279
AMD Opteron	199	0.75	90	233

- What is the yield for the AMD Opteron?
  - alpha = 4
- What is the yield for the Sun Niagara?
- Why does Niagara have worse yield?