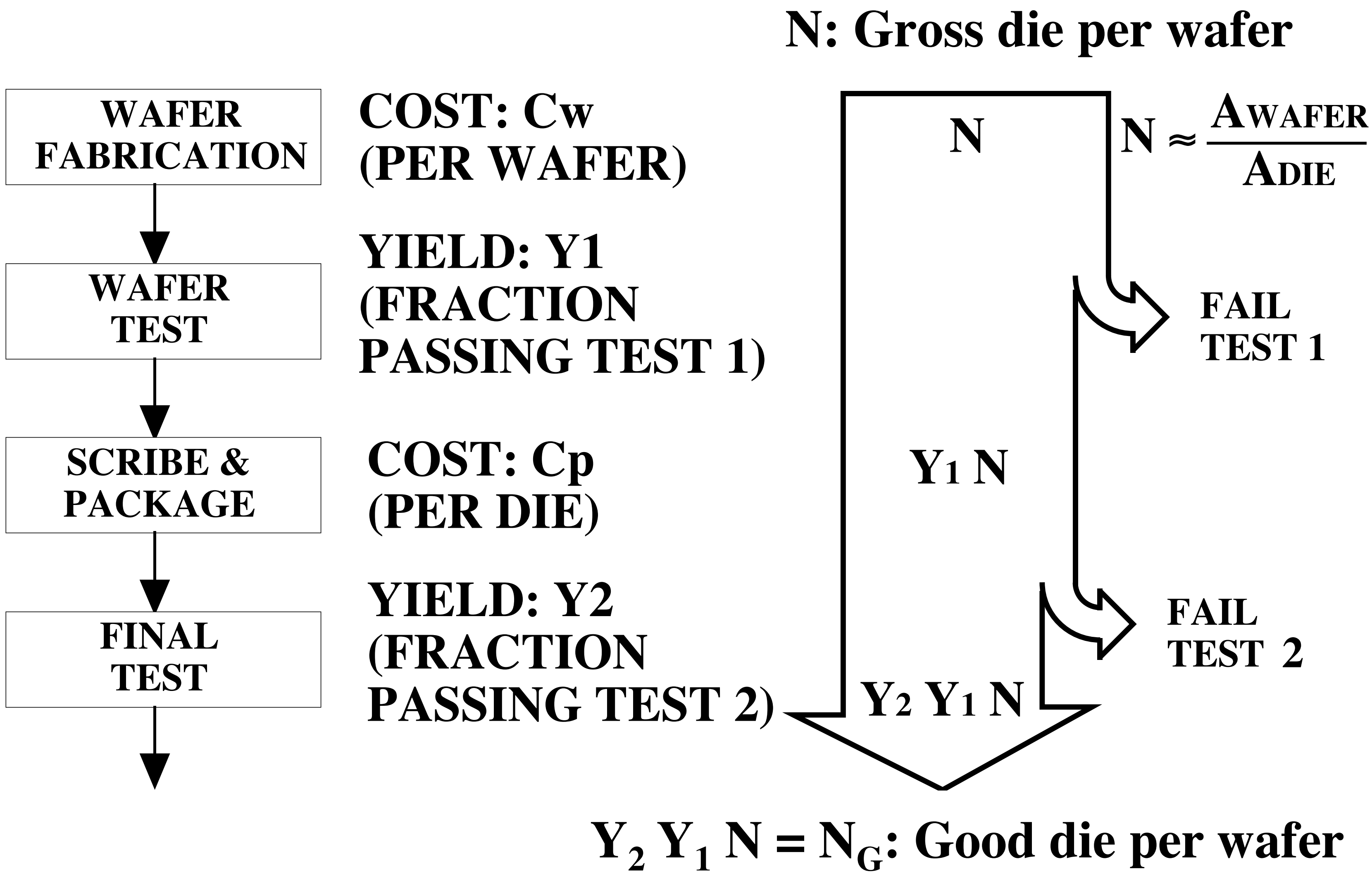
Overview

- IC Fabrication: Silicon Run video
- Process Flow
- Economic Issues

Process Flow



Cost per Die

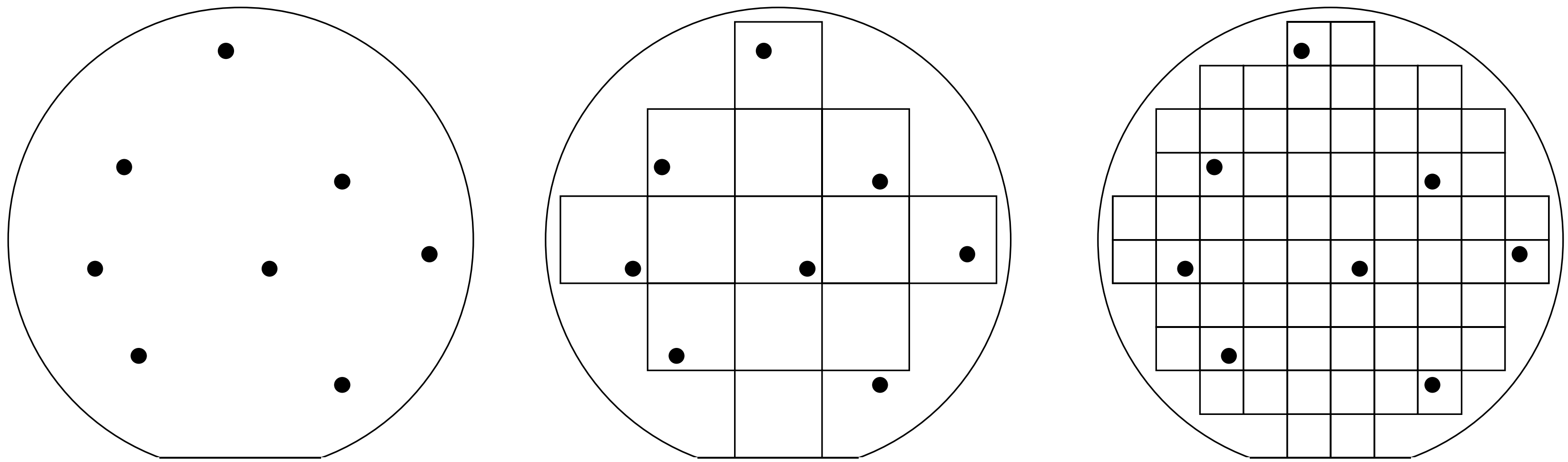
- **Total Cost** $C_W + Y_1 N C_P$
- **Total number of good die** $Y_1 Y_2 N$
- **Cost per good die**

$$\frac{C_W + Y_1 N C_P}{Y_1 Y_2 N} = \underbrace{\frac{C_W}{Y_1 Y_2 N}}_{\substack{WAFER \\ FAB}} + \underbrace{\frac{C_P}{Y_2}}_{PACKAGE}$$

Benefits of Smaller Chip Area

- **More die per wafer (higher N)**
- **Higher Yield**

Smaller Die Size: Higher Yield

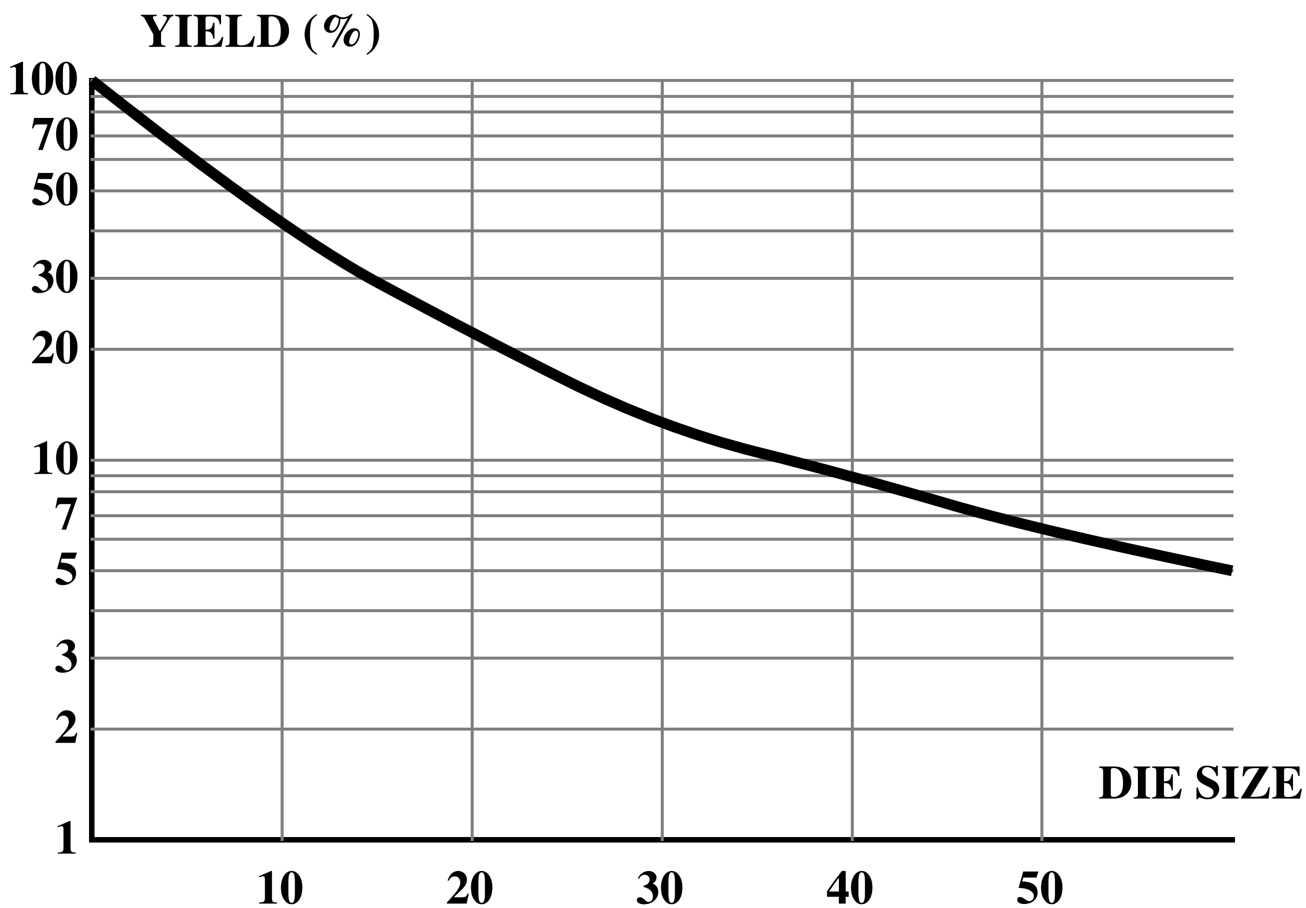


POINT DEFECTS RANDOMLY DISTRIBUTED OVER WAFER

N = 13 die
6 good
Y = 6/13 = 46%

N = 68
60 good
Y = 60/68 = 88%

Example: Yield vs. die size



Example

- **Process:**
  - **20cm diameter wafer**
  - **Wafer cost: C_W = \$4000 per wafer**
  - **Package cost: C_P = \$1.70 per package**
  - **Final test yield: $Y_2 = 0.95$**
- **A_{DIE}=40mm^2**

Die per wafer A_{DIE}=40mm^2

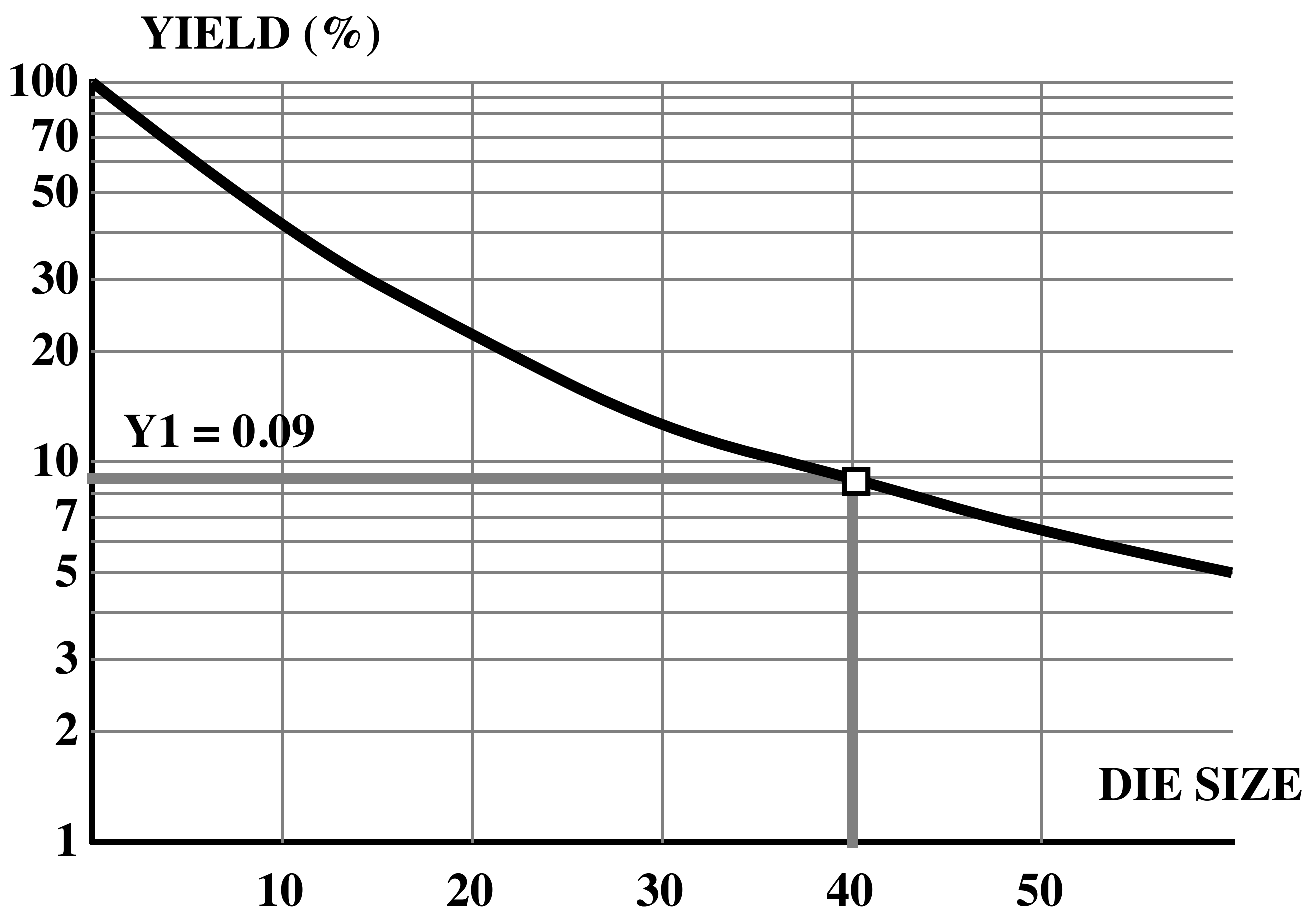
- **Wafer area**
  Wafer diameter = 20cm = 200mm $\Rightarrow$ r=100mm

$$A_{WAFER} = \pi r^2 = \pi(100mm)^2 = 3.14E+04\,mm^2$$

- **Gross die per wafer**

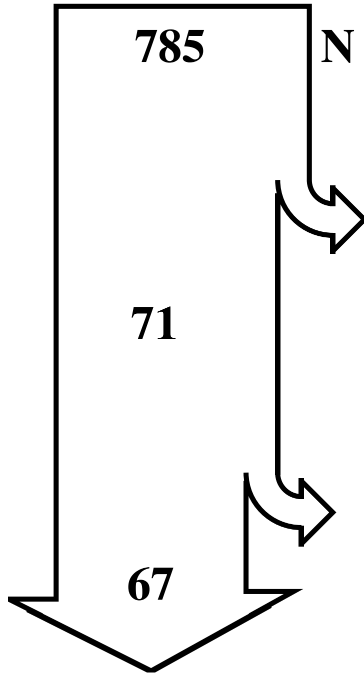
$$N = \frac{A_{WAFER}}{A_{DIE}} = \frac{3.14E+04\,mm^2}{40\,mm^2} = 785$$

Yield A_{DIE}=40mm^2



Process flow A_{DIE}=40mm^2

COST



$N \approx \frac{A_{WAFER}}{A_{DIE}}$

N

Y_1 N = (0.09)(785)

C_W = $ 4 000

Y_1 Y_2 N = (0.95)(71)

Y_1 N C_P= (71)($1.70) = $120.70

Cost per die A_{DIE}=40mm^2

- **Total cost: $ 4 120 . 70**
- **Good die: 67**
- **Cost per good die:** $C = \frac{\$4120.70}{67} = \$61.50$

- **Reduce die area by 4X to 10 mm^2**
  - **Difficult (Big = Easy)**
    - **Example: computer science**
  - **Worth the effort? Cost impact?**

Die per wafer A_{DIE}=10mm²

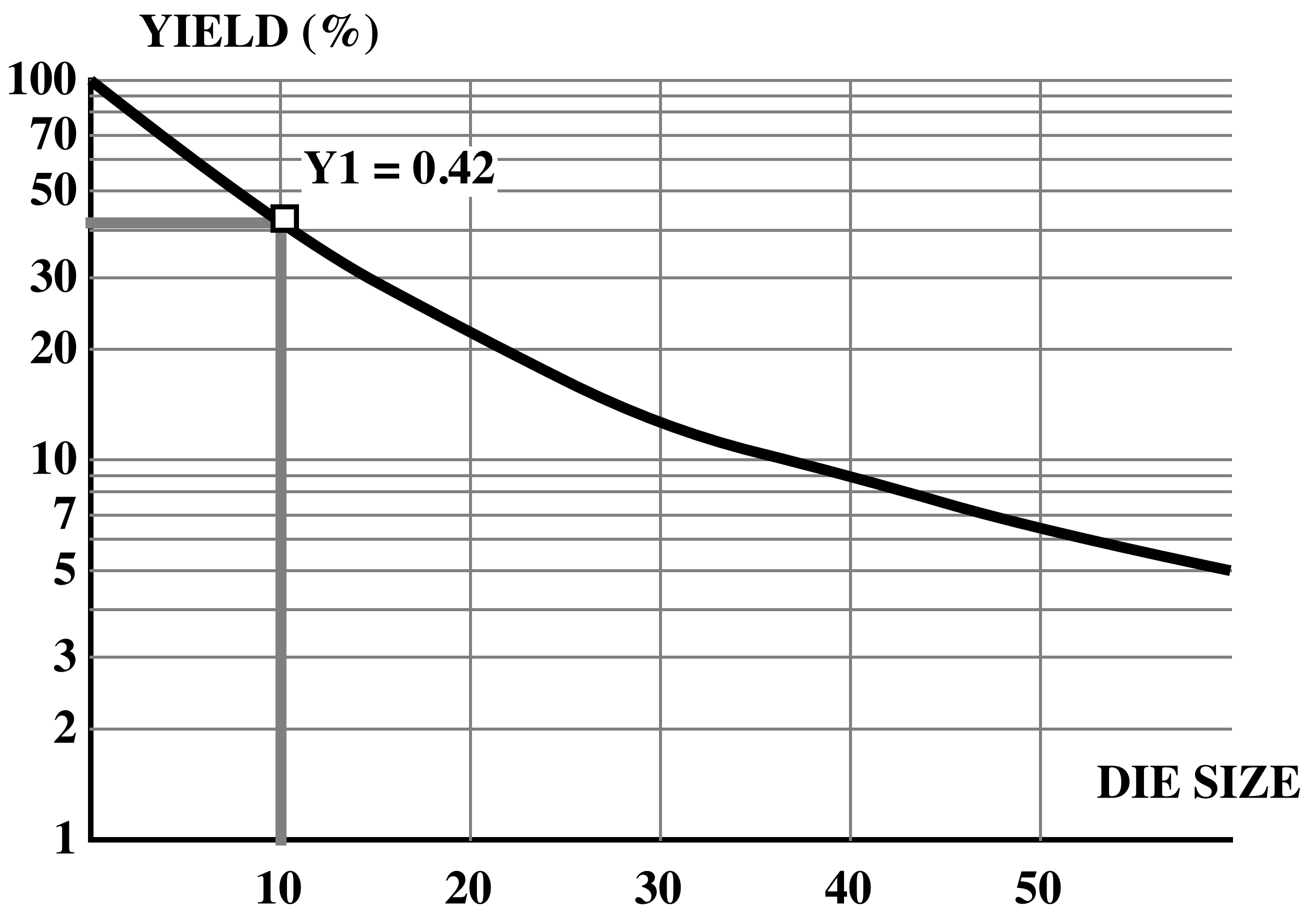
- **Wafer area**
  Wafer diameter = 20cm = 200mm ⇒ r=100mm

$$A_{WAFER} = \pi r^2 = \pi(100mm)^2 = 3.14E+04\,mm^2$$

- **Gross die per wafer**

$$N = \frac{A_{WAFER}}{A_{DIE}} = \frac{3.14E+04\,mm^2}{10\,mm^2} = 3140$$

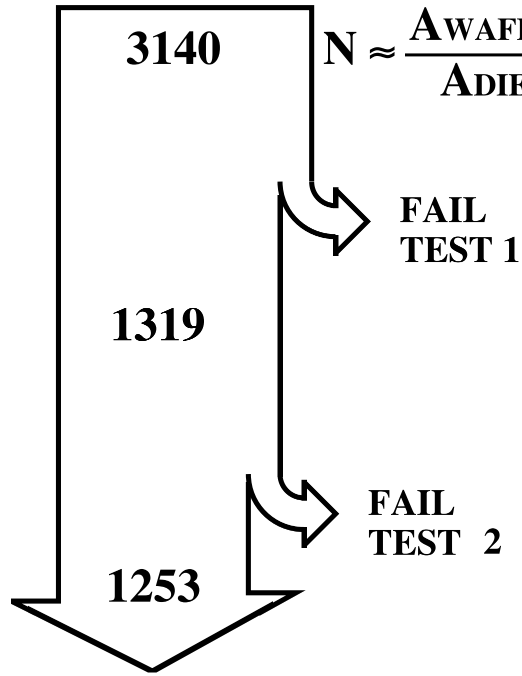
Yield A_{DIE}=10mm^2



- **Compare to yield Y_1=0.09 for A_{DIE} = 40mm^2**

Process flow A_{DIE}=10mm^2

N



$$N \approx \frac{A_{WAFER}}{A_{DIE}}$$

Y_1 N =
(0.42)(3140)

Y_1 Y_2 N =
(0.95)(1319)

COST

C_W = $ 4 000

Y_1 N C_P=
(1319)($1.70) =
$2 242.30

Cost per die A_{DIE}=10mm^2

- **Total cost: $ 6 242 . 30**
- **Good die: 1253**
- **Cost per good die:** $$C = \frac{\$6242.30}{1253} = \$4.98$$

- **Compare to C = $61.50 for A_{DIE}=40mm^2**
- **Reducing die area by 4X reduces cost by better than 10X**

Definitely worth the effort!

Summary

- IC Fabrication Process
- Process Flow
- Costs:
  - Wafer cost (fixed per wafer)
  - Package cost (per die)
- Key: minimize die area
- Implication for circuit design: Area of devices more important than number of devices