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CHE323/CHE384
Chemical Processes for Micro- and Nanofabrication
www.lithoguru.com/scientist/CHE323

Lecture 32

Semiconductor Manufacturing: Yield and Defects

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Yield

- Alas, not every chip we make actually works
 - Yield = the fraction of die started that can be sold

$$\text{Wafer Yield } (Y_w) = \frac{\text{wafer starts} - \text{wafers scraped}}{\text{wafer starts}}$$

$$\text{Die Yield } (Y_d) = \frac{\# \text{ good die per wafer}}{\# \text{ die per wafer}}$$

- Also, assembly yield, burn-in yield

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Yield Loss

- Two basic sources of yield loss: defects and parametric
- Parametric yield loss
 - Errors in film thickness, feature size, doping concentration, etch depth, etc.
 - A major source of yield loss for state-of-the-art processes
- Defects
 - More random in nature
 - Requires yield learning: new processes have high defects but are quickly improved

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Defects

- Defects: particles, contamination, scratches, crystal defects, chemical impurities, ESD (electrostatic discharge)
- Defects environment
 - Clean rooms, "bunny suits", HEPA filters, eliminate sources
- Particles in process chemicals
 - Purify and filter chemicals
- Handling Errors
 - Automation and static electricity control
- Equipment-induced defects
 - Monitor using defect detection and review, eliminate sources

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Defect Model

- Assuming independent defects,

$$Y = (1 - G)e^{-A_c D_0}$$

G = fraction of die that always fail (edge die)
 A_c = critical area (area of die where a defect matters)
 D_0 = defect density (# killer defects/area)
- In reality, defects often cluster, so yield is somewhat higher than this prediction

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Reducing Defect Yield Loss

- Reduce the critical area: design for manufacturability (DFM)
 - Wire spreading
 - Redundant vias
- Reduce the defect density
 - Requires defect inspection, review, classification, and analysis

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Defect Characterization

- Defects are classified based on size and type
- First, defects must be found
 - Wafer inspection (optical)
- Then, defects must be reviewed and classified
 - Defect review (optical and/or SEM)


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Defect Detection and Review



KLA-Tencor Surfscan SP3
Bare Wafer Inspection



KLA-Tencor 8900
Patterned Wafer Inspection



KLA-Tencor eDR-7100
Defect Review

Issues: sensitivity vs. throughput, false defect rate, missed defect rate

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Defect Types

- Example: contact layer


	CMP MICROCRATTER		PREVIOUS LAYER DEFECT
	CMP MICROSCRATCH		TIN PARTICLE
	MISSING CONTACTS		TIN PARTICLE
	CLOSED CONTACTS		TIN PARTICLE

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Defect Types


- Example: CMP defects




SURFACE PARTICLE




RESIDUAL SLURRY



SURFACE VOID




EMBEDDED PARTICLE



MICROSCRATCH

Five types of CMP defects



<http://micromagazine.fabtech.org/archive/98/02/dennison.html>

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Lecture 32: What have we learned?

- What are the two major types of die yield loss?
- What are the two parameters in our simple yield model?
- What is “DFM”?

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