13th Discussion Forum Life-Cycle Assessment
"Environmental Impacts of Telecommunication System and Services"
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Comment
Yield losses in electronics production are significant to LCA

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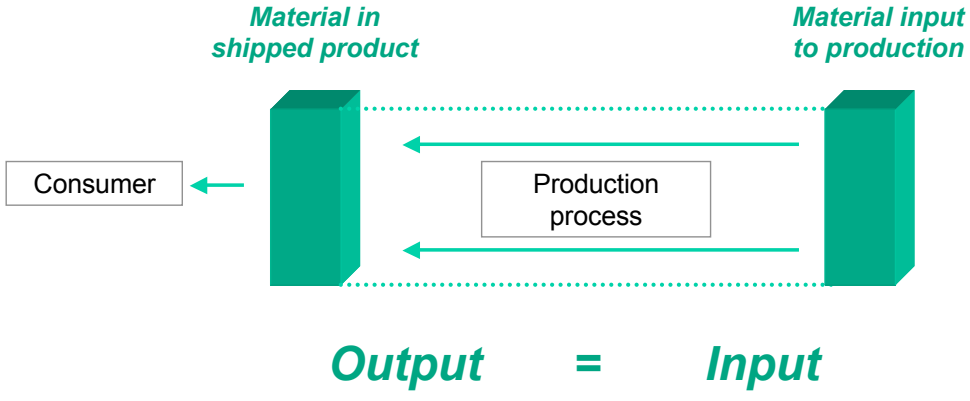
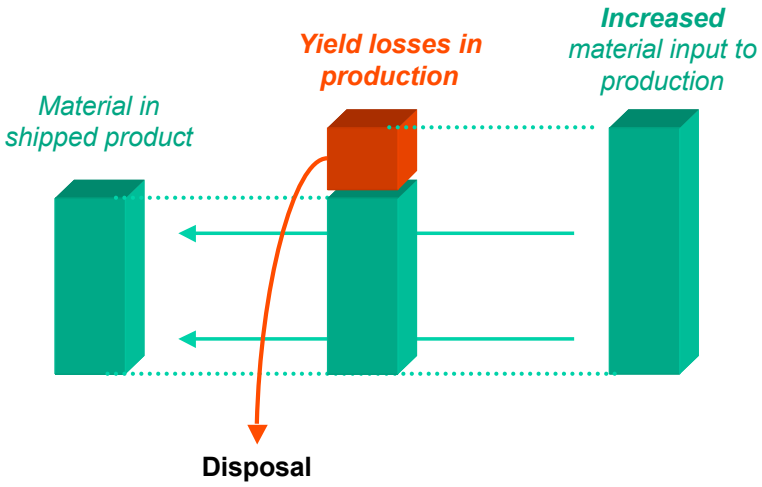
Simplified Inventory procedure

- Material inventory determined by **disasembly of shipped product**
- **This approach is often used in LCA studies of electronic products**
- Assumes a production yield of approximately 100%...

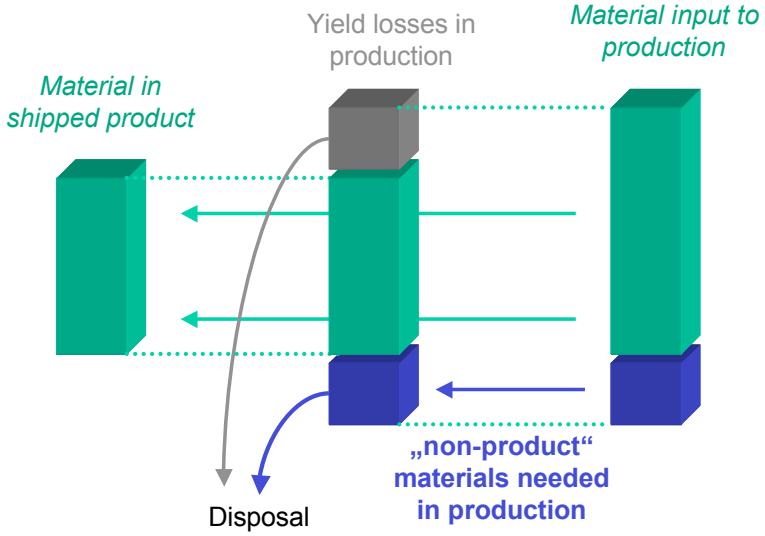


Output = Input

Inventory heeding yield losses...



..and auxiliary materials



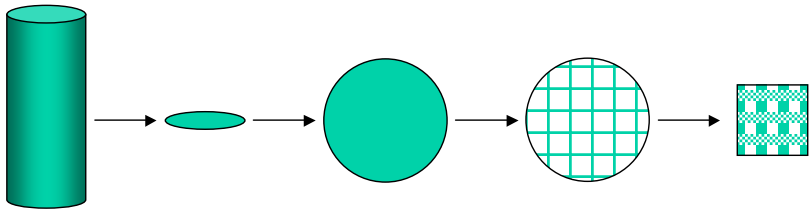
The problem

Yield losses *in production of electronic components are* ***not generally negligible*** *as sometimes assumed, i.e. can be much higher than a few percent.*

Production yield losses can have a considerable effect on life-cycle inventories of electronic products:

- *Increased material and energy demand*
- *Increased waste volumes to disposal*

Example 1: Integrated Circuit (IC) production

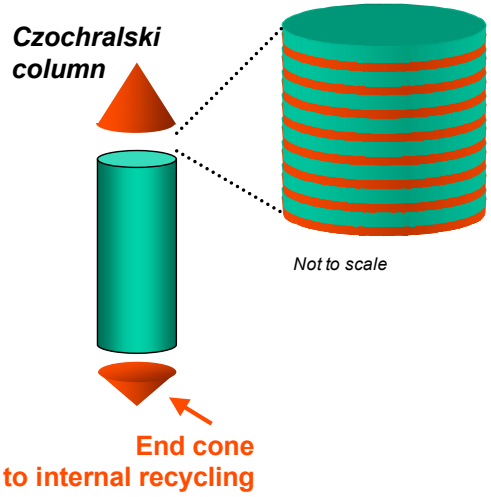


Czochralski column
high-purity mono-crystalline silicon column

Silicon wafer
silicon disk
~ 250 nm thickness

Microchip or Die
Integrated Circuit (IC) var. sizes

Wafer Sawing Losses



Wafer currently ~250 nm

Sawing slit

slit gap currently ~150 nm

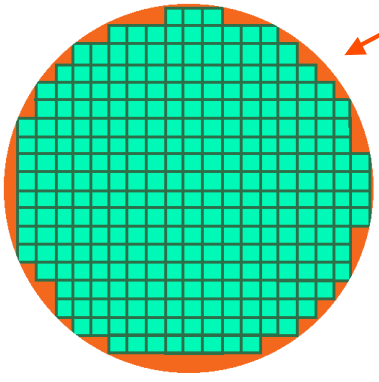
$$Yield = \frac{Material\ in\ wafers}{Material\ in\ column} = 62.5\%$$

Losses of high-purity silicon = approx. 37.5%

in this production step alone

Geometric Losses Wafer/Die

IC layout on wafer



Geometric losses

increase with bigger sized ICs

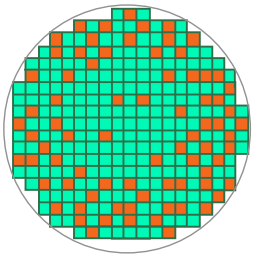
$$Yield = \frac{Material\ in\ IC\ dies}{Material\ in\ wafer} = 85\%$$

Losses of wafer area = approx. 15%

in this production step alone (depending on wafer and die sizes)

Yield losses in quality control

Not all produced ICs are functional due to defects.
Yield losses increase with IC area.
Yield losses decrease with development time and money.

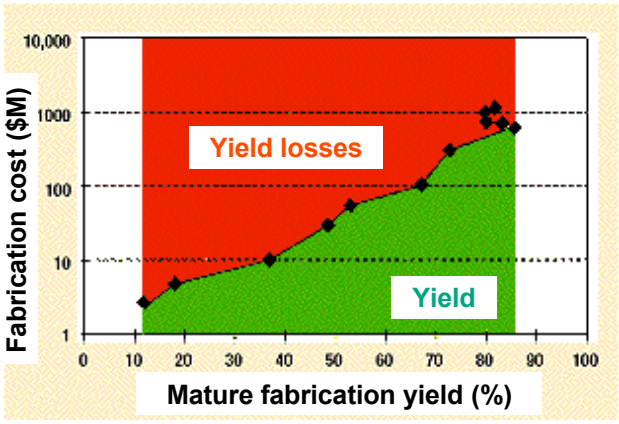


Range of yield losses in IC production:

Introduction	**84%**
Mature	**22%**

Typical figures for Ultra-large systems Integration ULSI chips (eg. 486 or Pentium) from P. van Zant, 'Microchip Fabrication', McGraw-Hill, 1997

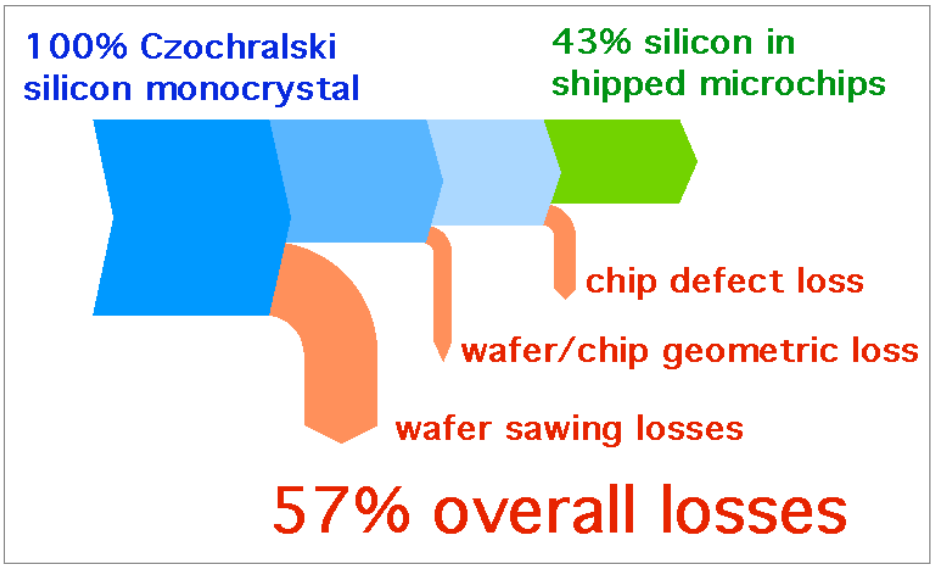
Yield and fabrication cost



Fabrication cost vs. mature fabrication yield of Very Large Systems Integration VLSI microchip production. Yield losses decrease with development time and money. (D. Jensen, C. Gross, D. Mehta, 'New industry document explores defect reduction technology challenges', MICRO Magazine, January 1998).

Overall losses

Best case, i.e. 22% chip defect loss
Excluding other up- or downstream losses



Overall losses IC production

In the **best case** (with 22% chip defect loss) the overall loss is 57%.
This increases material and energy demand by a factor of 2.4

In the **worst case** (with 84% chip defect loss) the overall loss is 92%.
This increases material and energy demand by a factor of 12.

Example 2: LCD displays

Chunghwa Picture Tubes Ltd.,Taiwan, reports a current (1999) production yield of 50%, i.e. **50% of the produced displays are not functional**.

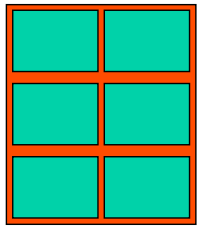
Chunghwa Picture Tubes Ltd.,Taiwan, hopes to achieve a yield of **70% in the future.** Still 30% of all displays would be not functional.

Other manufacturers like Acer Display Technologies (ADT) report similar future goals.

Source: China Economic News Service, Sep 29 1999

Example 2: LCD displays (cont.)

- TFT-LCD displays are produced from **glass panel substrates** of approx. 60 by 72 cm size
- **Six 13.3‘ or 14.1‘ displays** can be produced from one glass panel substrate.
- A **geometric loss of 15% to 23%** of the glass substrate results.



- **Overall loss** from substrate to shipped LCD display is **40% to 62%,** resulting in an **increased material and energy demand by a factor 2.6 to 1.7** (as compared to an ideal 100%-yield production).

Conclusions

- Yield losses in production of electronic components can be **much higher than usually encountered in industrial production**.
- These yield losses can **increase the material and energy demand** and **waste volumes** in production inventories considerably.
- **Infrastructure** of electronic products and components might be **environmentally more relevant** than currently assessed (with a 100%-yield inventory).
- Neglecting yield losses or assuming a near 100%-yield production in product inventories **needs to be verified**.