ASML and EUV Lithography

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Palaiseau, April 28, 2014
ASML Headquarters in Veldhoven, The Netherlands
ASML global presence

San Diego (CA)

Wilton (CT)

Korea

Chandler (AZ)

Veldhoven

Taiwan
ASML global presence

2,522 employees
2,184 employees
5,654 employees

Over 70 sales and service offices located worldwide
Main 12 customers of ASML

Estimations 2013:
- Revenue: $165bn
- CapEx 2013: $45bn
<table>
<thead>
<tr>
<th></th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>Sales</td>
<td>5,245</td>
</tr>
<tr>
<td>Cost of Goods (CoG)</td>
<td>3,068</td>
</tr>
<tr>
<td>Gross profit</td>
<td>2,177</td>
</tr>
<tr>
<td>Gross margin %</td>
<td>41,5</td>
</tr>
<tr>
<td><strong>Research and Development (R&amp;D)</strong></td>
<td><strong>882</strong></td>
</tr>
<tr>
<td>Salary General and Administrative costs (SG&amp;A)</td>
<td>312</td>
</tr>
<tr>
<td>Net income</td>
<td>1,015</td>
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<tr>
<td>Net income as % of net sales</td>
<td>19,4</td>
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Semiconductors
Microelectronic chips are everywhere
The transistor was invented at Bell Labs in 1947
First integrated circuits: IC

1958
The First IC
TI / Fairchild

1961
The First Planar IC
Fairchild

IC: all elements are
• made from the same semiconductor material (e.g. Si),
• in-situ interconnected.
Moore’s law introduction: Reduction of cost per component led to technology revolution

Relative Manufacturing Cost / Component

@ minimum cost

Number of Components per Integrated Circuit
doubles every 18 months

1962 1965 1970

Major trends since 1965

- More powerful chips for same price or lower in price for same chip
- Chips consumed less energy
- Possibility to develop chips for new applications
Technology evolution illustration

1971

Intel® 4004
Speed: 108 kHz
Gate size: 10µm
Transistors: 2,300
Area: 12 mm²
Price: $60 = $346

2013

Intel® Core™ i7
Speed: 3,90 GHz
Gate size: 22nm
Transistors: 1,4bn
Area: 177mm²
Price: 339$
Making chips cheaper…

Lithography cost per $/GB

Source: Gartner. High quality Flash
... and more energy-efficient

Computations per kWh

Year


Source: Jonathan Koomey, Lawrence Berkeley National Laboratory and Stanford University, 2009
Feature size reduction (shrink) history

Year


Components $10^{11}$ per chip

1 25µm 14nm
Lithography
Photolithography principle

Mask

Lens

Wafer
Chip City
Defining resolution limit

Resolution = \( k_1 \frac{\lambda}{NA} \)

\( \downarrow \)
Resolution = \( k_1 \frac{\lambda}{NA} \)

\[
3 \mu m = \frac{436nm}{0.3NA} = 14 nm
\]

\[
193nm = \frac{193nm}{1.35NA} = 14 nm
\]

1978 \quad \text{year} \quad 2014
ASML Technology
State-of-the-art
ASML system: Resolution, Overlay, Throughput

\[ \lambda = 193\text{nm} \]

Resolution: < 20nm (DP)
Overlay: < 2nm
Throughput: 250 wafers per hour
The future of lithography: Extreme Ultra Violet (EUV)

\[ \lambda = 13.5 \text{nm} \]
EUV Source Principle

Pre-pulse

Main Pulse

tin droplet ~40kHz repetition rate

10µm, >20kW CO₂ Drive Laser

250W EUV (13.5nm)

Conversion Efficiency (CE): EUV Pulse Power / Drive Laser Pulse Power

Current CE Levels: ~ 3%
EUV Source Principle

Laser-Produced Plasma (LPP) source

CO2 drive laser

Tin droplets

plasma

Collector
ASML can be interested in output of ICAN project

Two areas of interest in EUV source applications

1. Pre-pulse fs laser

2. Other
Open Innovation makes complexity and cost manageable

Academia

Technology partners

Suppliers

Customers

Public