Optical interconnection and technologies

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## SIA ROAD MAP

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>0.18(\mu)</td>
<td>0.13(\mu)</td>
<td>0.1(\mu)</td>
<td>0.07(\mu)</td>
</tr>
<tr>
<td>Speed</td>
<td>1200MHz</td>
<td>1600MHz</td>
<td>2000MHz</td>
<td>2500MHz</td>
</tr>
<tr>
<td>Number of pins</td>
<td>700</td>
<td>900</td>
<td>1300</td>
<td>1800</td>
</tr>
<tr>
<td>Transistors</td>
<td>6 millions/cm²</td>
<td>18 millions/cm²</td>
<td>36 millions/cm²</td>
<td>84 millions/cm²</td>
</tr>
</tbody>
</table>
ELECTRONS and PHOTONS

- Losses
- Data rate
- Distance
- Electrical link
- Optical link
- Laser threshold

Laser threshold

Electrical link

Optical link

Data rate Distance
Electrons and photons

Data rate

1 Tbits/s
100 Gbits/s
10 Gbits/s
1 Gbits/s
100 Mbits/s
10 Mbits/s

distance

1 µm
10 µm
100 µm
1 mm
1 cm
1 m
10 m
100 m
1 km
10 km
100 km
1000 km

ELECTRONS

PHOTONS

VCSELs

INTERCHIP
MCM- Pistes - Flip Chip

Laser diodes InP
1.3 - 1.55 µm
+ Fiber optics
TELECOM

LETI

28th SPEEDUP 10/6/2000
DATA COMMUNICATIONS

[Graph showing fiber capacity growth with years and Moore's Law]

- 1 Million phone calls
- 10 Million phone calls
- 565 Mbit/s
- 140 Mbit/s
- 2.5 Gbit/s
- 10 Gbit/s
- Internet Growth

Moore's Law
WDM
TDM
N x 2.5 Gbit/s
OPTICAL INTERCONNECT

- Inter computer and inter board
  - Optical link
  - $L<1\text{km}$
  - Low cost
- Interchip
  - Optical mother board
- Intrachip
  - Front end
  - Back end
**OPTICAL LINKS**

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**Spécifications**

**High data rate board interconnect**

- Maximum 200 m
- Parallel (10 fibres)
  - 8 channels
  - 2 clocks

Data rate:
- 2.5 Gbit/s per fibre
- to 10 Gbit/s
- Low cost
Optical mother board

Laser

chips

Detector

Electrical connection

Optical mother board
SOI or glass

Wave guide
On SOI: front-end level, Si waveguide
On Silicon, back-end level

- Intrachip interconnects
- SiN waveguide
- Detectors

SiN waveguide

techno levels
Technologies and components

- New laser sources
  - VCSEL’s
  - Micro disk lasers
- New detectors
  - SiGe; SiGeC
- Integrated optics
  - Photonic bandgap materials
  - Splitters
  - WDM
VCSEL’s

Quantum wells

Mirrors

h=8µm

N Contact
VCSEL’s
Interconnect scheme

detector

coupler

Laser
Photonic micro structures

- 1D PBM
  - holes 100nm
  - period: 300nm

- Ring filter
  - Diameter: 4 µm
  - Lines: 280nm

- PBM 2D
  - Φ 480nm
  - Pitch: 100nm
Integrated optics on silicon

"Phasar" WDM
1 x 8 SPLITTER
CONCLUSION

- Optical links between computers are a reality
- Intra chip optical interconnections are for tomorrow
- Today’s microelectronics challenge is to shift from aluminium to copper
- Next challenge is to shift from copper to photons