



photronics  
research  
group

<http://photronics.intec.UGent.be>

# Verticaal gekoppelde microringresonatoren gefabriceerd met waferbonding

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Ilse Christiaens





# Overzicht



- Inleiding
- Breedbandverbindingen
- Optische netwerken
- Optische chips
- Ringresonatoren
- Metingen
- Conclusies



# Breedbandverbindingen

- **ADSL:**

- Telefoonlijn
- Normaal 512 kb/s
- Maximum 6 Mb/s



- **Telenet:**

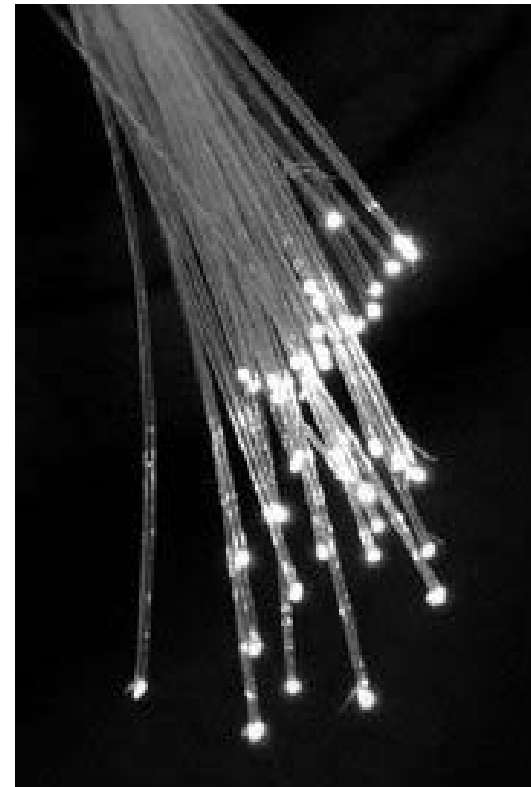
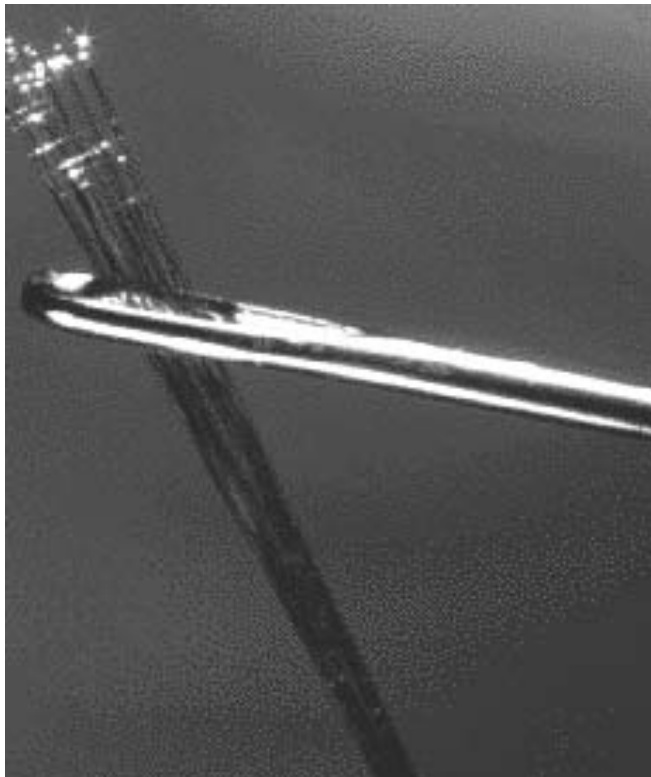
- Coaxiaal
- 5 Mb/s
- tot 10 Mbit/s





# Optische vezel

- **Optische vezel**
  - honderden Gbit/s of meer
  - 10 DVD's per seconde



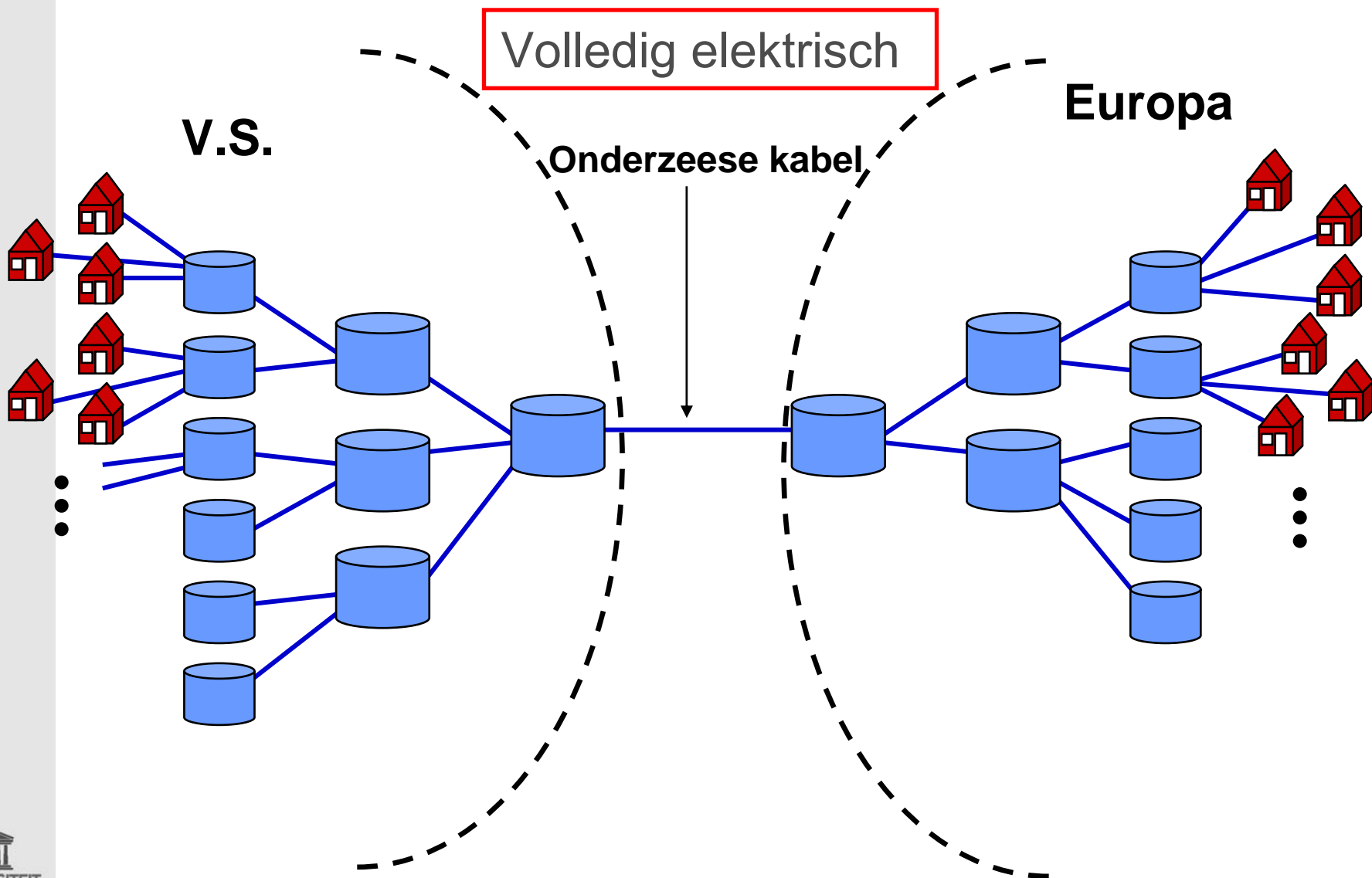


# Overzicht



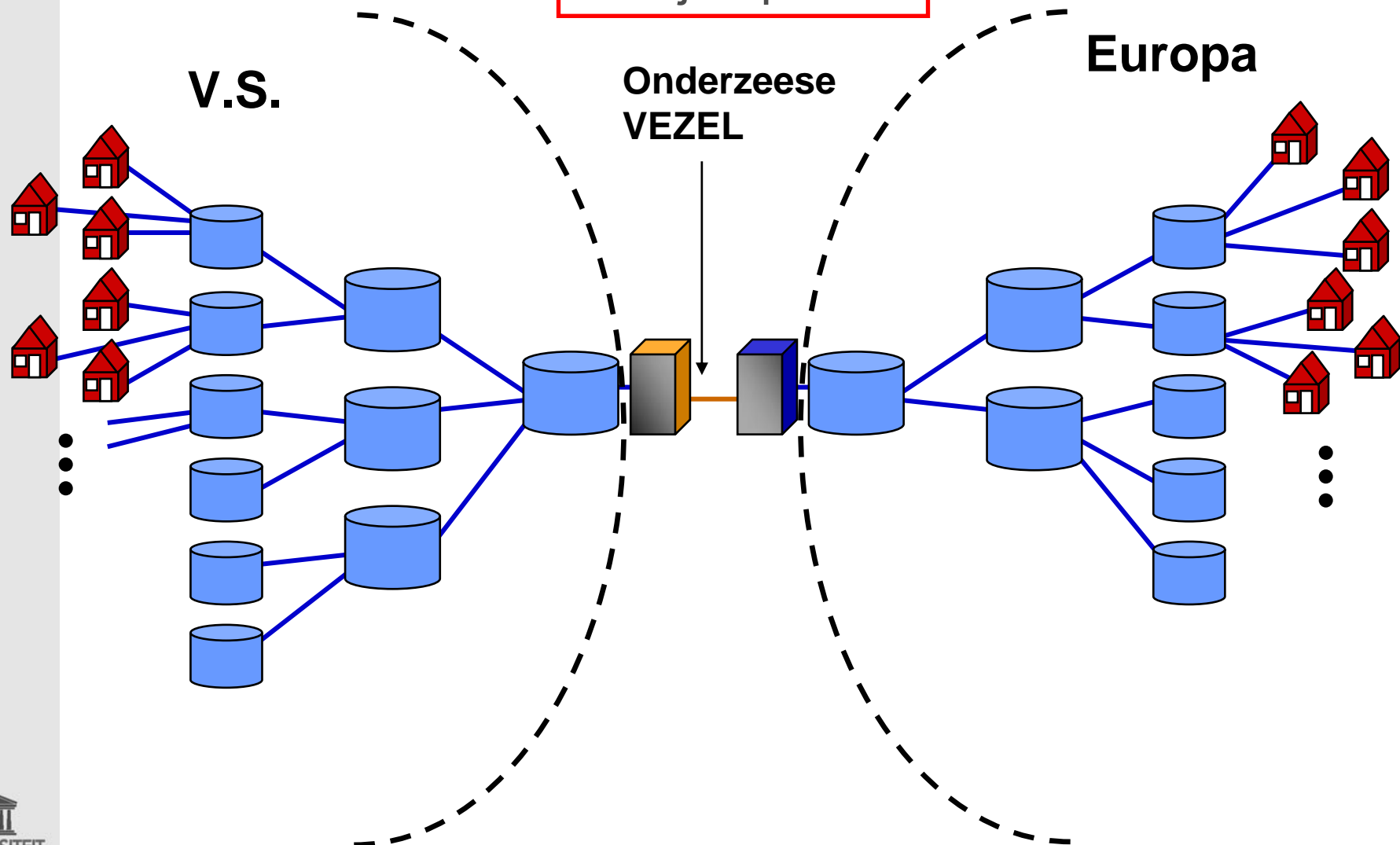
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  - Optische chips
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# Netwerken: vroeger

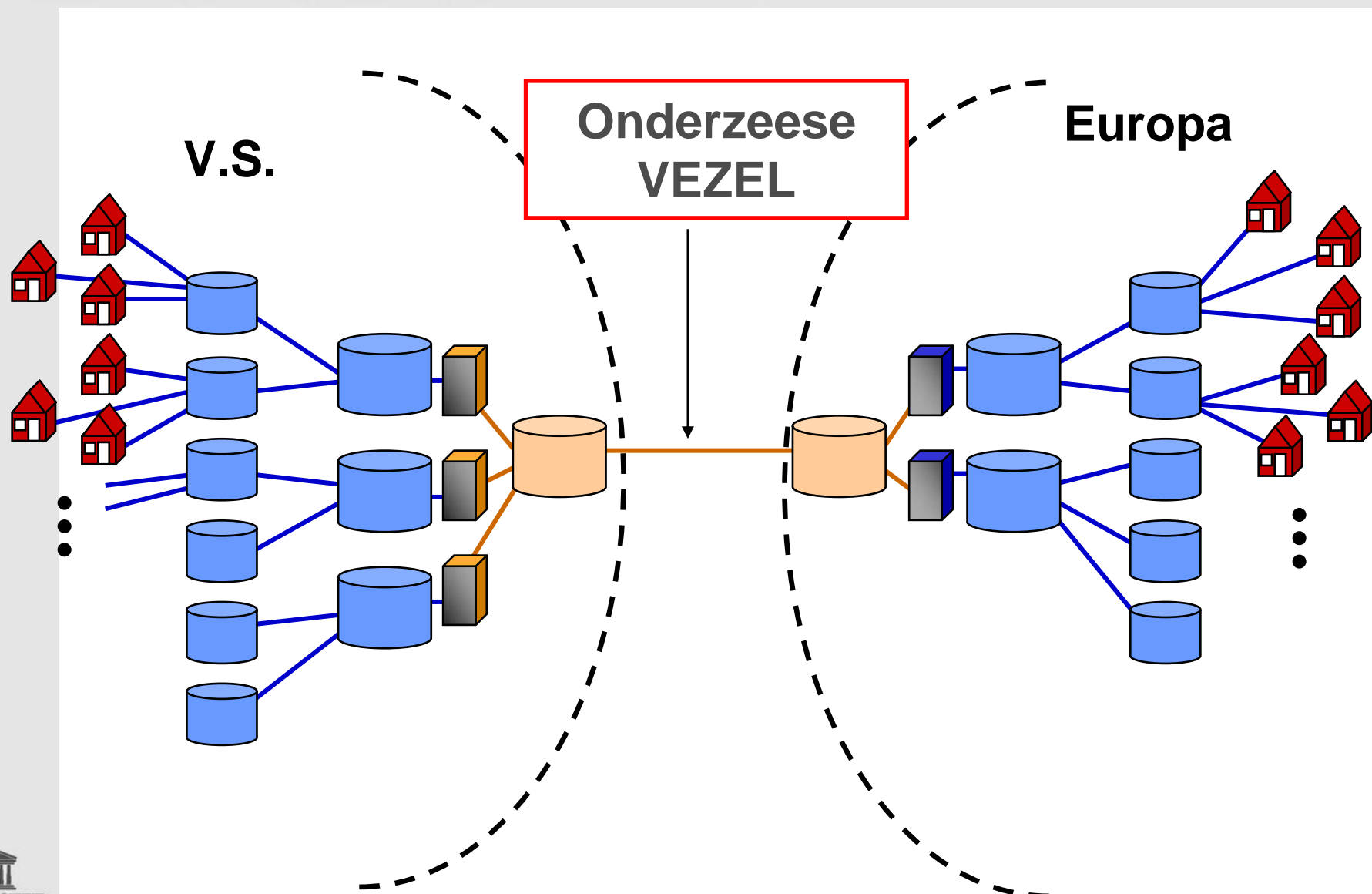


# Netwerken

Beetje optisch

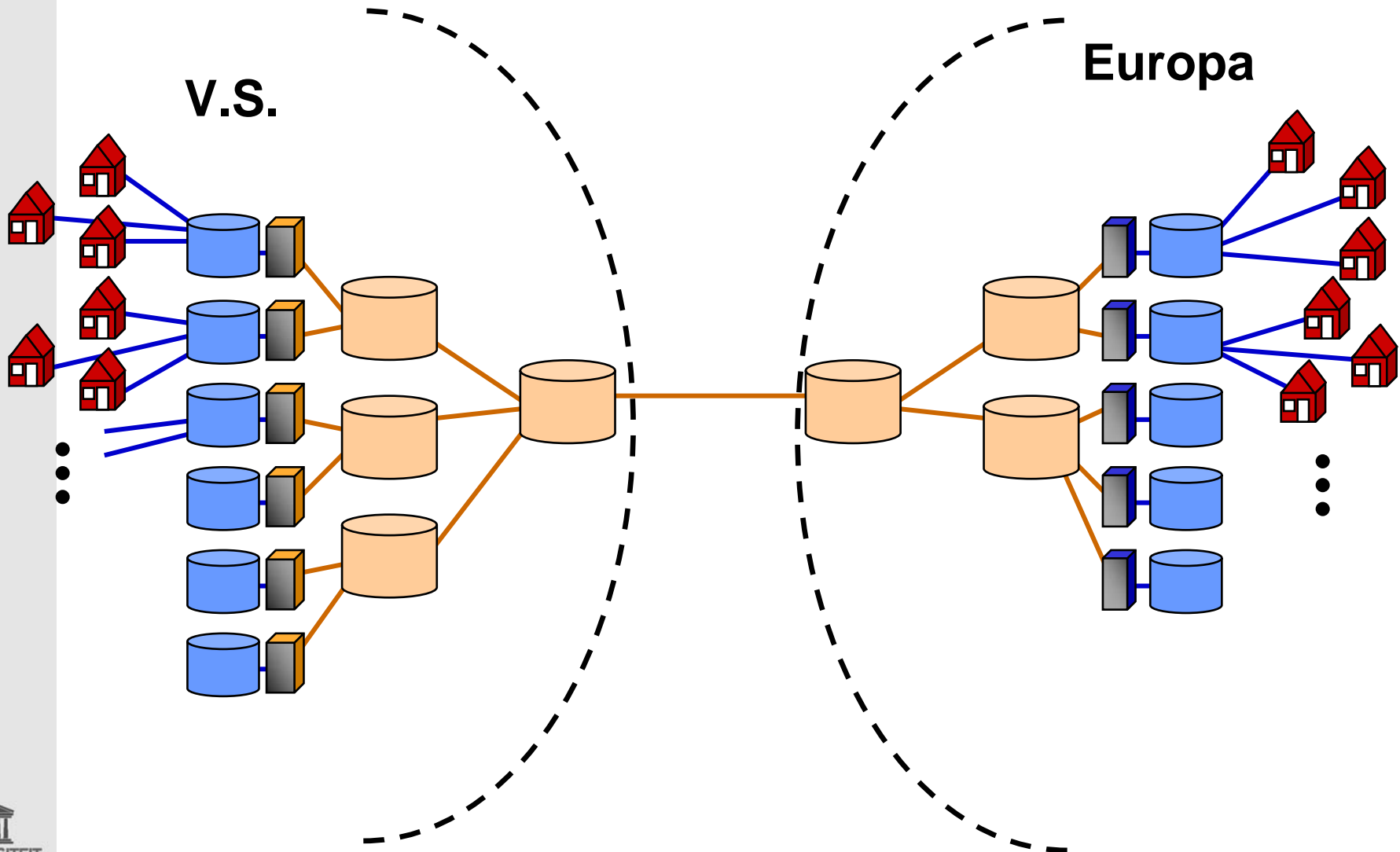


# Netwerken

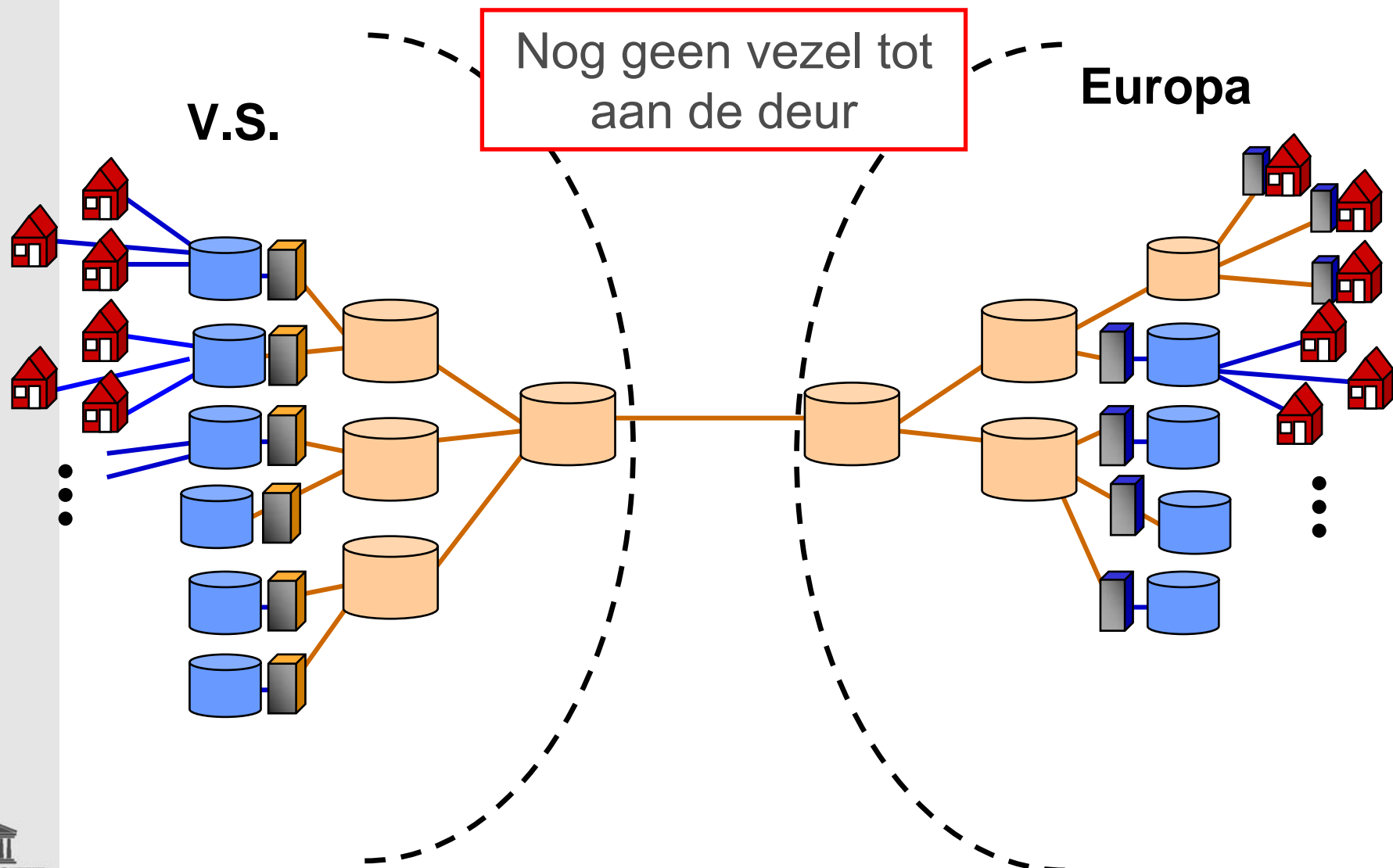




# Netwerken

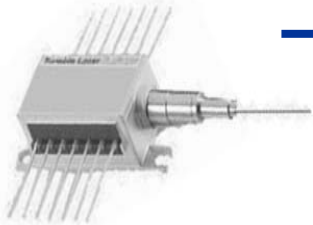


# Netwerken: vandaag



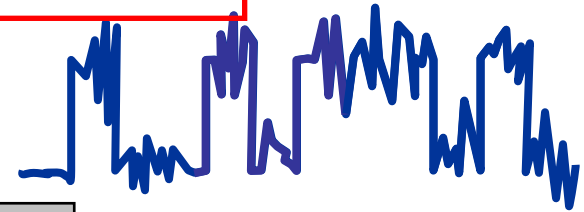
# Onderdelen van een optisch netwerk?

Laserdiode



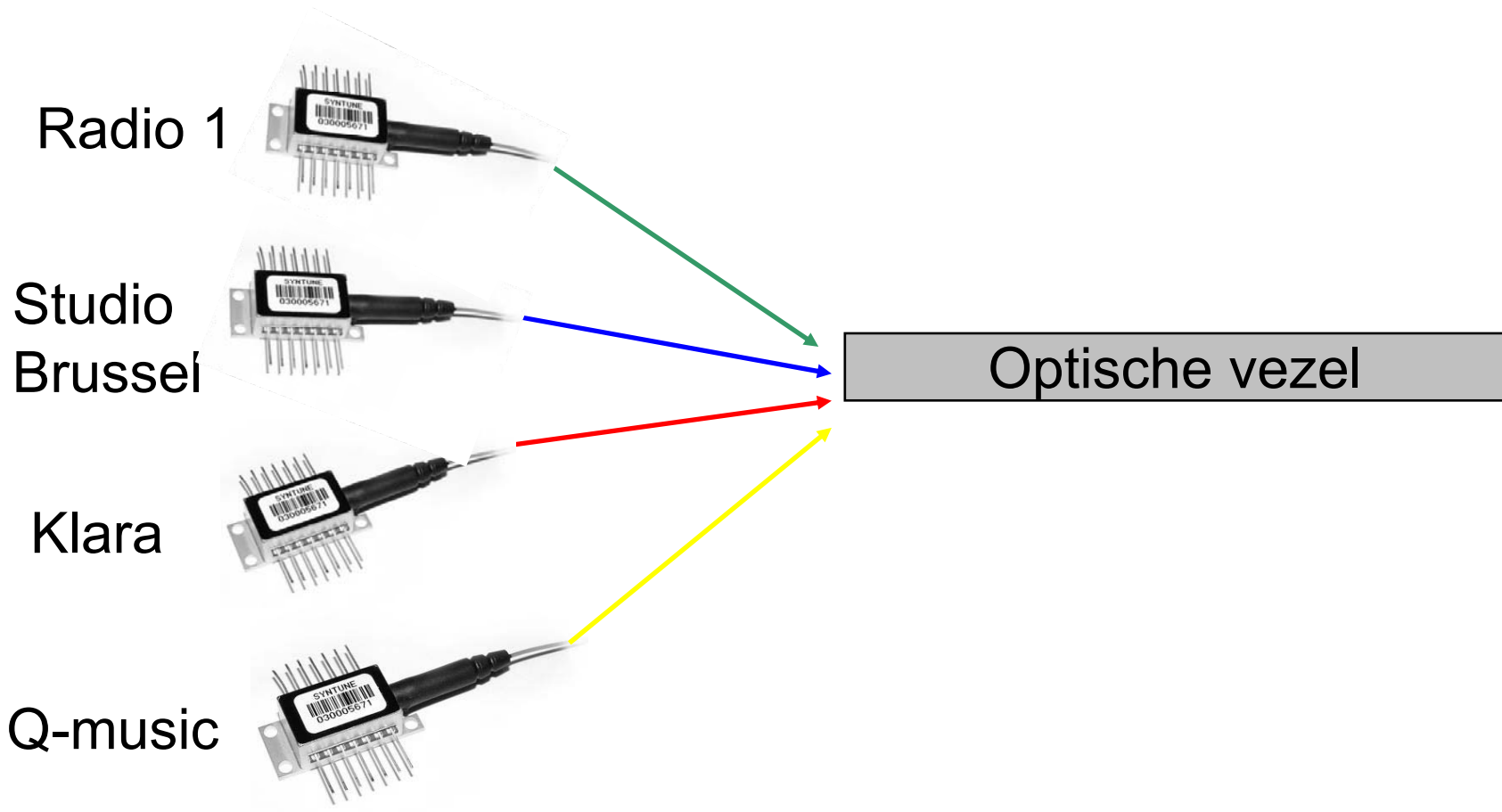
Optische vezel

Versterken  
Regenereren



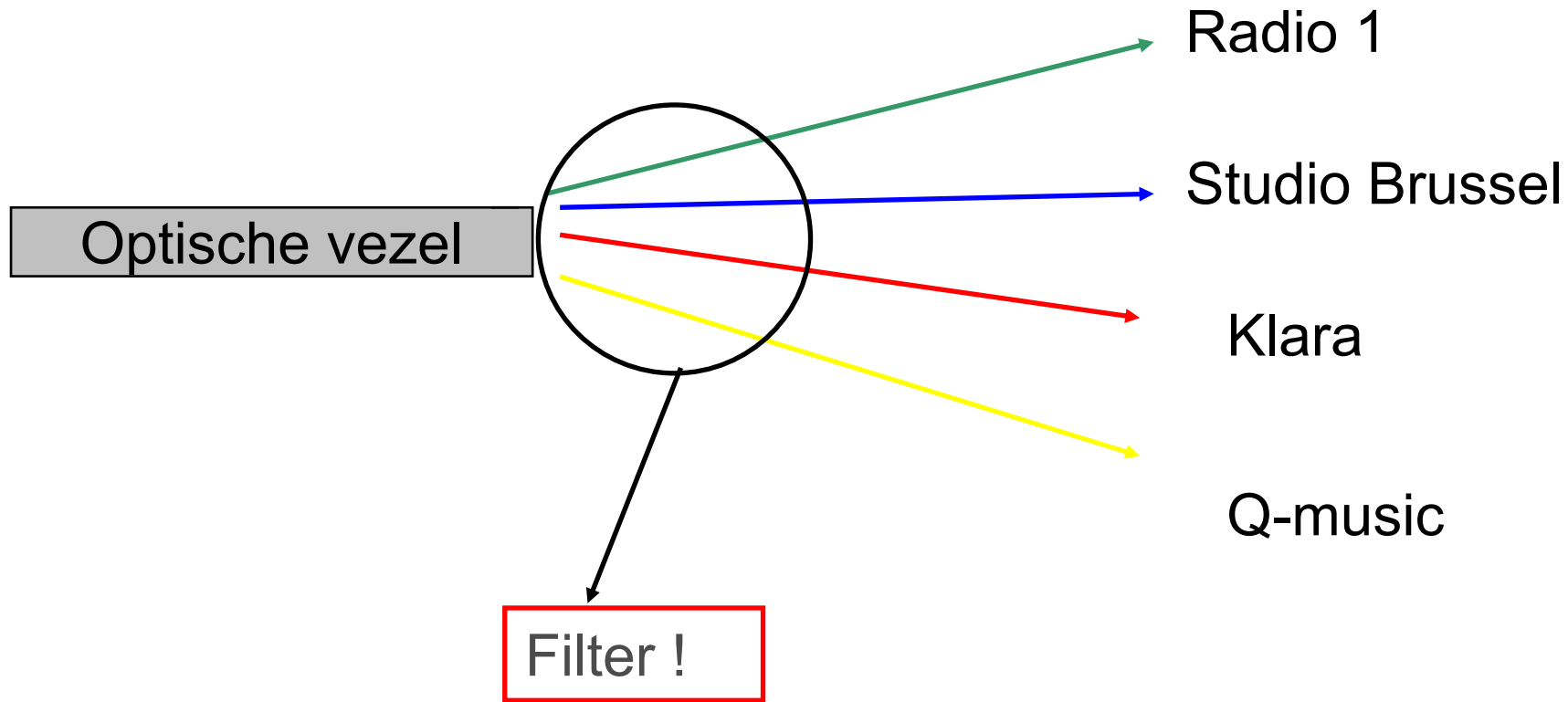
# Onderdelen van een optisch netwerk?

## WDM: wavelength division multiplexing

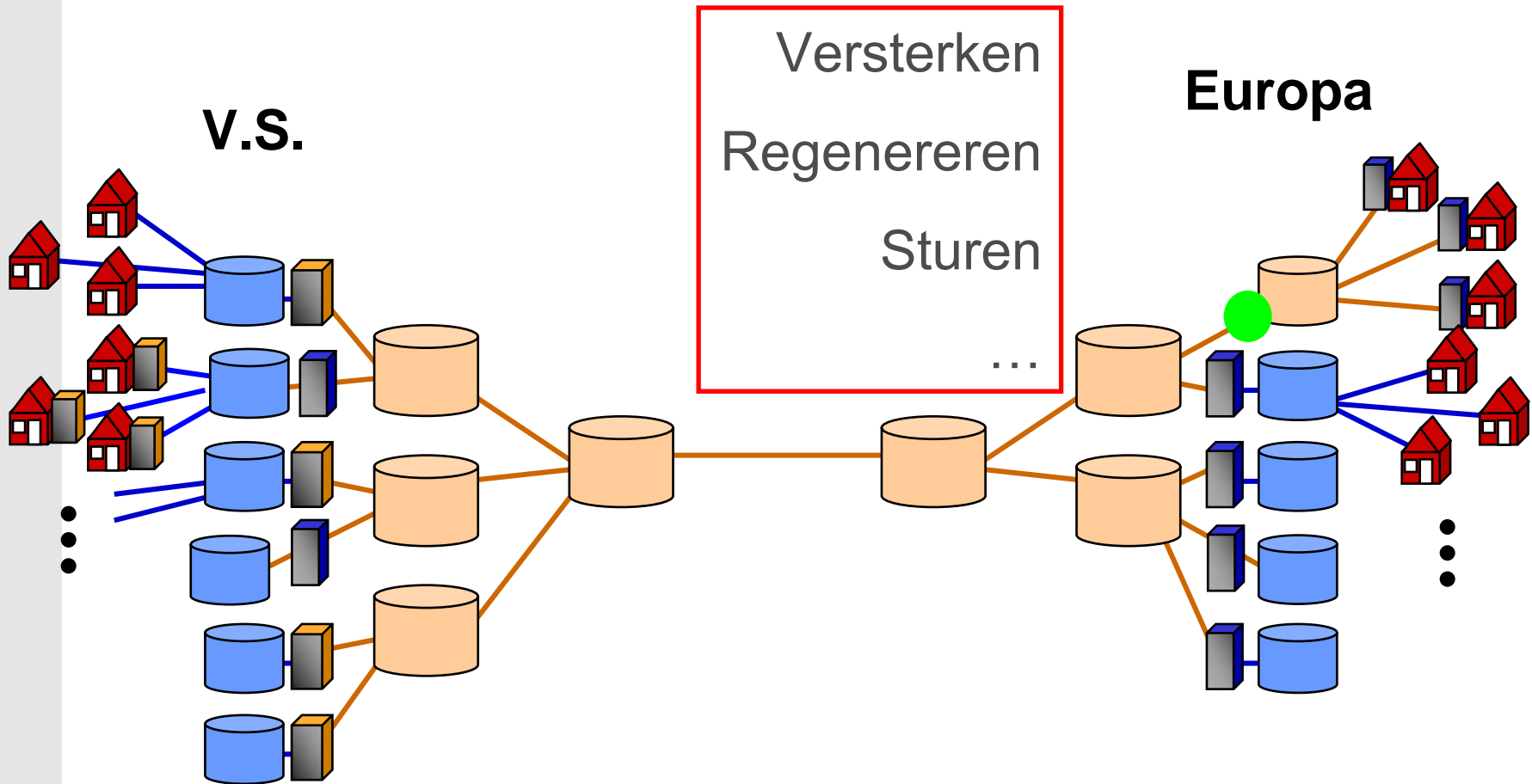


# Onderdelen van een optisch netwerk?

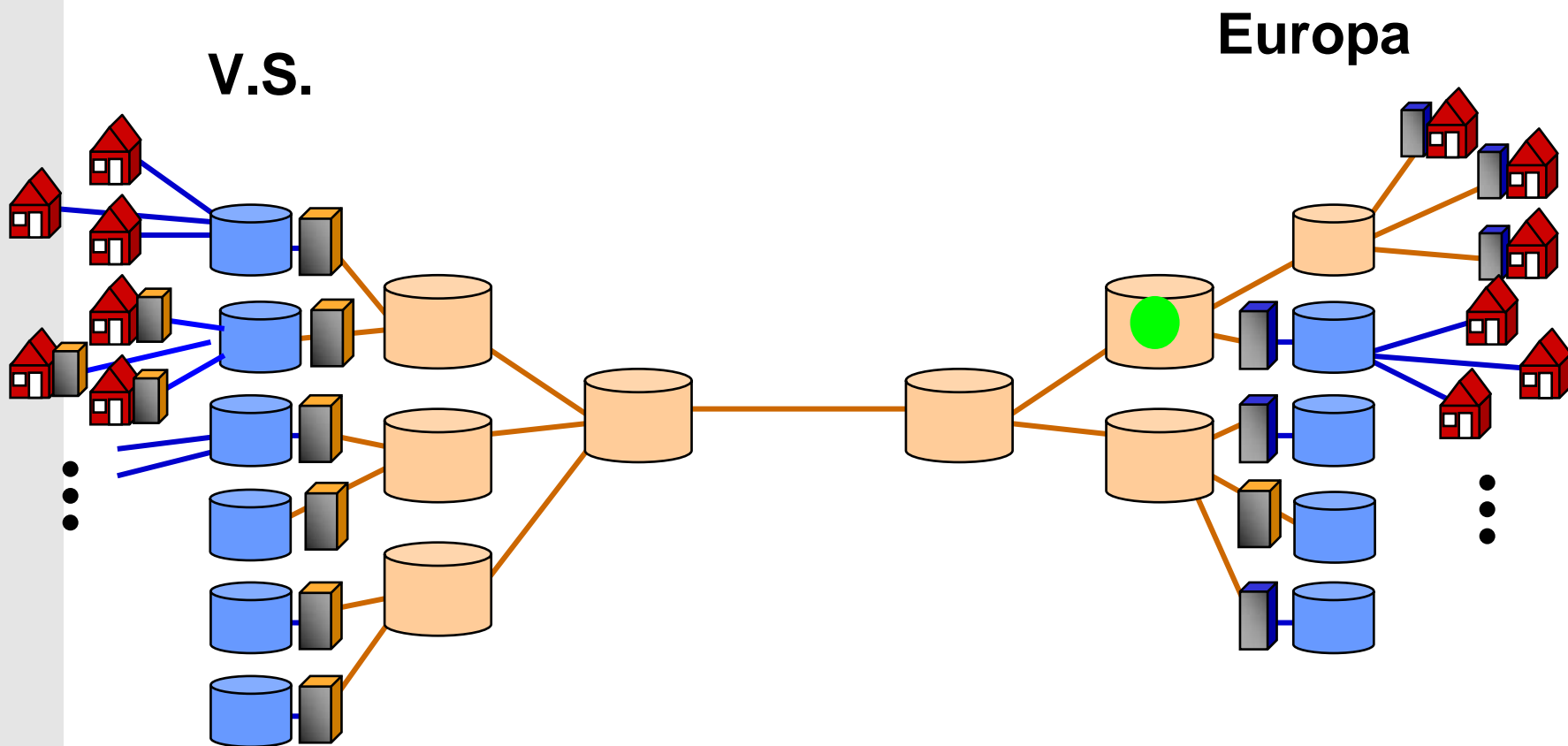
## WDM: wavelength division multiplexing



# Onderdelen van een optisch netwerk?



# Onderdelen van een optisch netwerk?

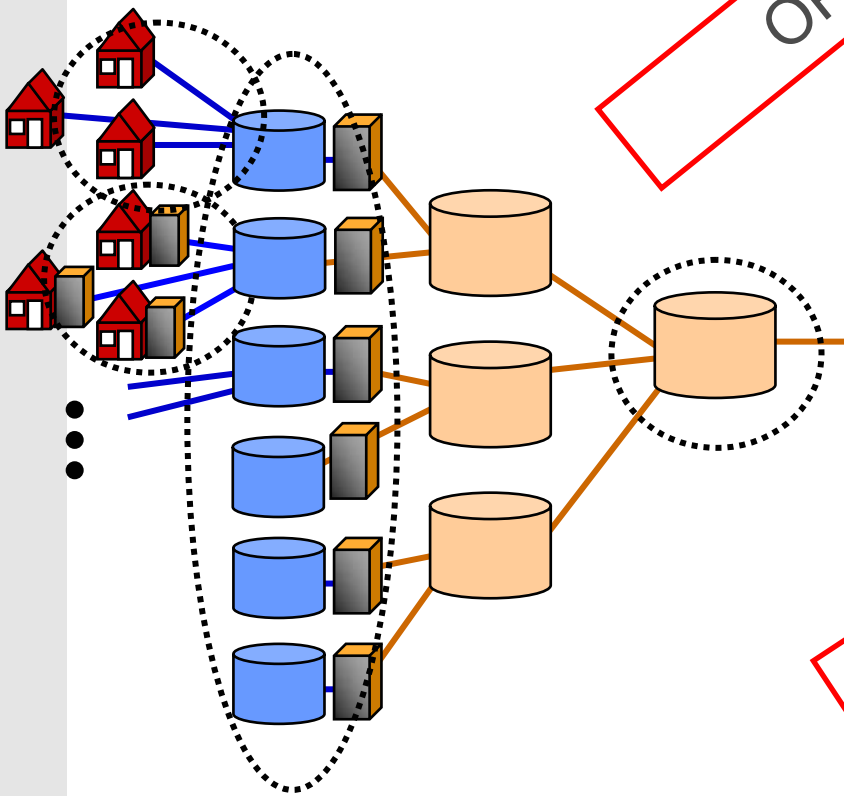


# Volledig optisch netwerk?

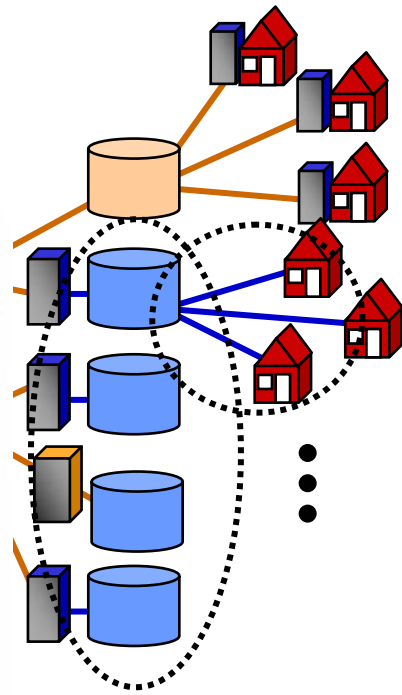
Elektrische toelevering  
Elektrische knooppunten

OPTISCH!

V.S.



Europa

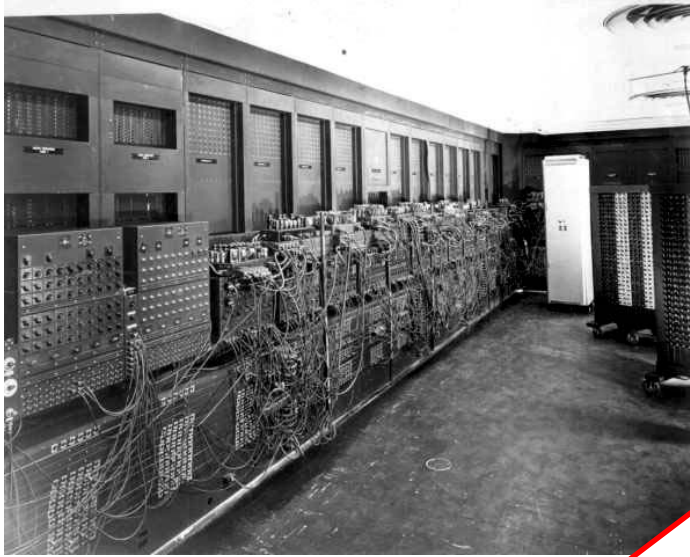


Groot, duur

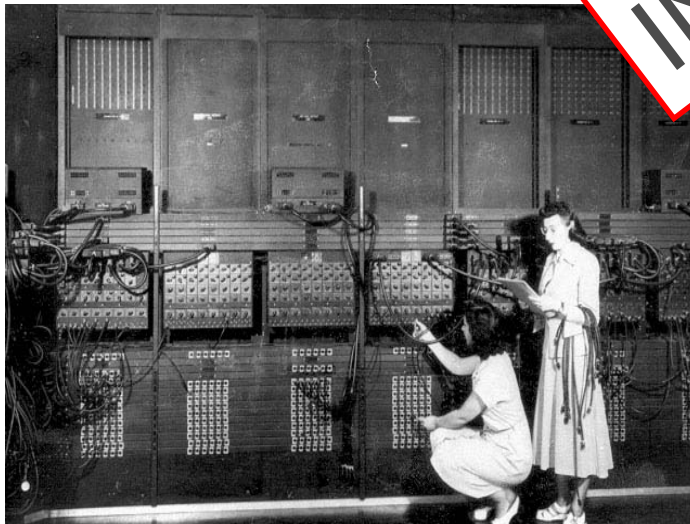




# Hoe deden ze dat in de elektronica?



ENIAC  
1948



**INTEGRATIE**



2000

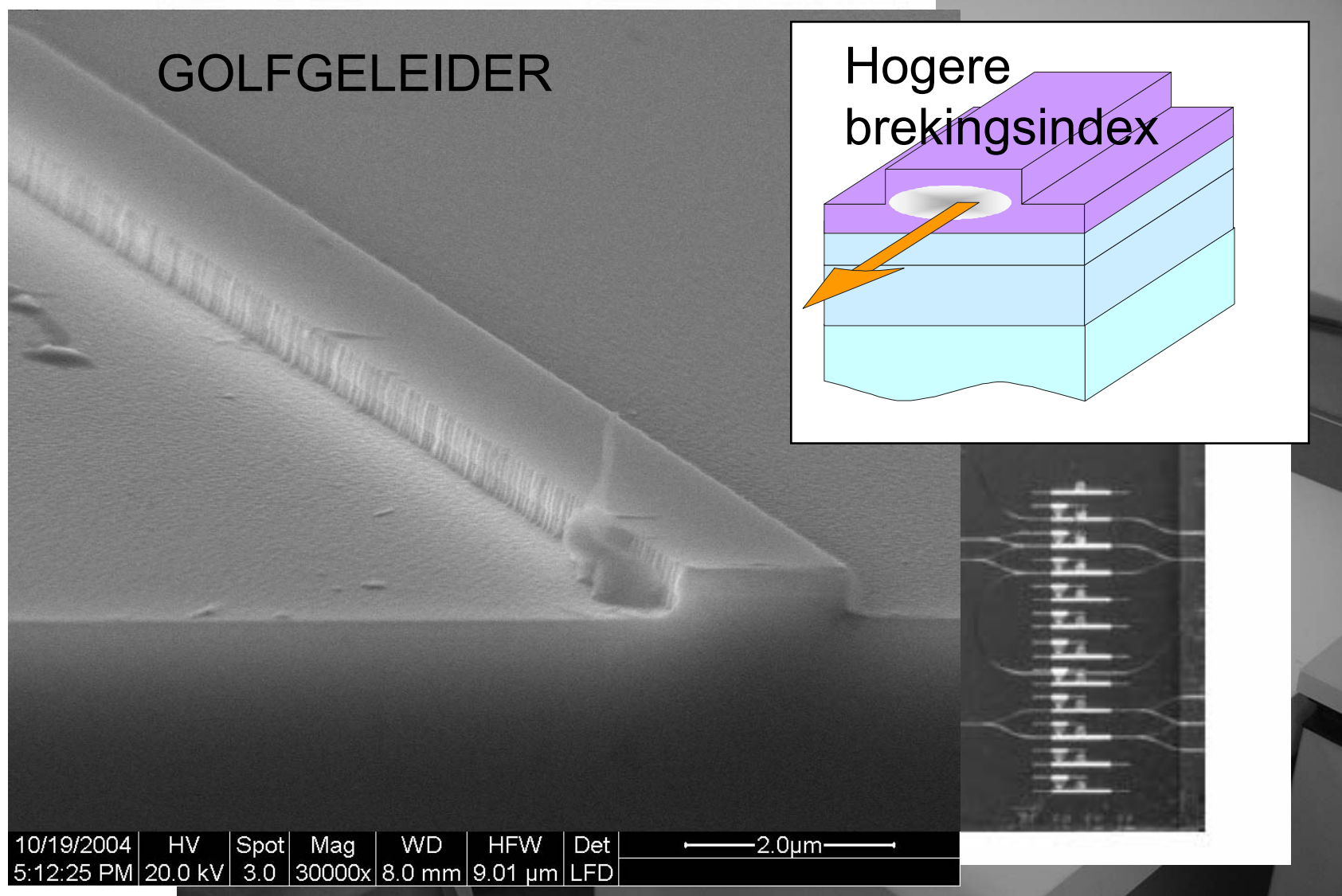




# Overzicht

- **Inleiding**
  - **Breedband verbindingen**
  - **Optische netwerken**
  - **Optische chips**
- **Ringresonatoren**
- **Metingen**
- **Conclusies**

# Optische chips



# Optische netwerken?

- Optische toegang Graafwerken
- Optische knooppunten met optische chips
  - Versterking
  - Regeneratie
  - Sturen van het signaal
  - Filteren
  - ...

**KOST!!!!**  
**Meer integratie**



# Goedkope optische chips?

- **Integratie**

- Zoveel mogelijk functies op een zo klein mogelijke oppervlakte

Elektronica

Fotonica

- Silicium

- Silicium, InP, GaAs, Glas, ....

Heterogene integratie met waferbonding

- Transistor

?

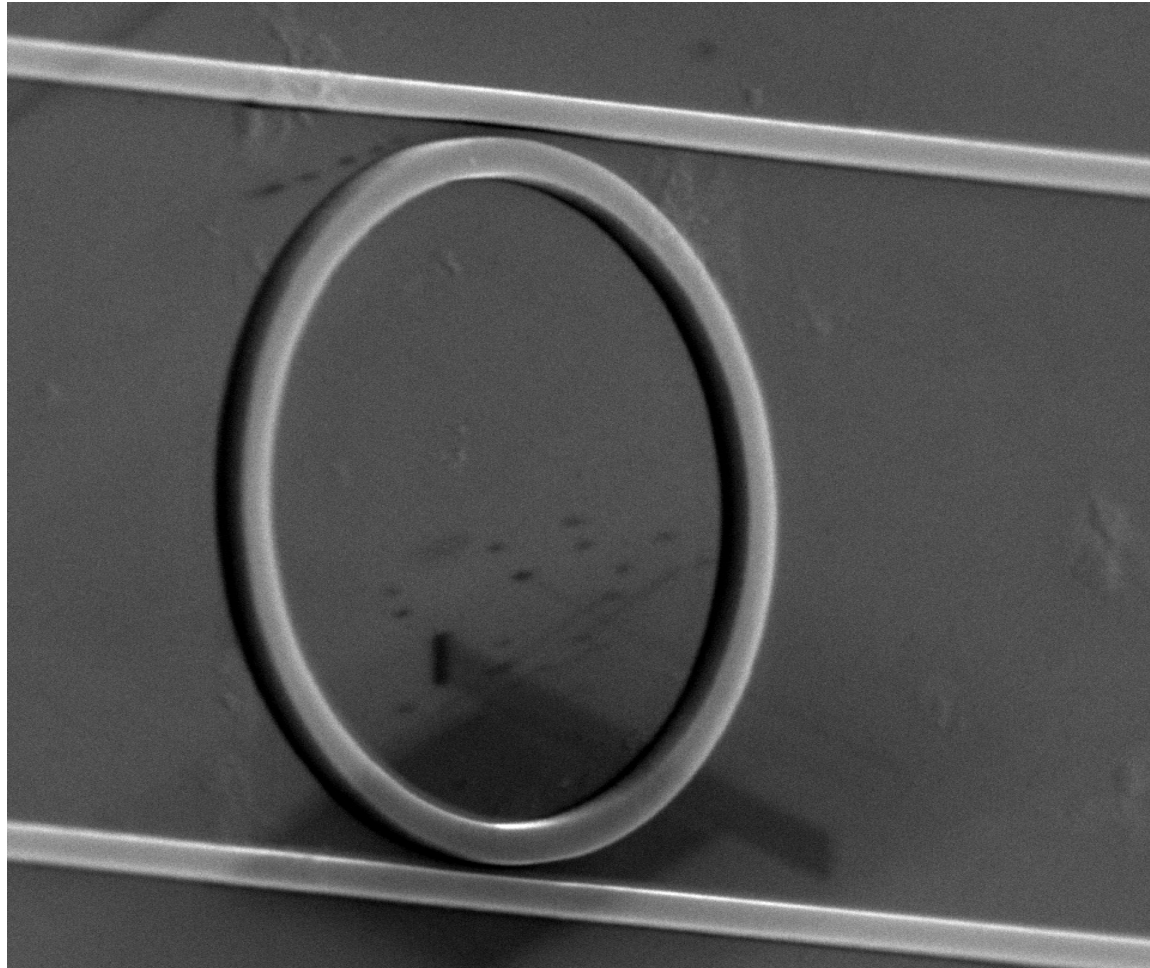
Ringresonator



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# Bouw van een ringresonator





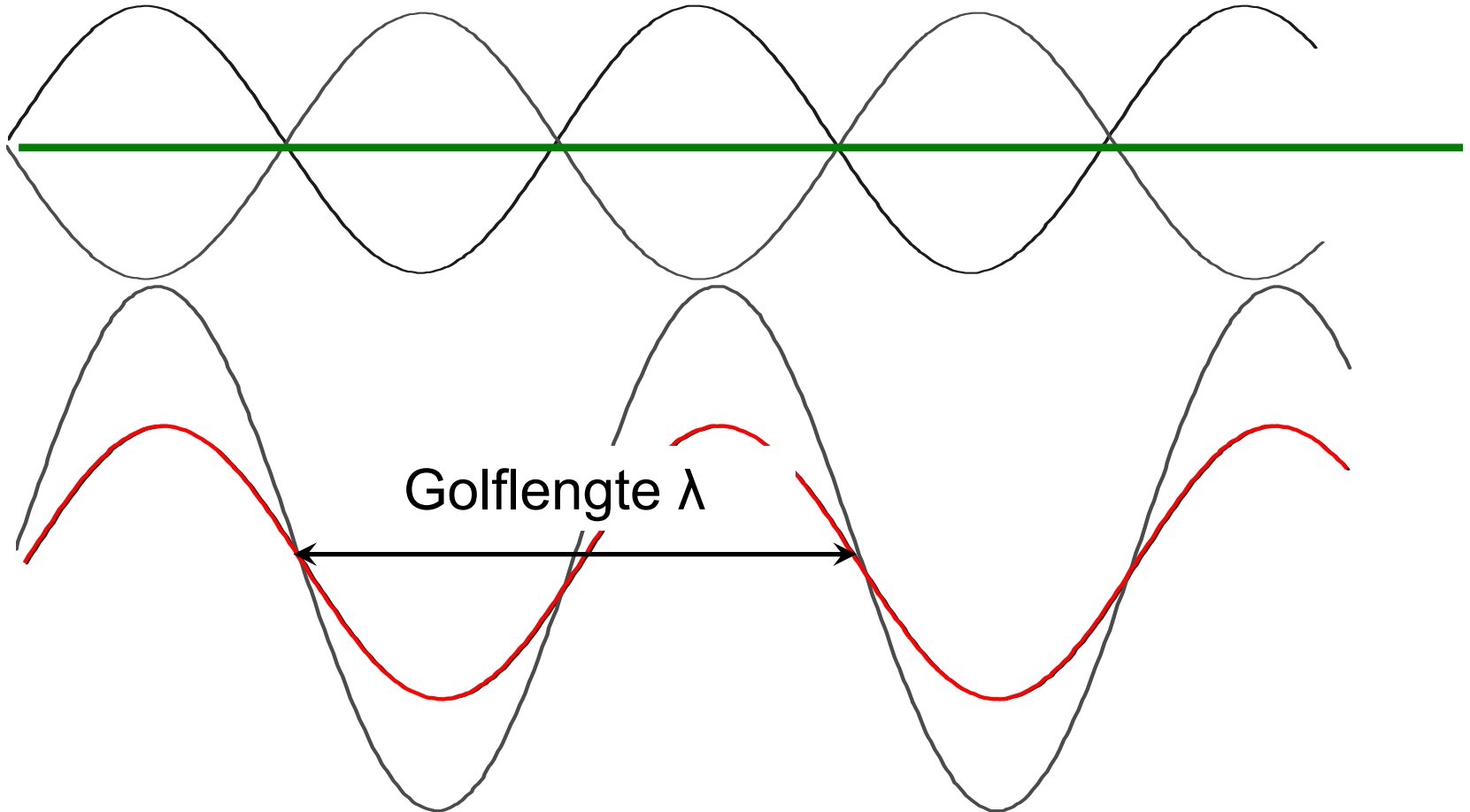
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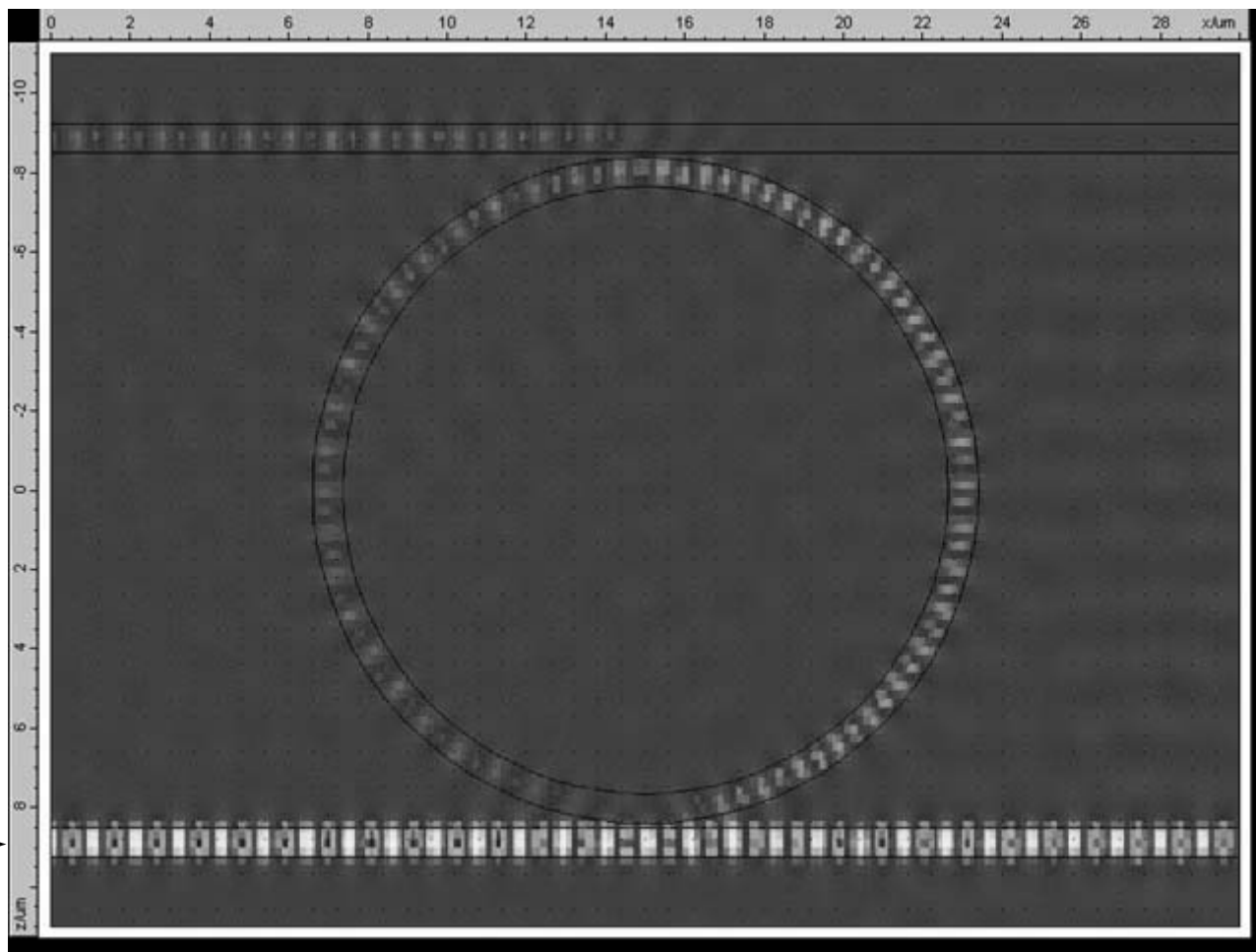
# Interferentie

Destructieve interferentie



Constructieve interferentie

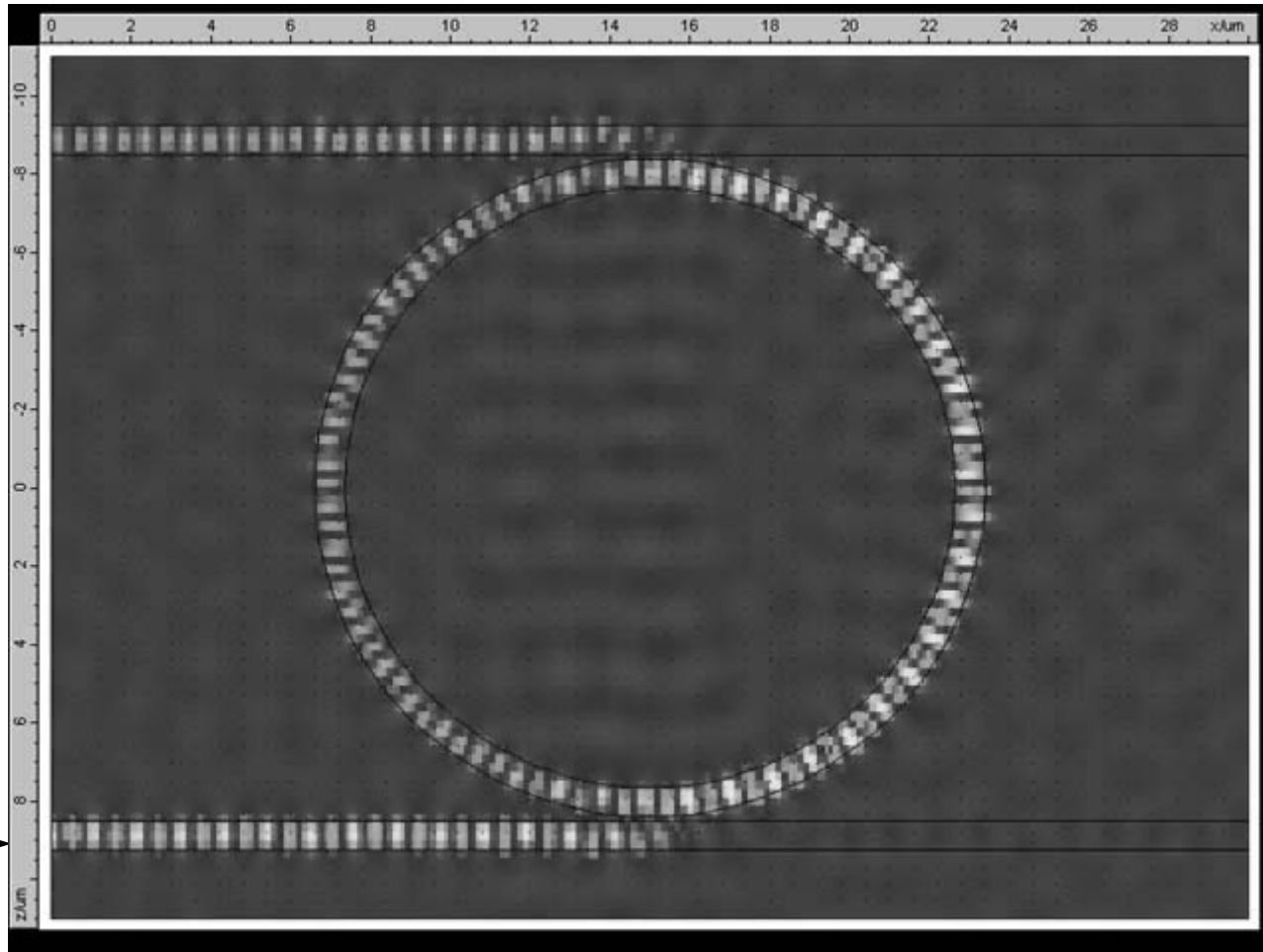
# Uit resonantie



$\lambda_1$



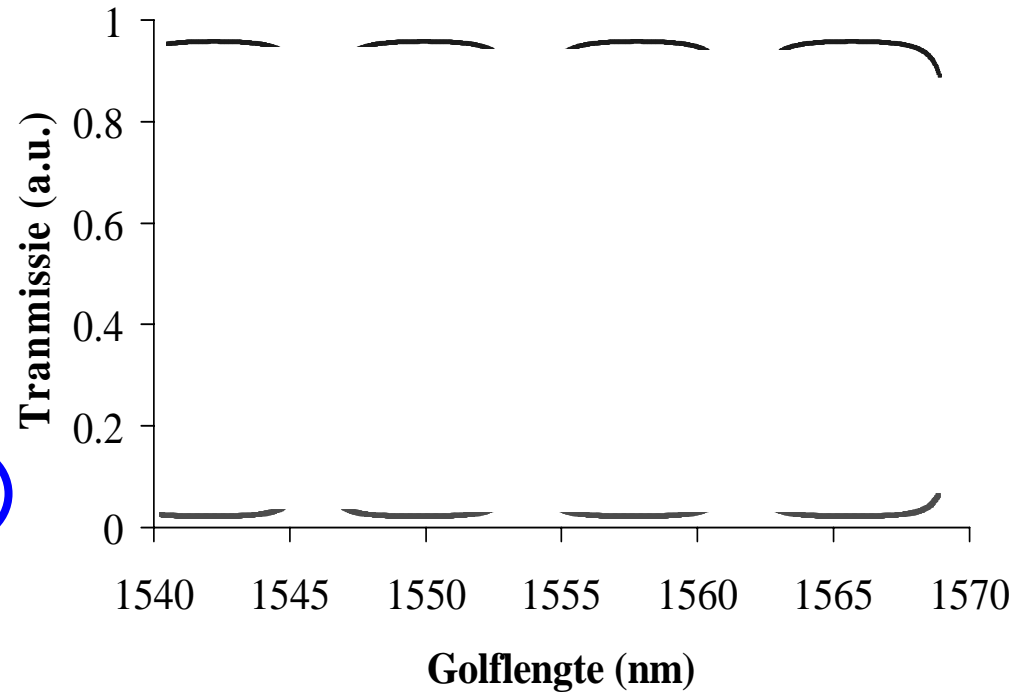
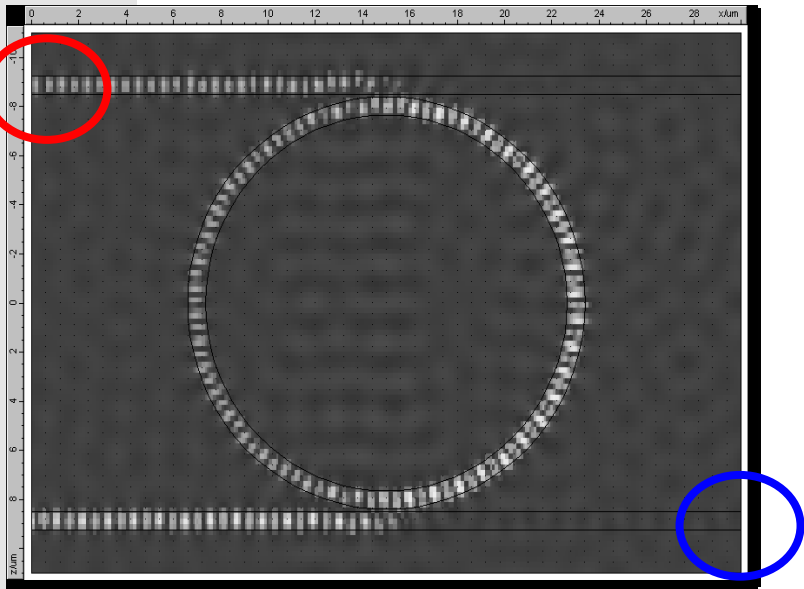
# In resonantie



$\lambda_2$

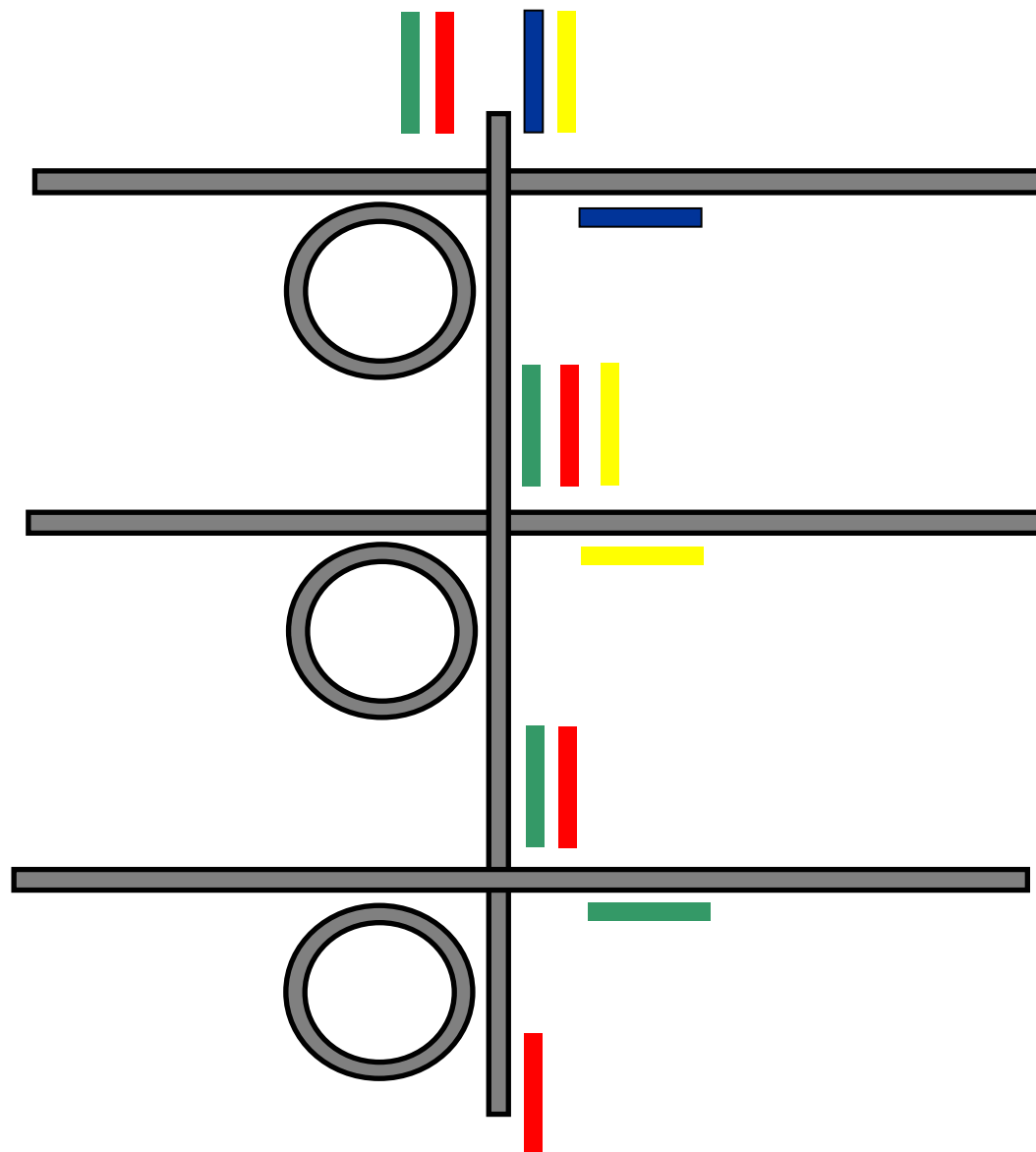


# Het geheel



# Functie, voordelen?

- Klein
- Schaalbaar
- Veelzijdig
  - Filter
  - Lasers
  - Schakelaar
  - ...



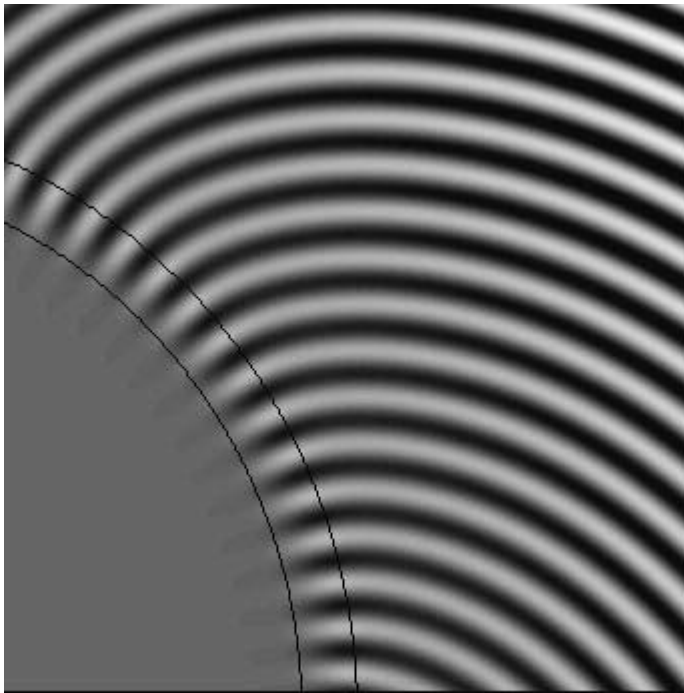


# Overzicht

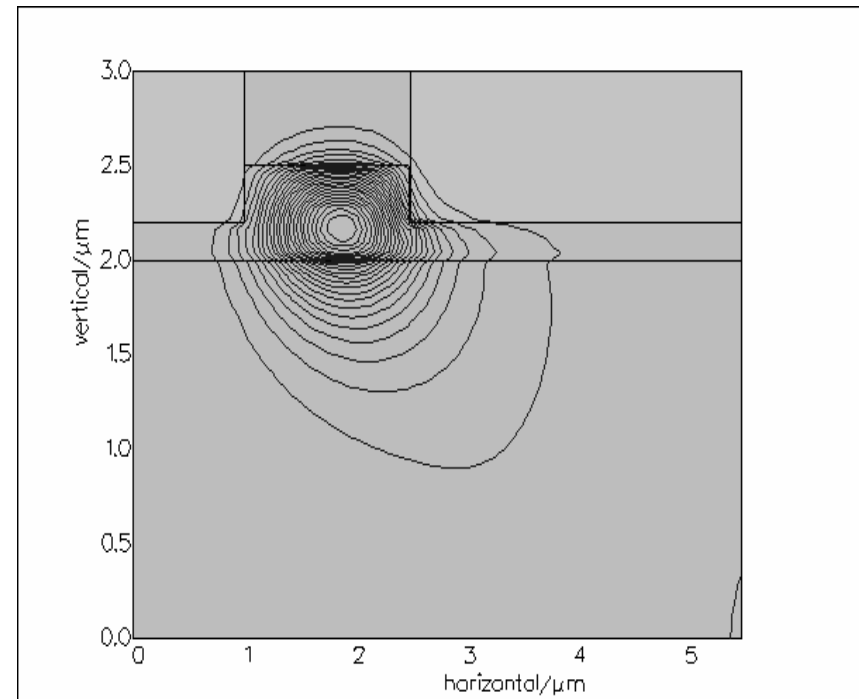
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# Gebogen golfgeleider

## Bochtmode



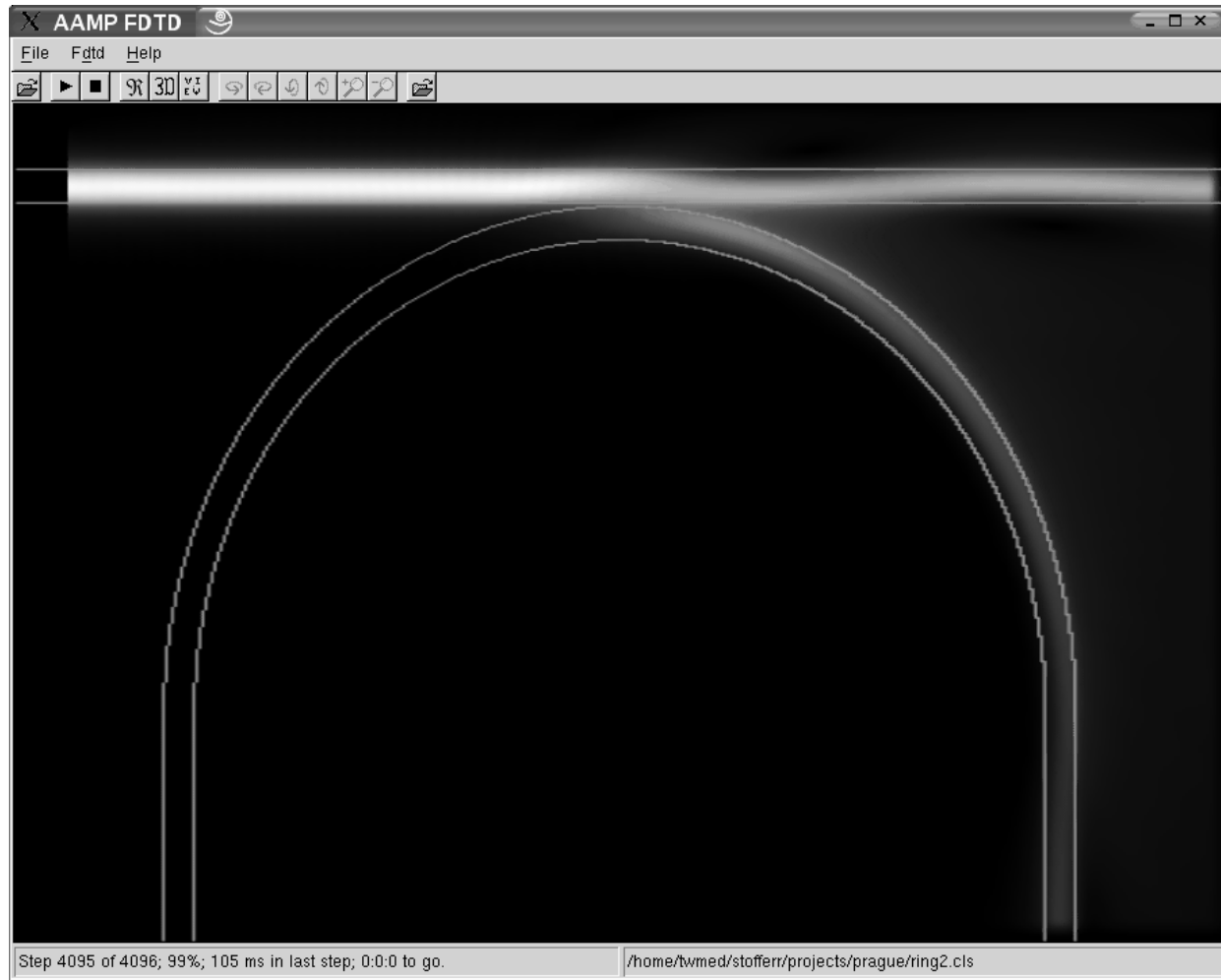
Bovenaanzicht



Zijaanzicht



# Koppeling tussen recht en bocht



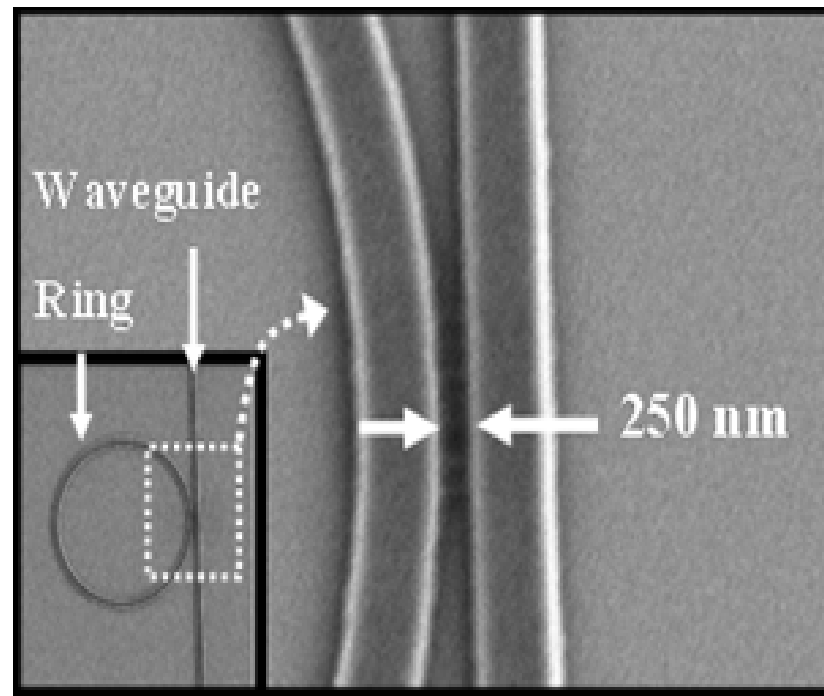
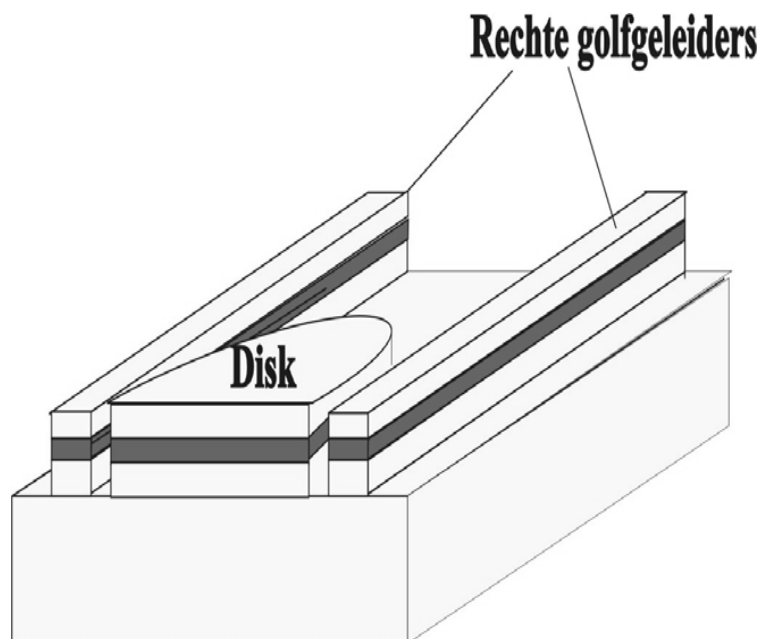




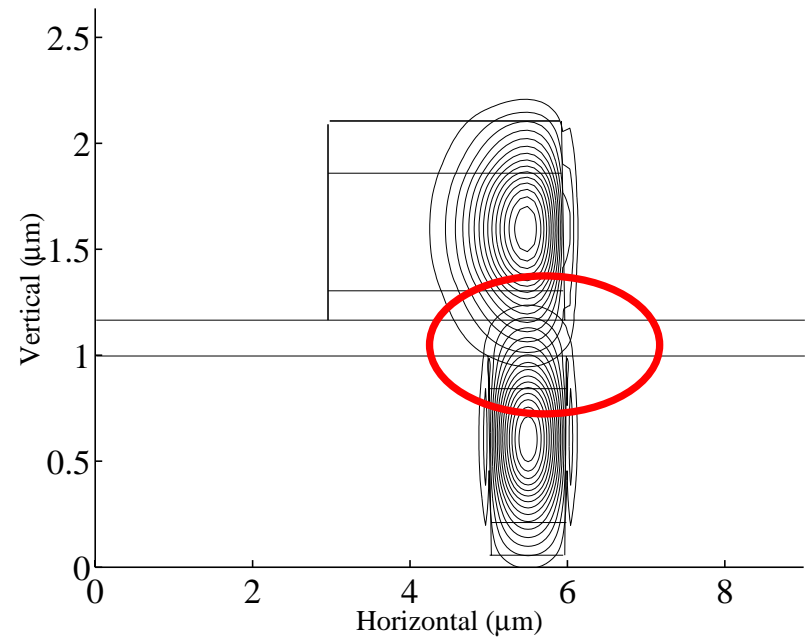
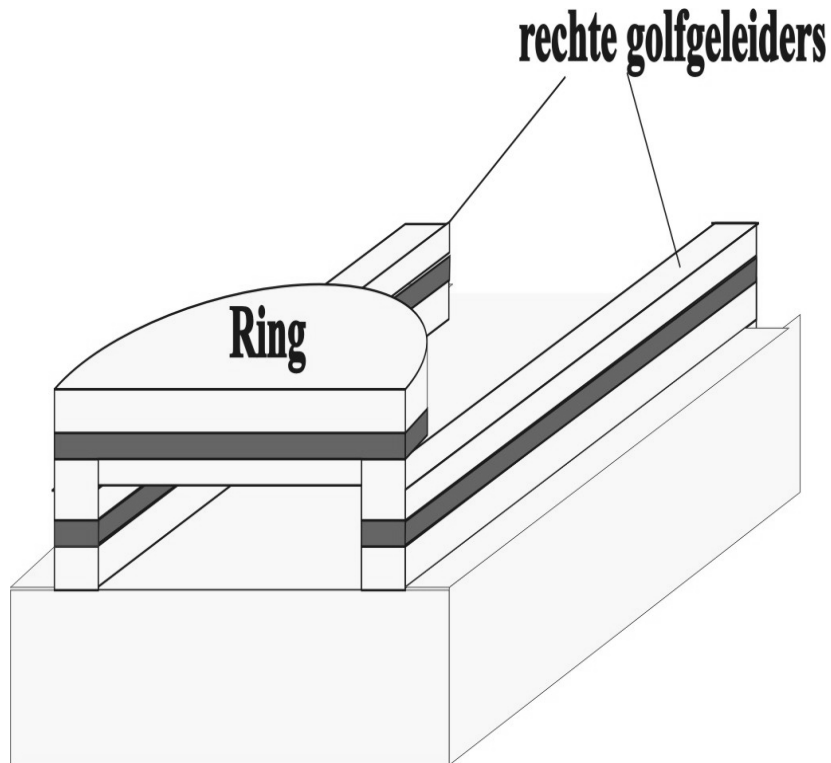
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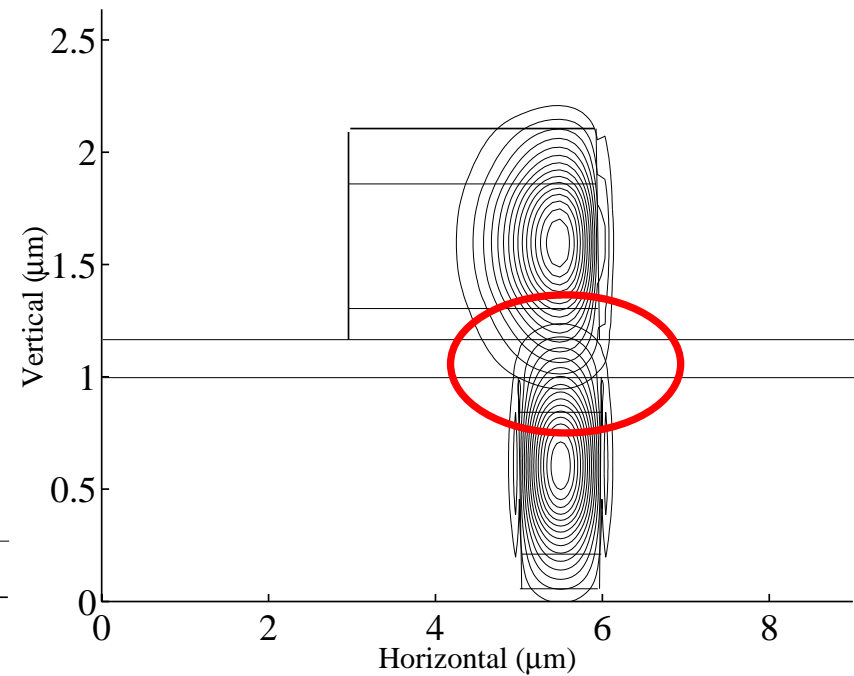
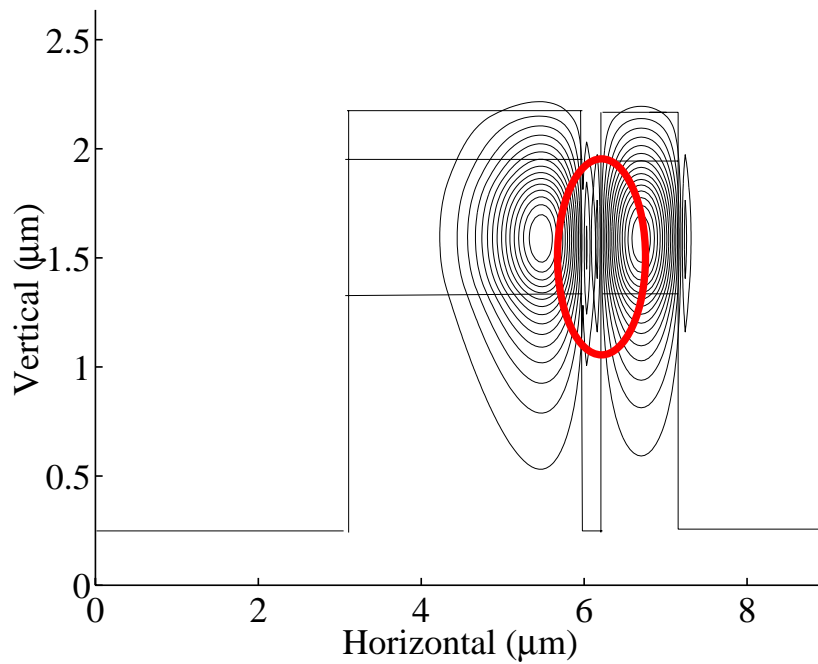
# Horizontaal gekoppeld



# Verticaal gekoppeld



# Vergelijking

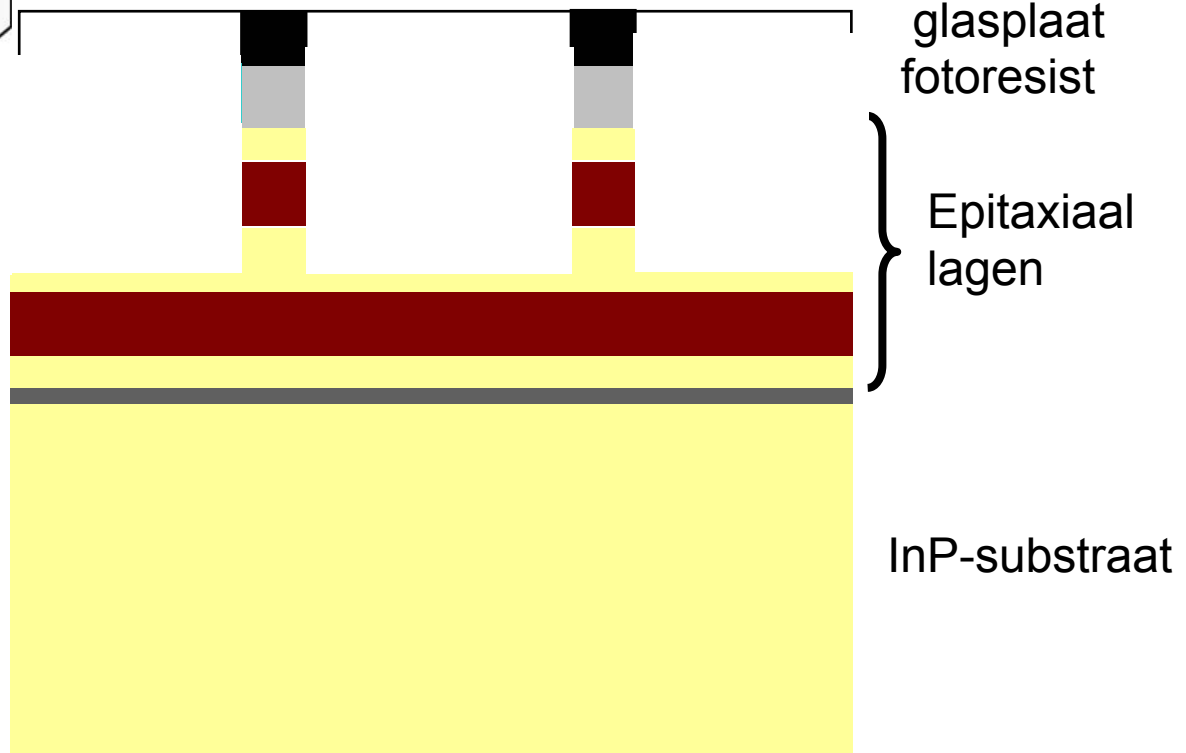
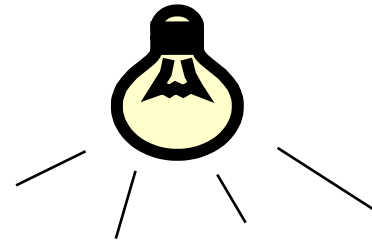
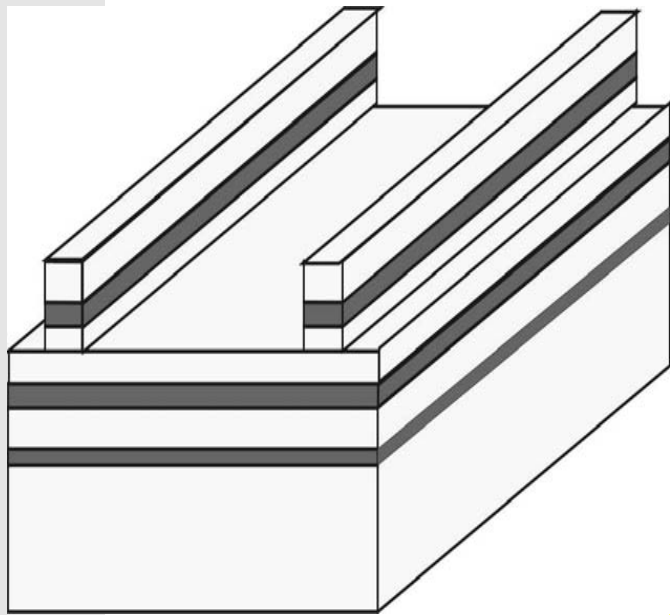







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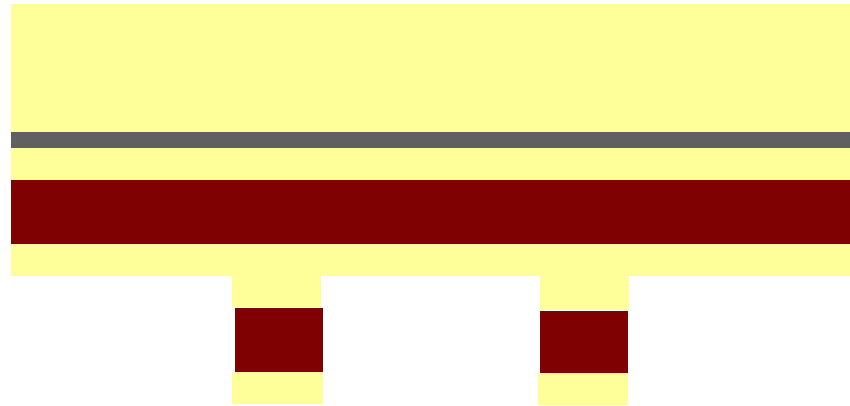
# Proces



-  InGaAsP
-  InP
-  Ets stop laag



# Proces

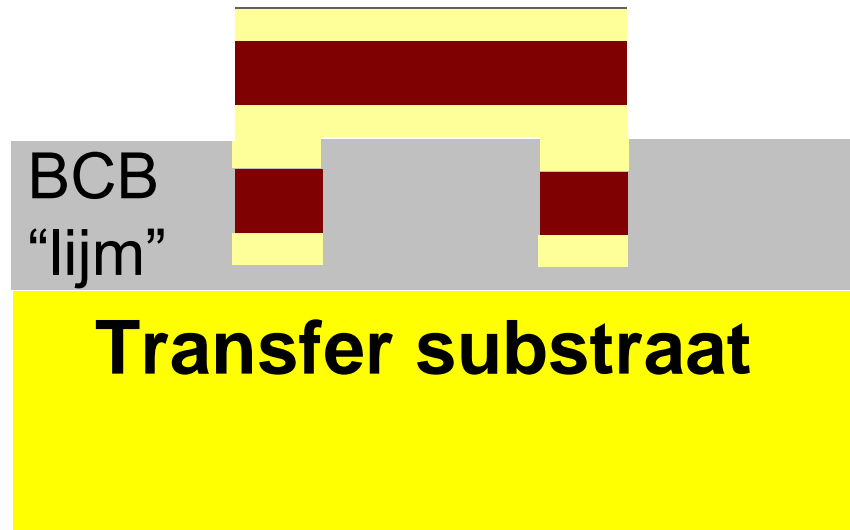
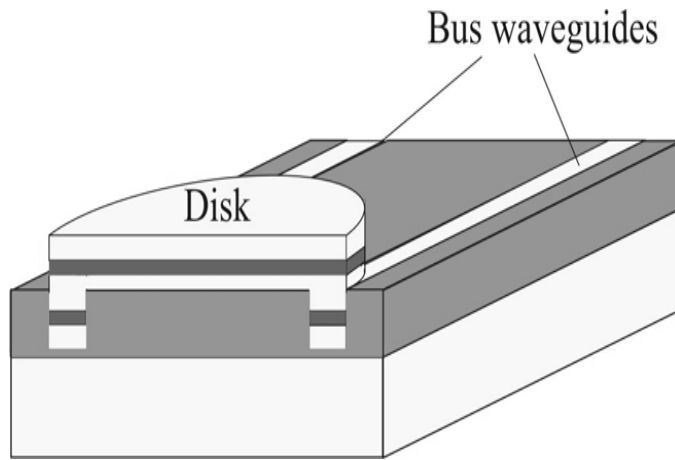


BCB  
“lijm”

**Transfer substraat**



# Proces







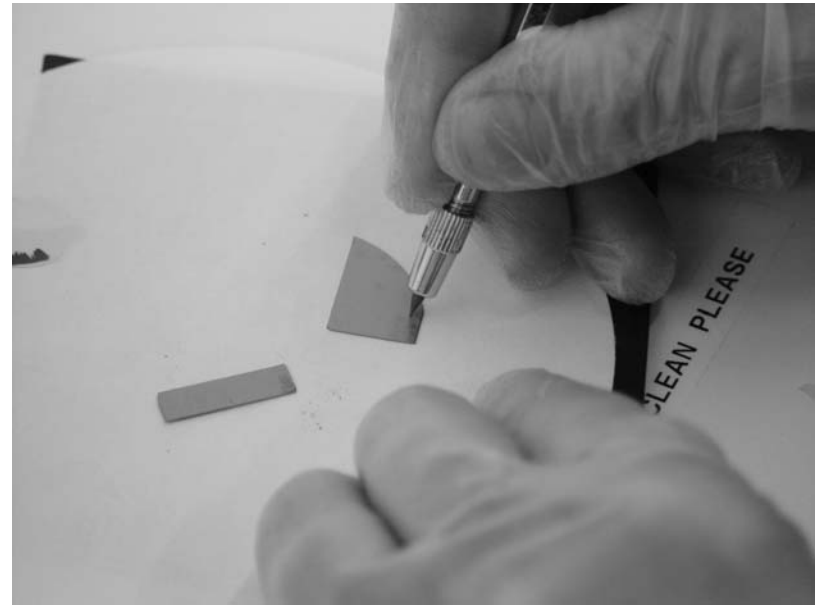
# Cleanroom

10 000 keer minder stof dan in de modale huiskamer



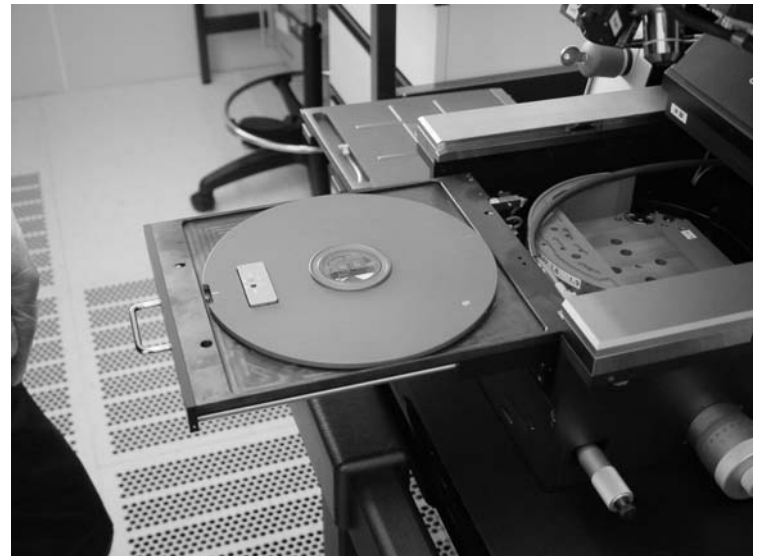
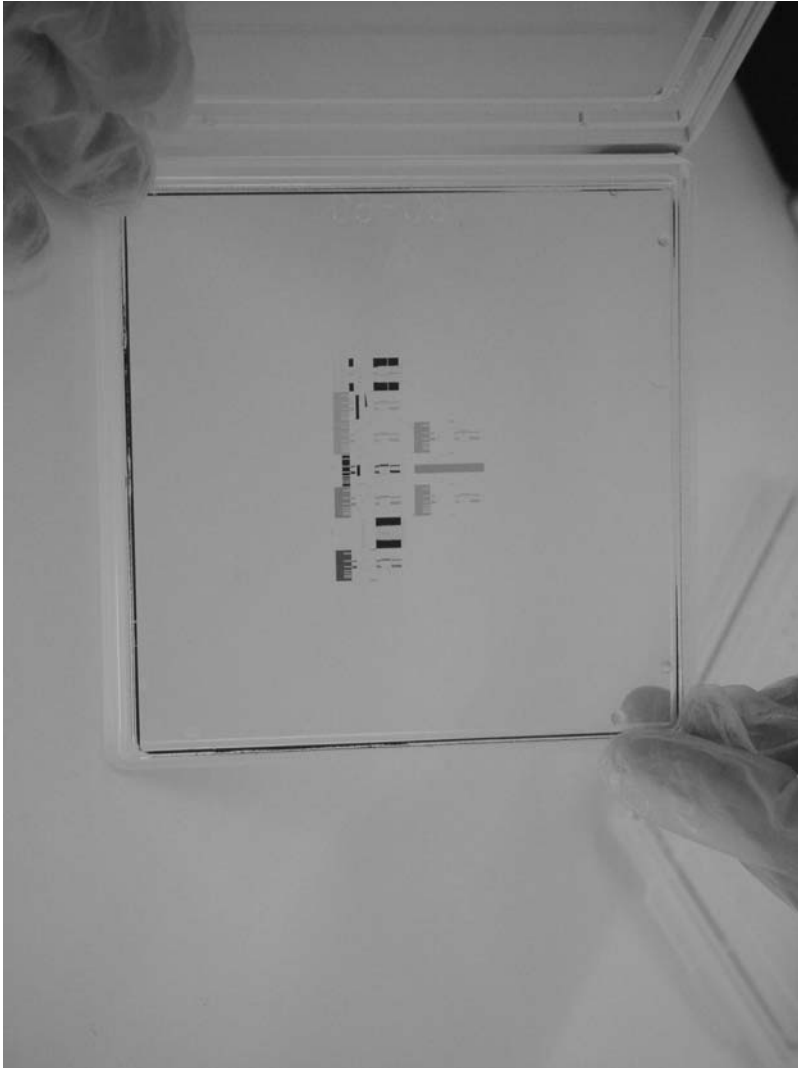


# Wafers





# Lithografie

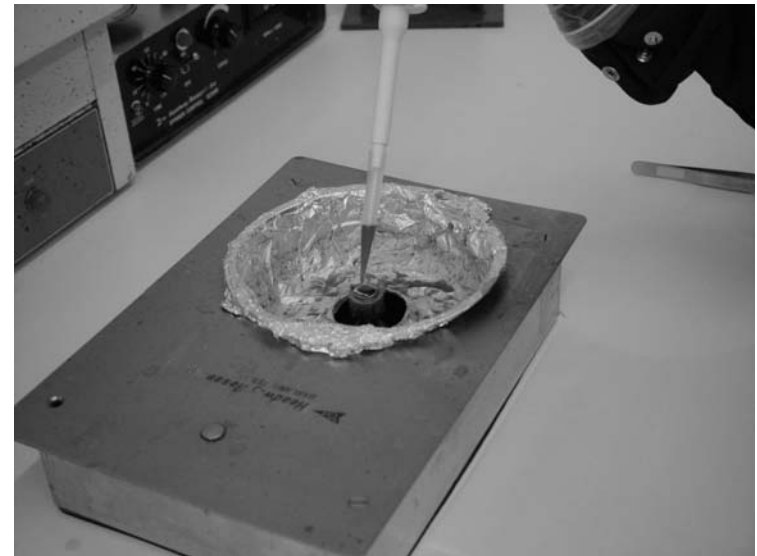
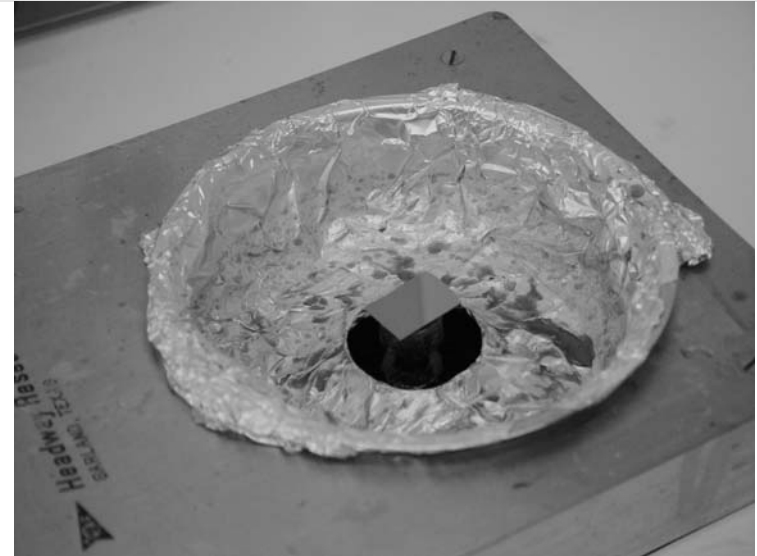




# Etsen

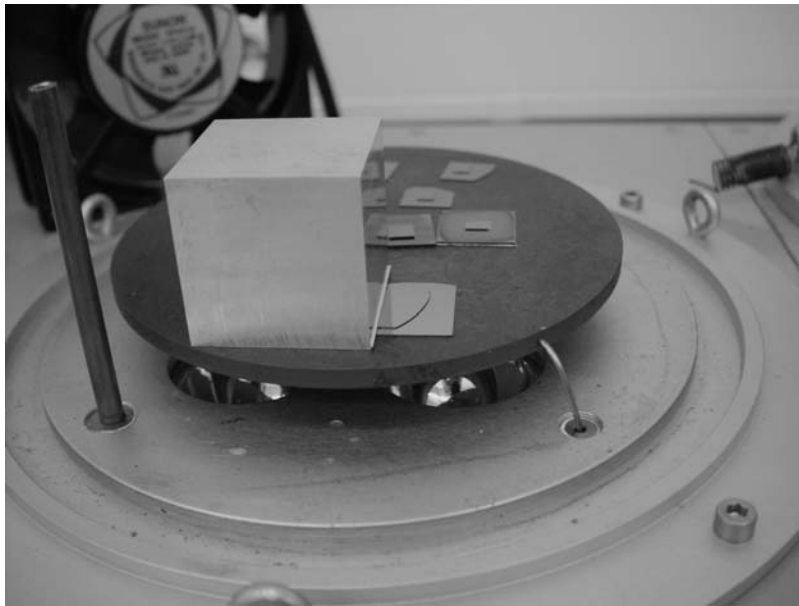


# Bonden met BCB



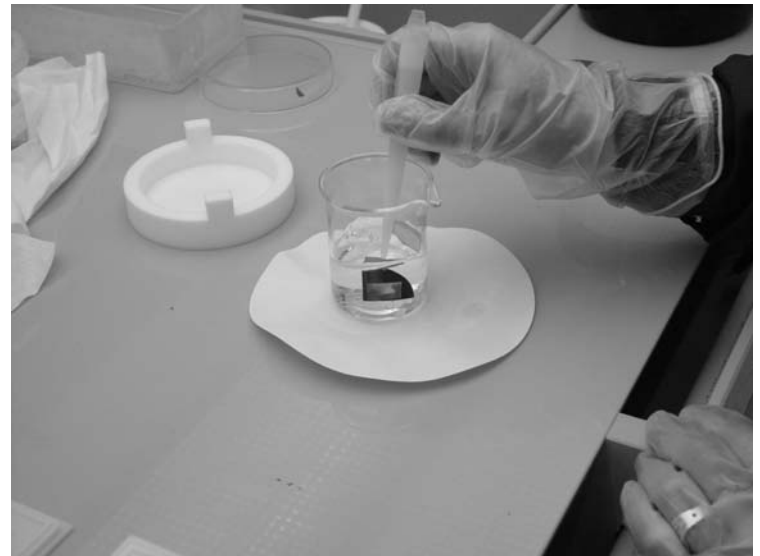
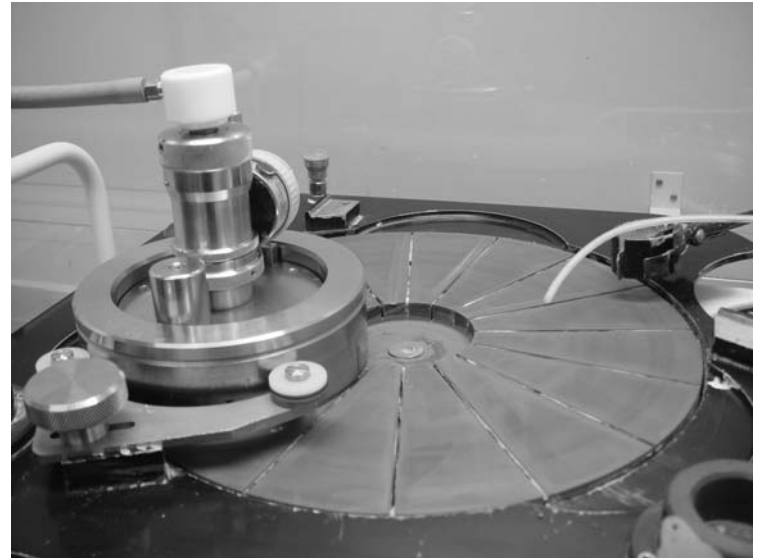


# Bonden met BCB



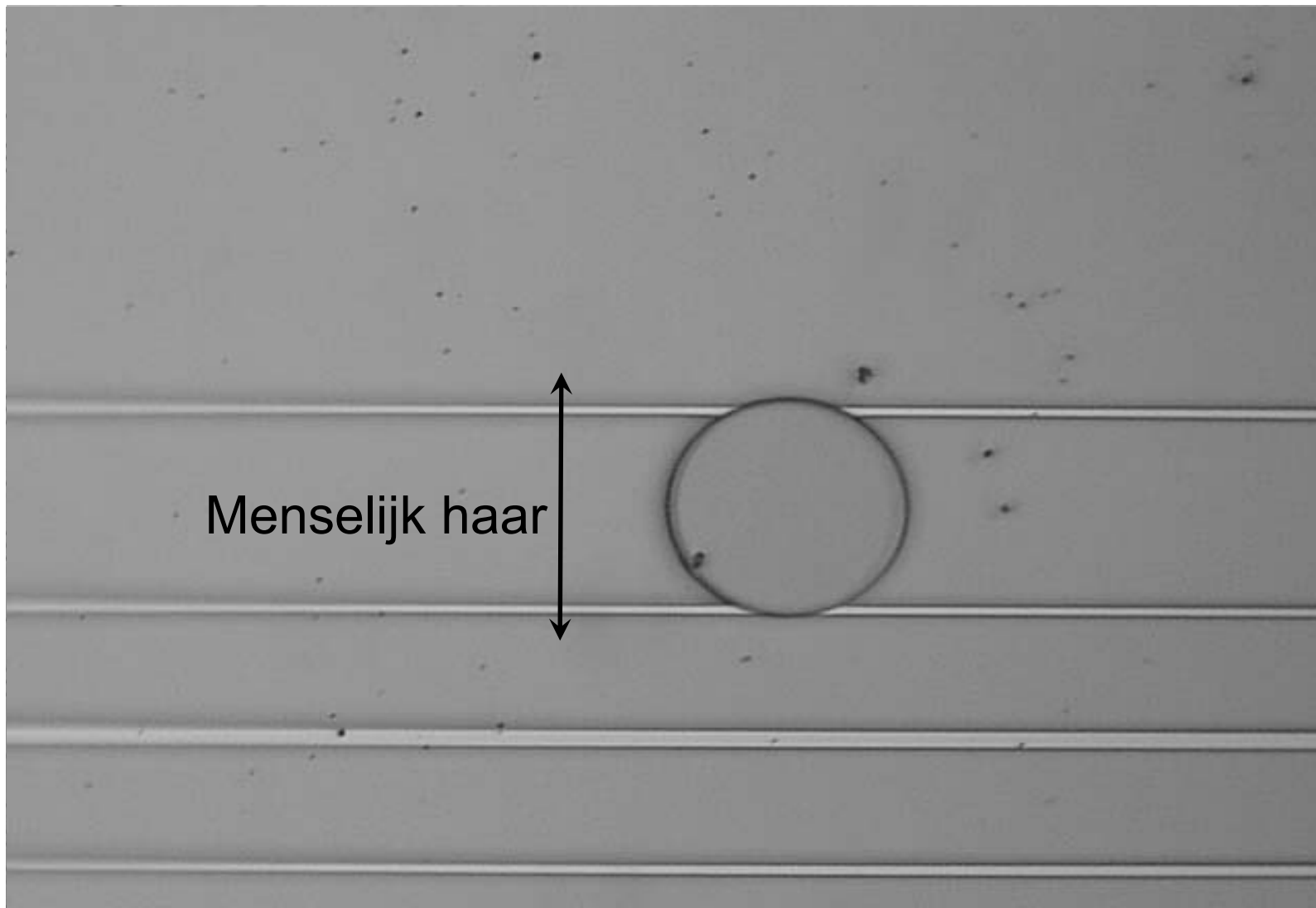


# Verdunnen



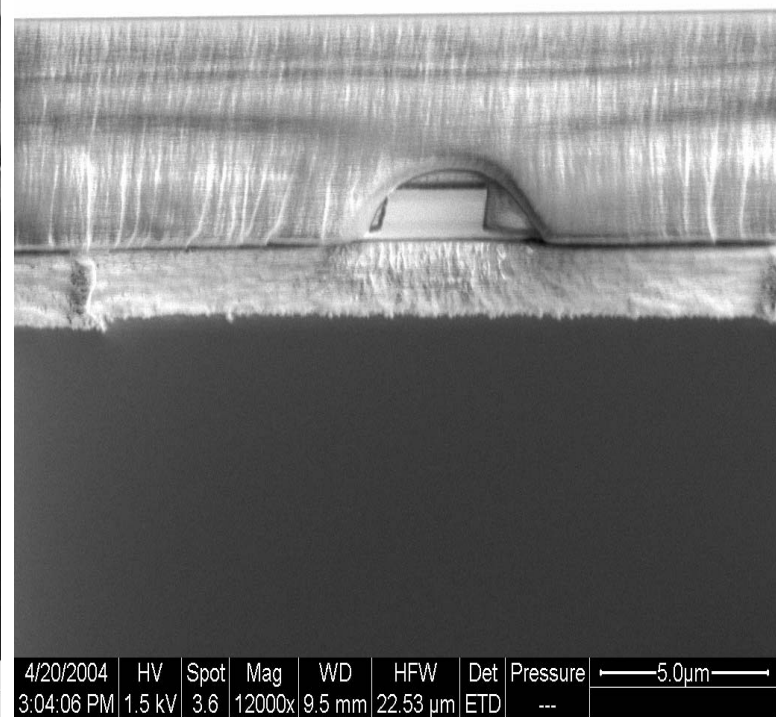
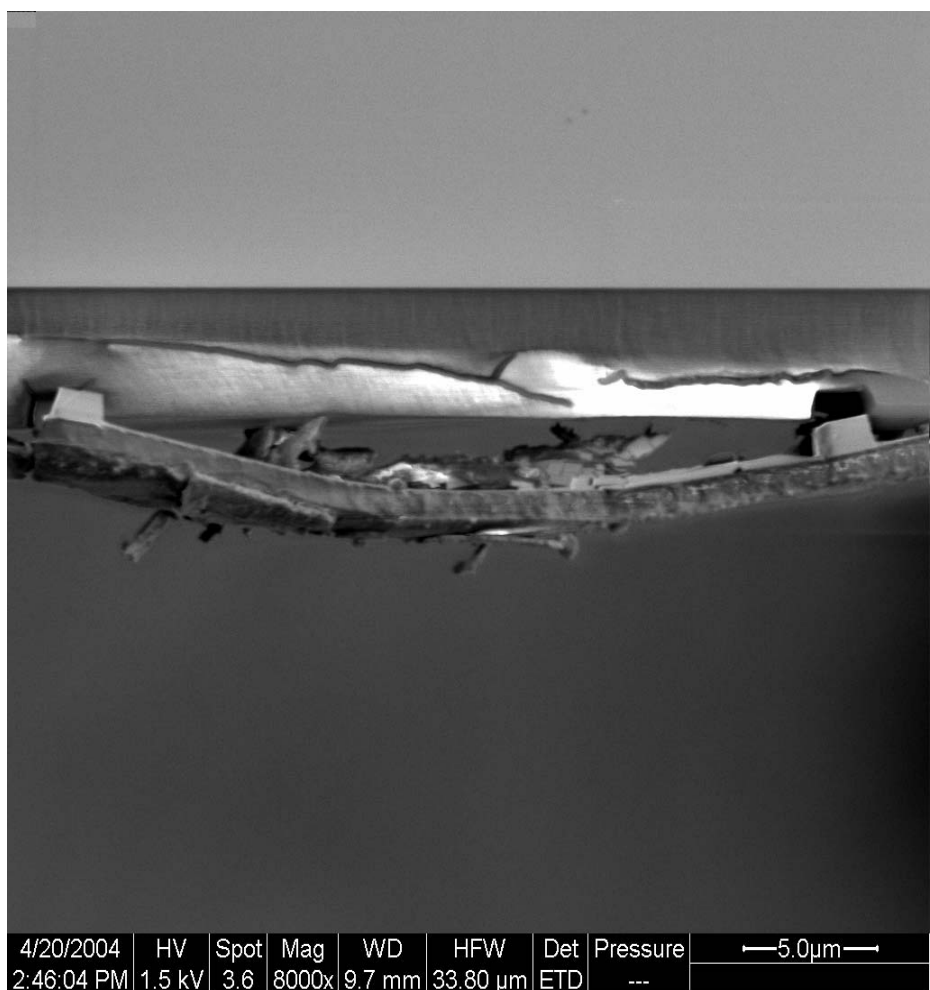


# Het eindresultaat





# Wat kan er fout gaan?





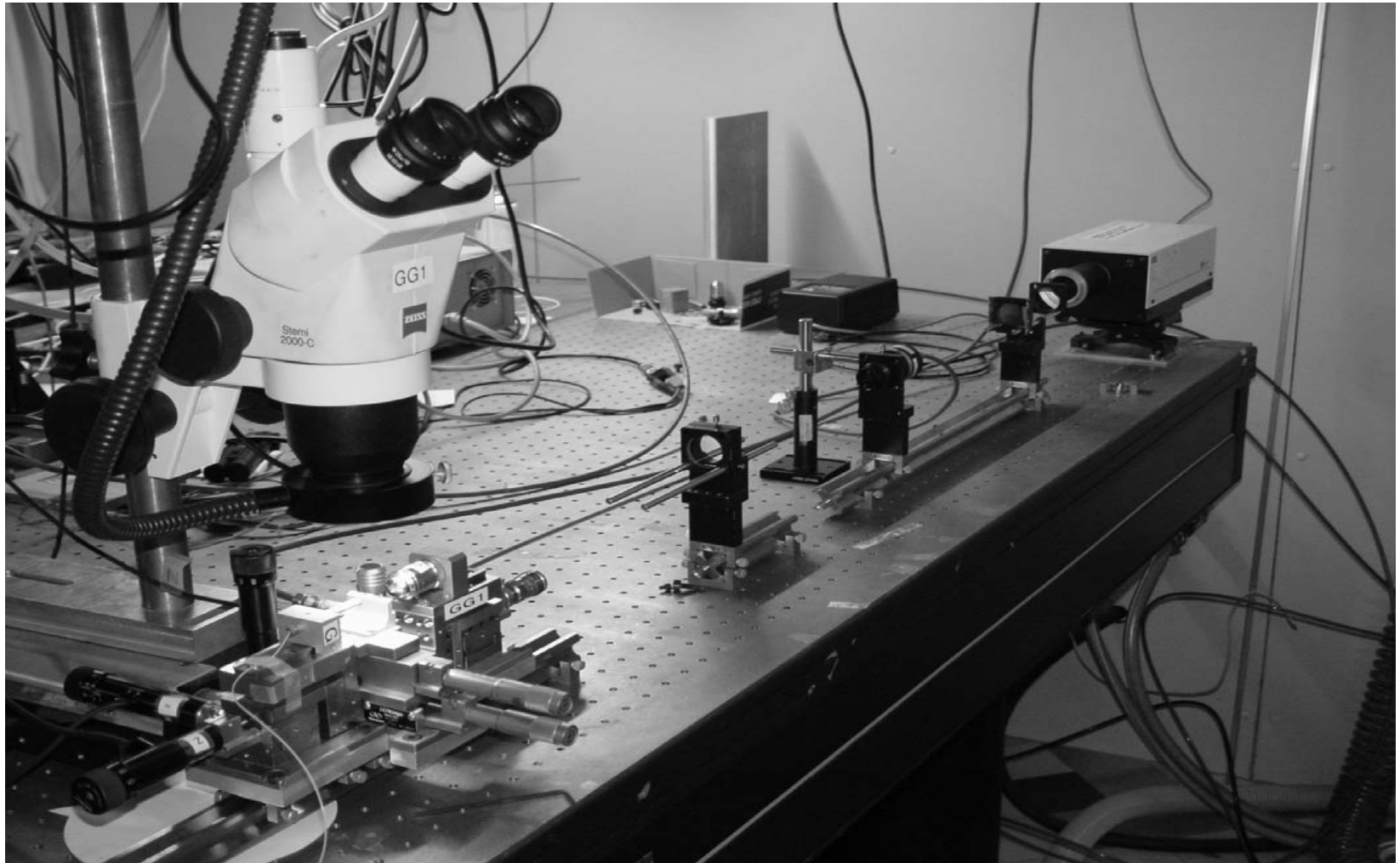
# Overzicht



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- Metingen
- Meetopstelling
- Metingen
- Thermisch afstemmen
- Conclusies



# Meetopstelling



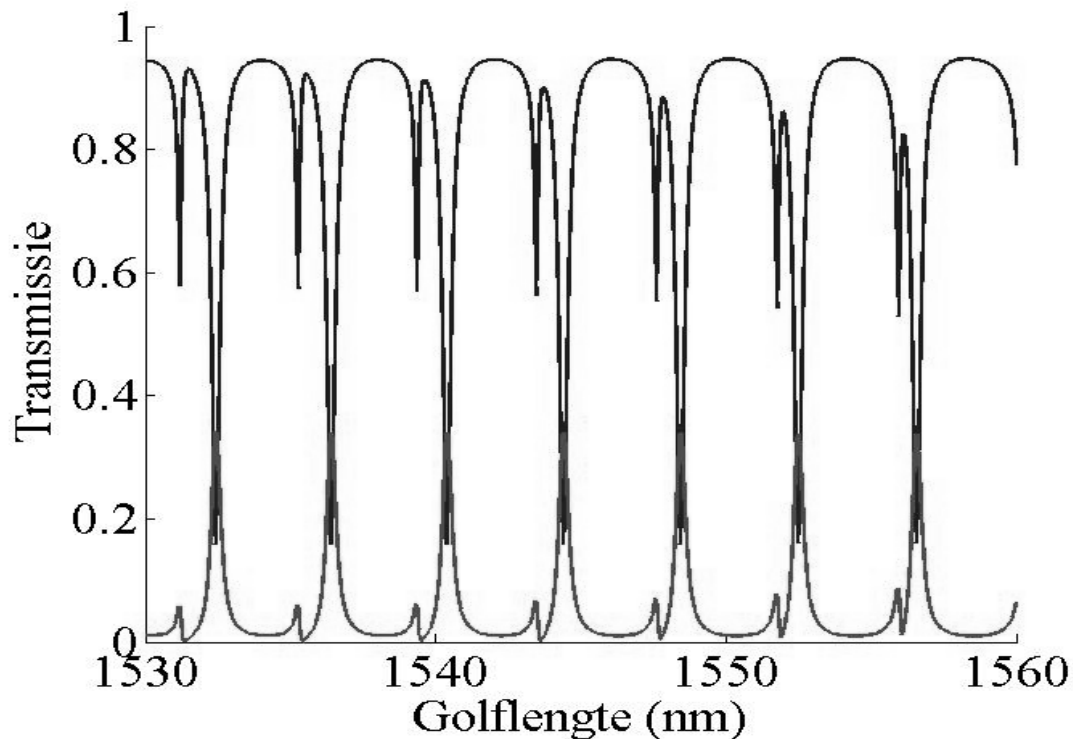


# Meetopstelling



# Metingen

- Stralen van 30  $\mu\text{m}$  tot 10  $\mu\text{m}$
- Simulatie laat toe om fenomenen als hogere orde excitatie en polarizatieconversie te voorspellen





# Overzicht



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# Afstemmen?

Radio 1



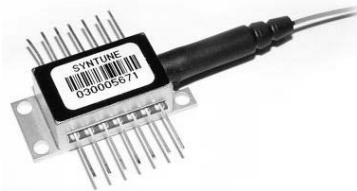
Studio  
Brussel



Klara

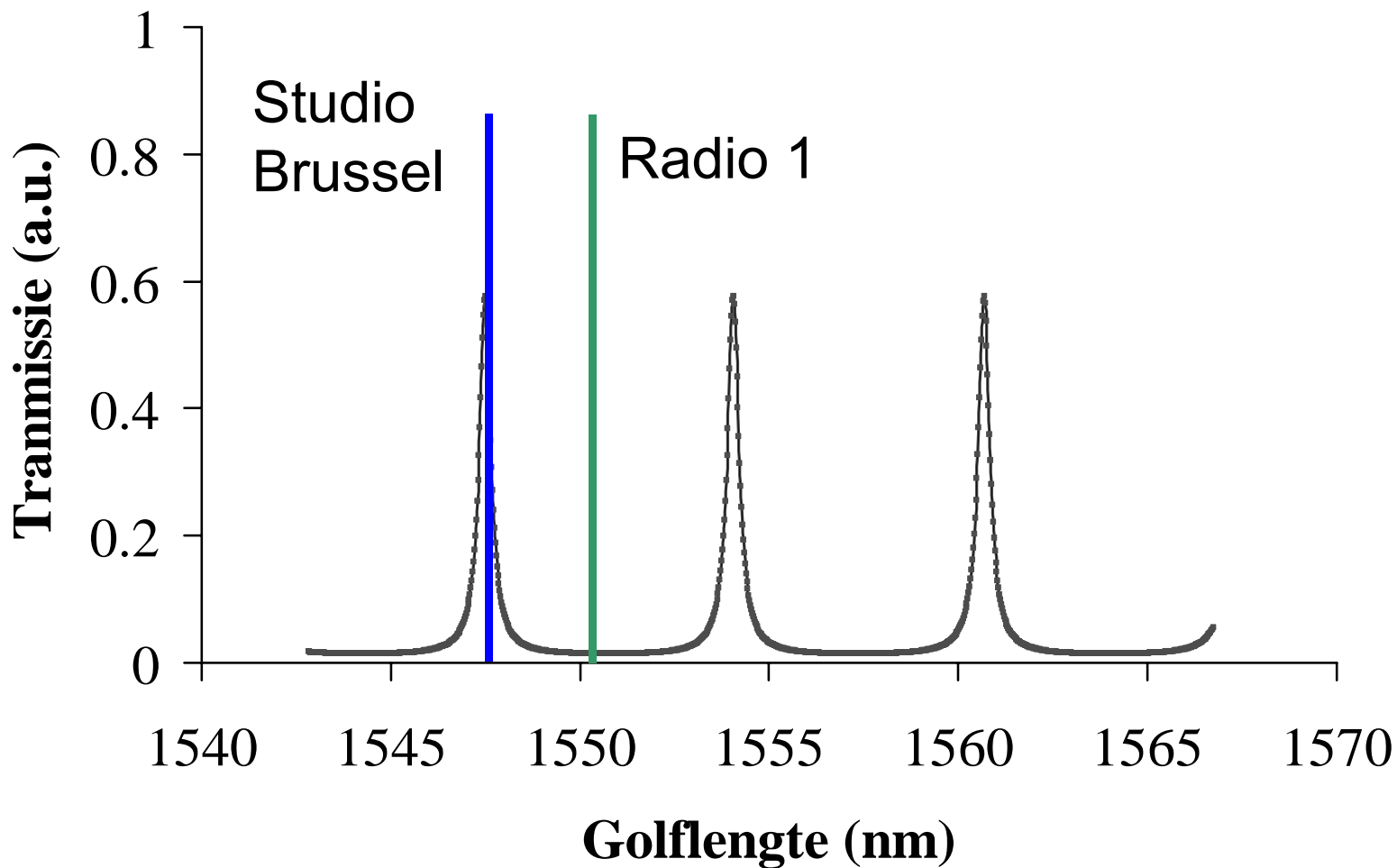


Q-music



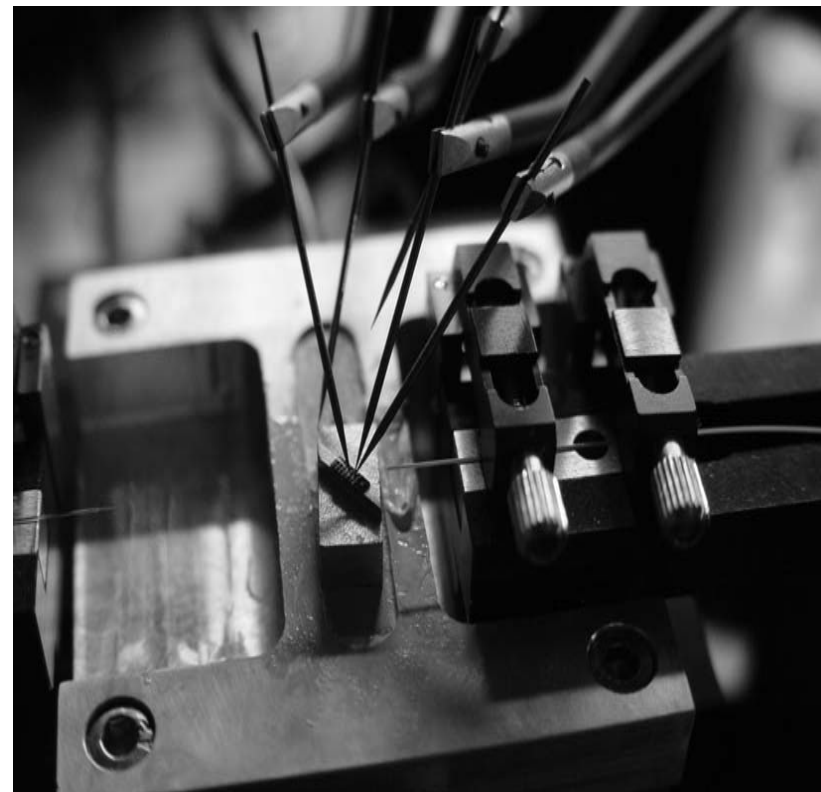
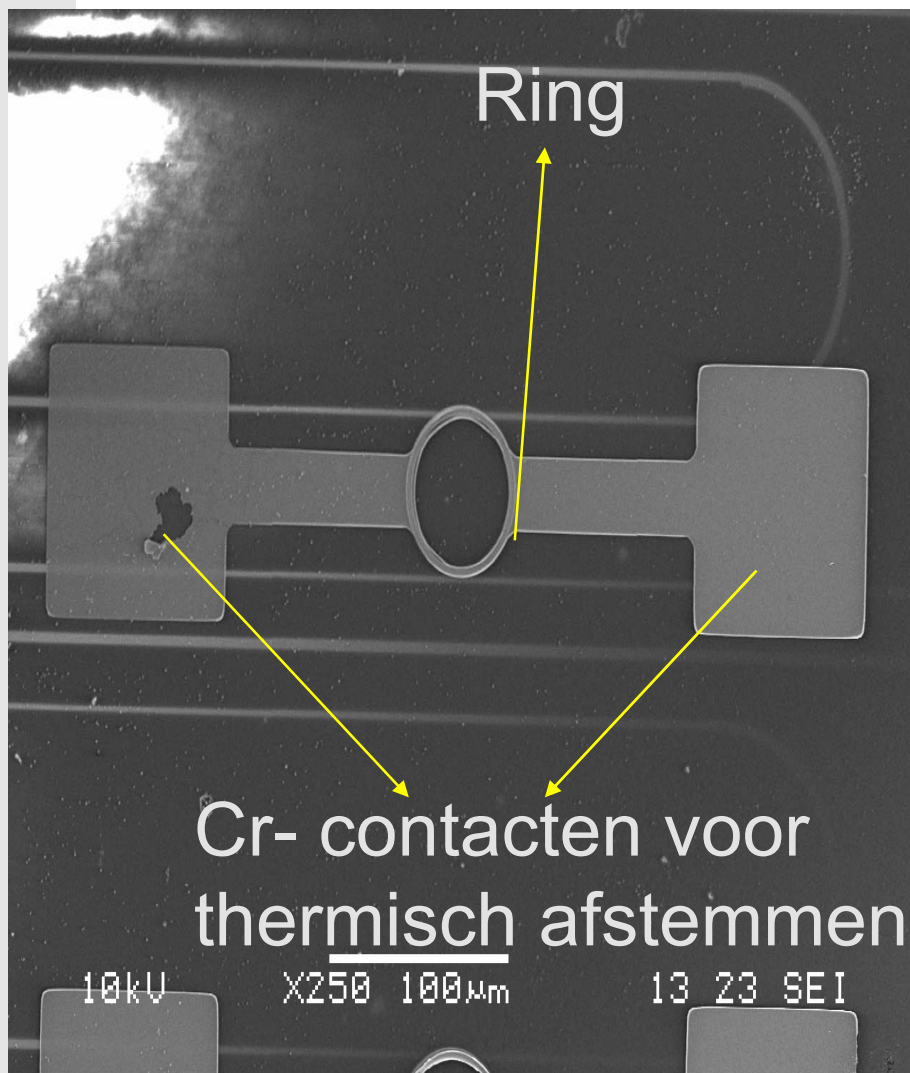
Optische vezel

# Afstemmen?



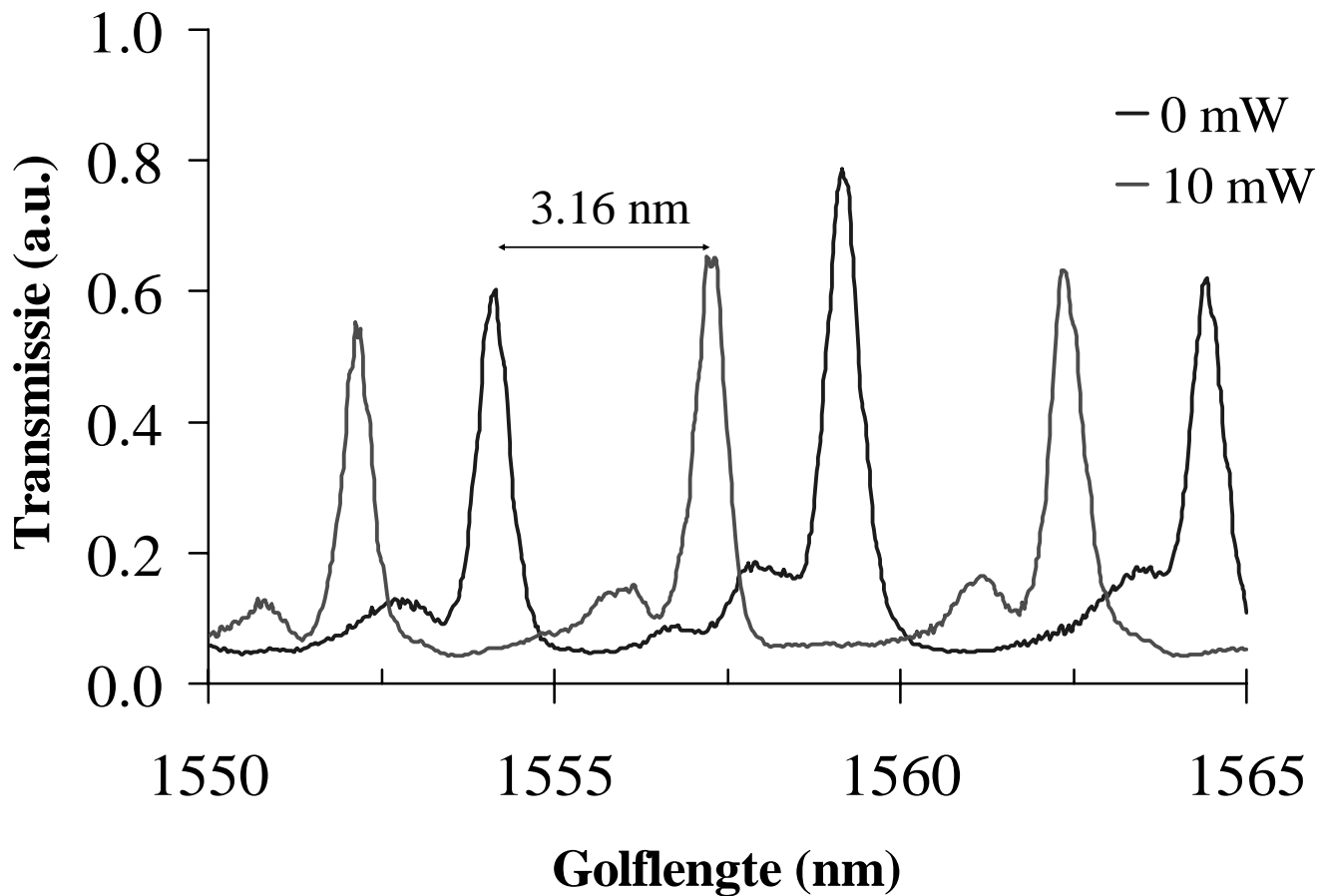


# Thermisch afstemmen



# Thermisch afstemmen

50 mW → 15nm





# Conclusies

- **Waferbonding proces**
  - Werd ontwikkeld
  - Ringresonatoren gefabriceerd
  - Ook actieve componenten zoals lasers en LED's
  - Thermisch afstembare ringresonatoren gedemonstreerd
  - Basis voor nieuw onderzoeksdomein in de fotonicagroep
- **Simulatie**
  - Ontwikkelen van eigen software voor de koppeling
  - Evaluatie van commerciële software
  - Goede overeenkomst met experiment

