Bundelsturing met een vloeibaar kristal

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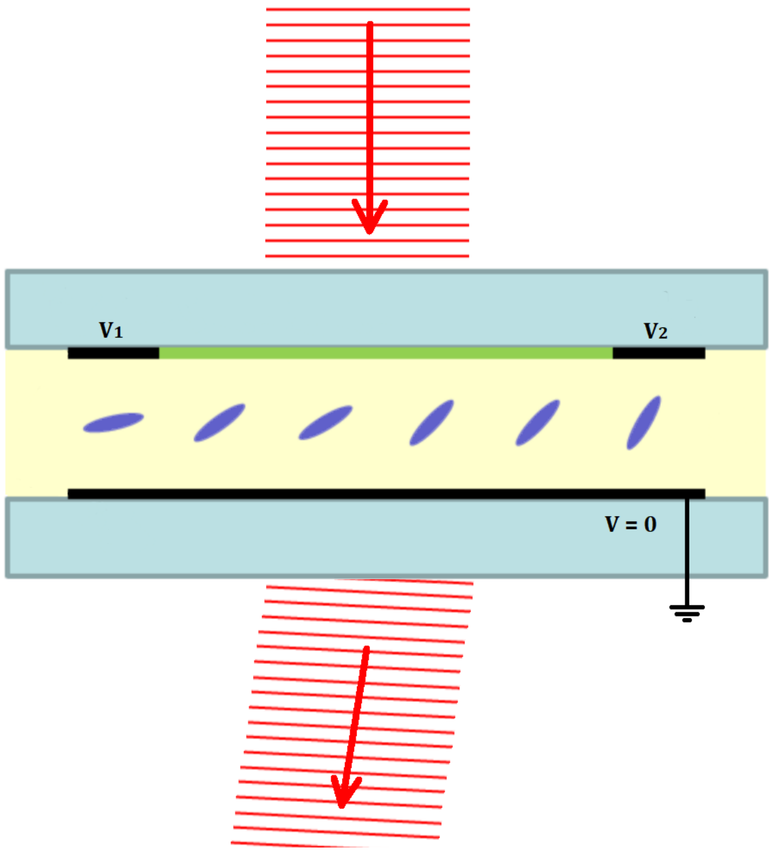
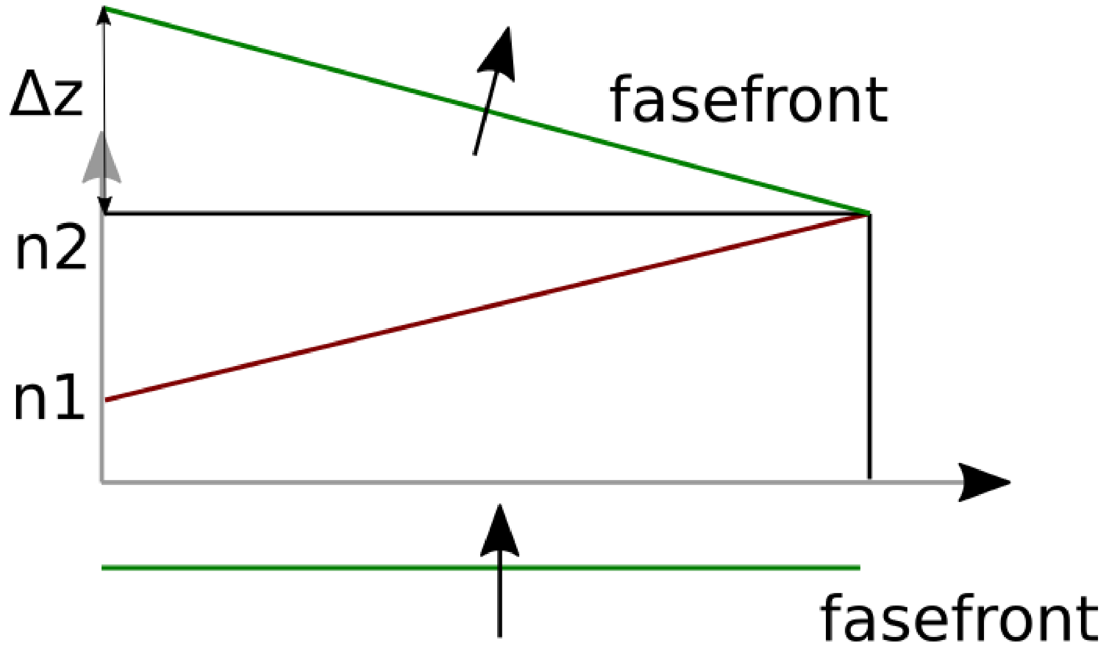
Inleiding

- Doelstelling van dit project:
  - Inkomende vlakke lichtbundel deflecteren
  - Hoek exact elektronisch sturen
  - Hoek zo groot mogelijk
  - Device zo klein mogelijk



Principe

- Typische waarden:
  - $\Delta n = 0.2$
  - $L = 50\text{-}100\ \mu m$
  - $d = 5\text{-}20\ \mu m$
- $\Theta \approx \Delta n\ d/L = 4.5°$

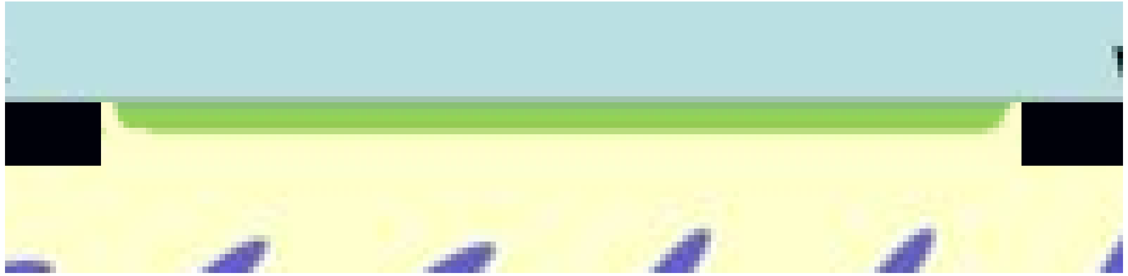


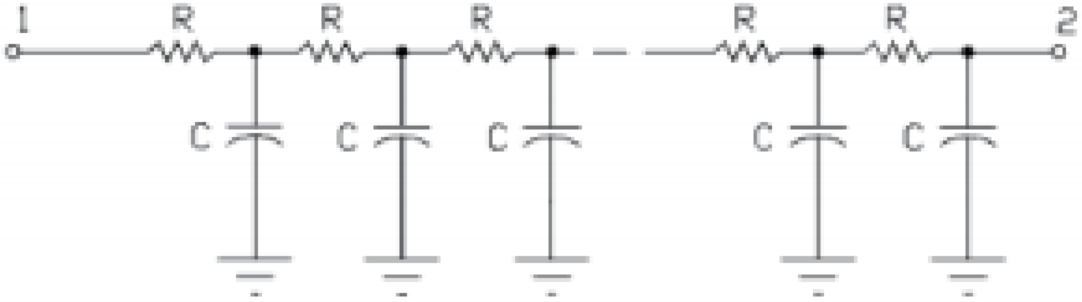
Problemen met het 1e ontwerp

- 20µm vloeibaar kristal
- 5nm laag germanium

$$x_0^c = \sqrt{\frac{\sigma d d_1}{\omega \varepsilon_\perp}}$$

d = dikte LC
d_1 = dikte germanium

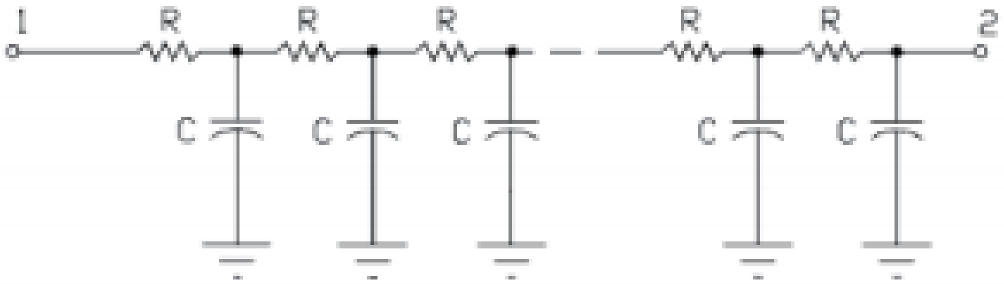




De oplossing: dikker germanium

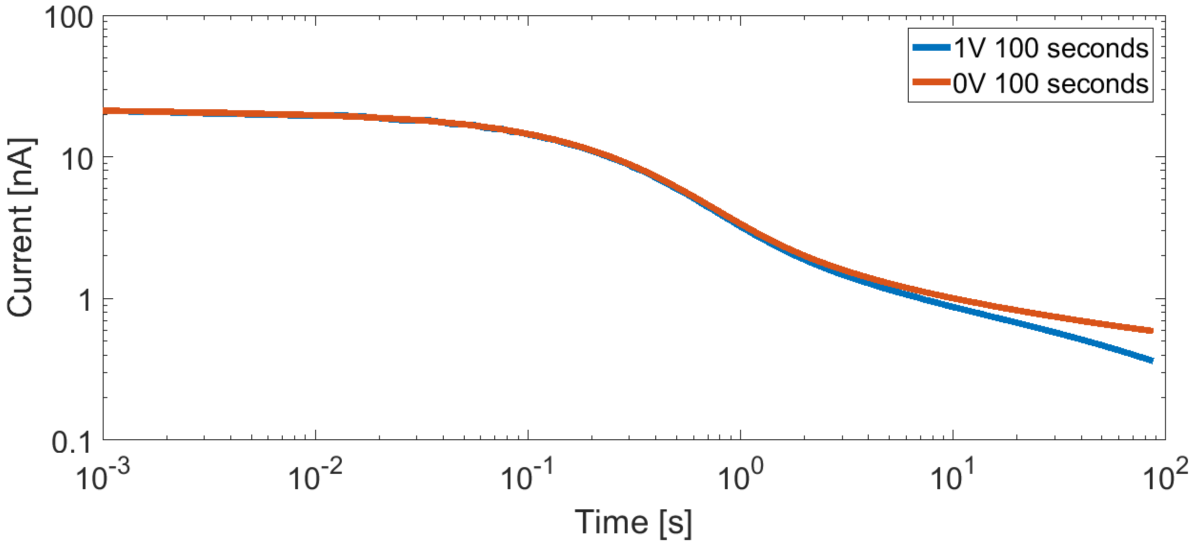
Dikte germanium: 5nm -> 50nm

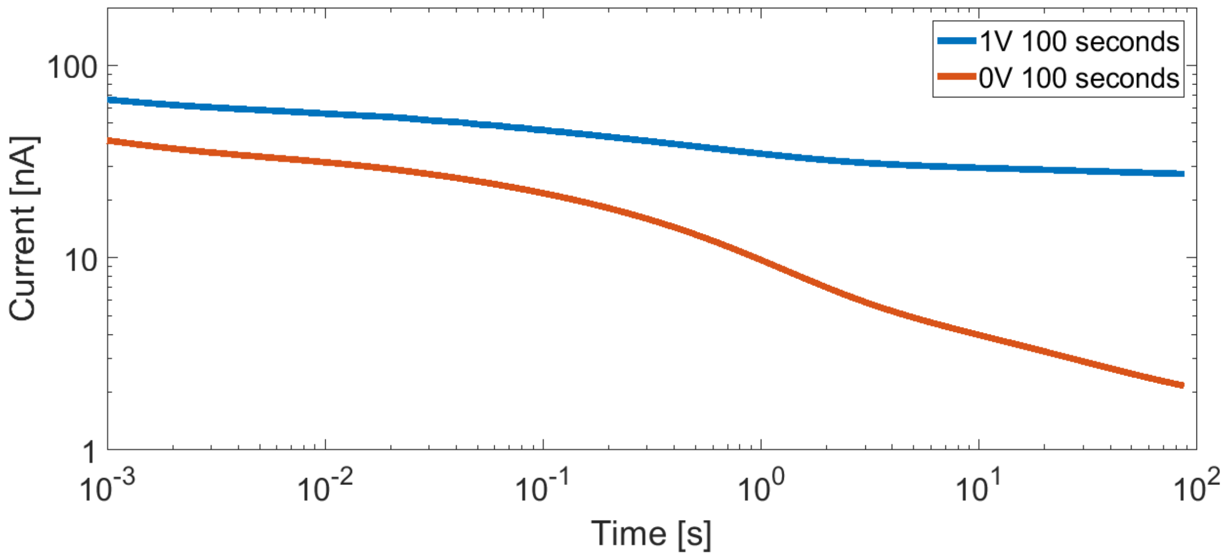
Karakteristieke lengte: x_c -> $\sqrt{10}\, x_c$



IV metingen

Capactieve effecten treden op bij het te dun germanium

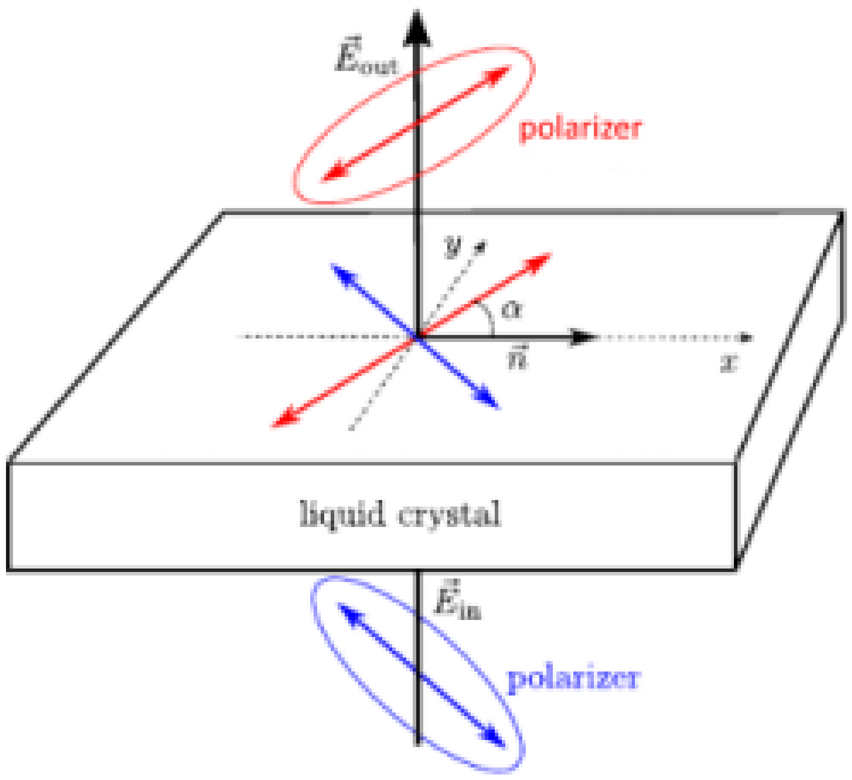




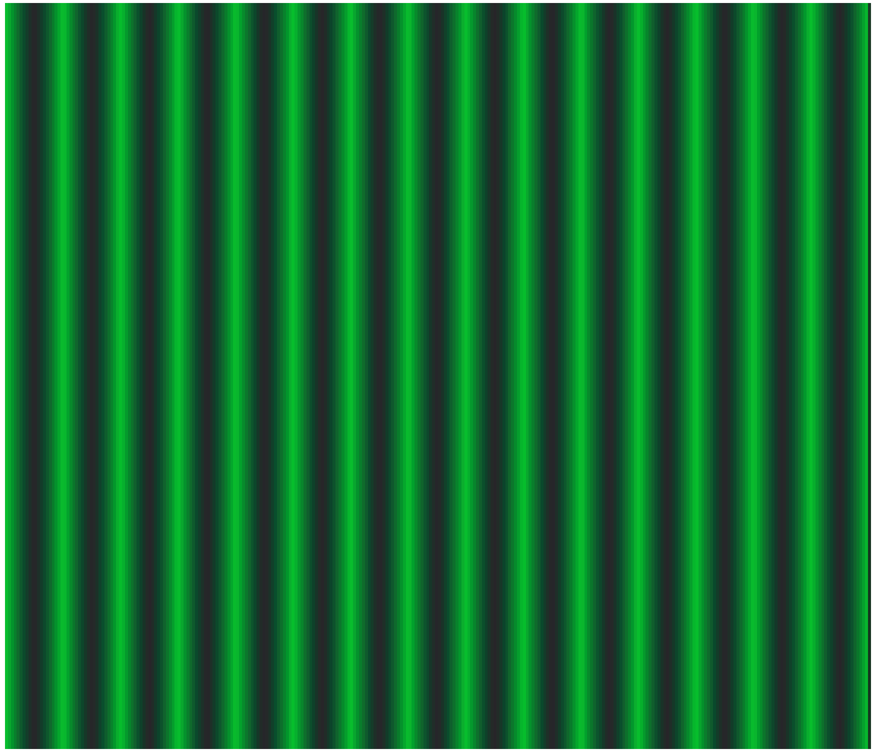
Microscopie - Theorie

$$I = sin^2\left(\frac{\pi \Delta n d}{\lambda}\right)$$

$$n_e(x) = n_o + Cx \Rightarrow I \propto sin^2\left(\frac{C\pi d}{\lambda}x\right)$$



Microscopie - Praktisch



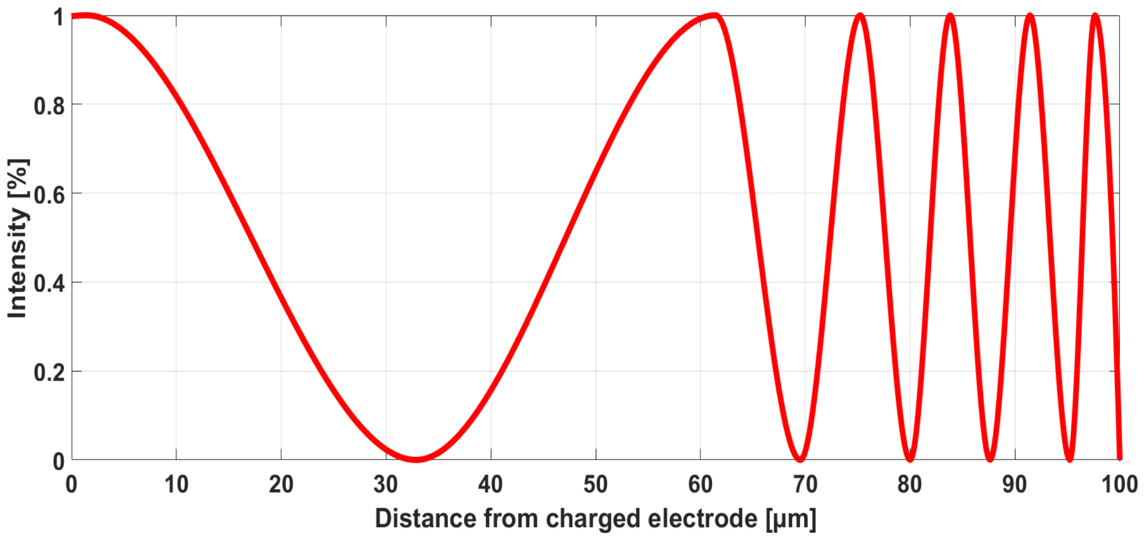
Microscopie - Praktisch

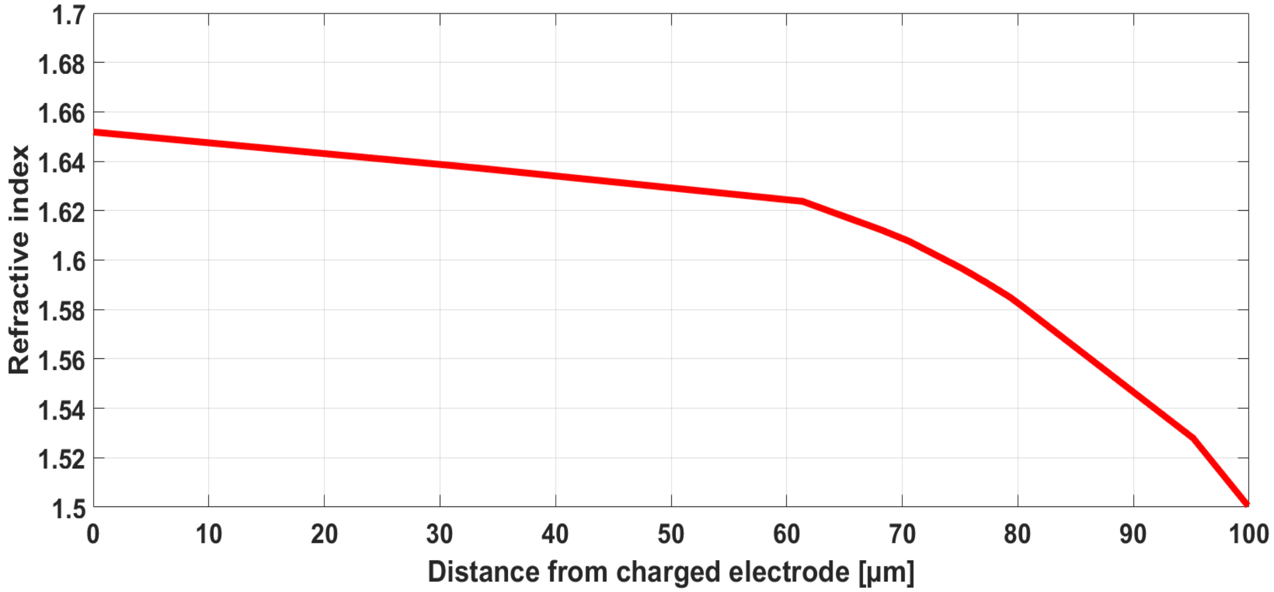
$$n_e(x) = n_0 + \frac{\lambda}{\pi d} arcsin(\sqrt{I(x)})$$

$$I(x) \propto sin^2(\frac{2\pi}{T}x)$$

=>

$$n_e(x) = n_0 + \frac{2\lambda}{Td}x$$

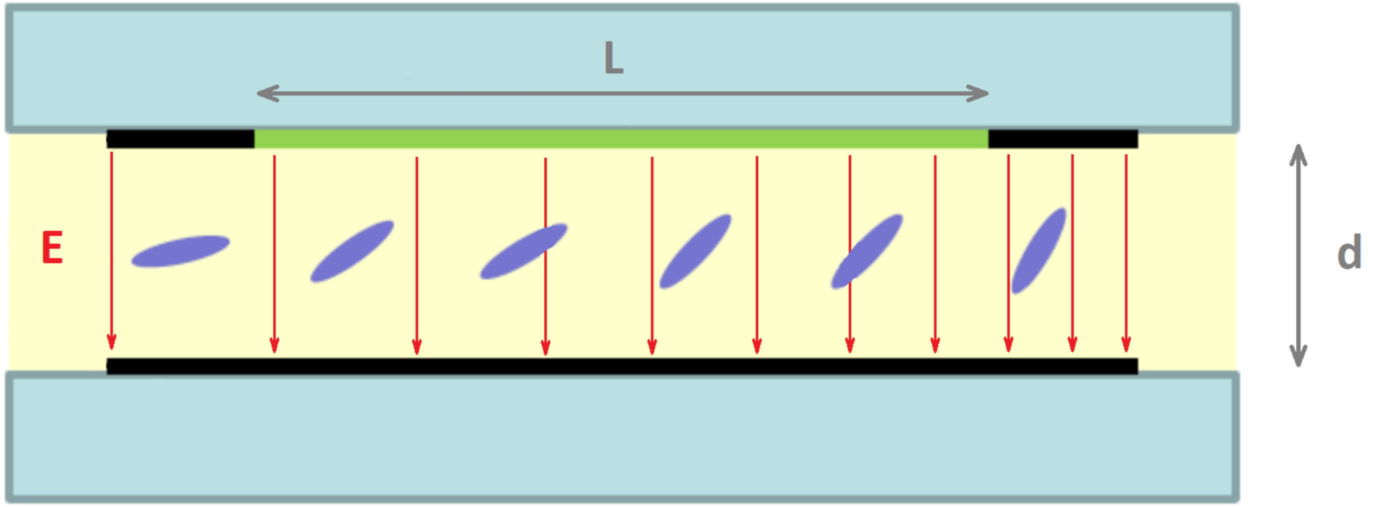


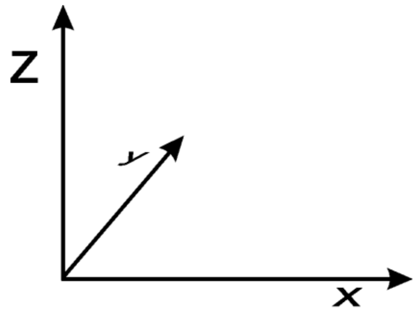


1D simulatie

$$d \ll L \quad \Rightarrow \quad \vec{E} \approx E\,\vec{u}_z$$

$$\frac{\mathrm{d}^2 V}{\mathrm{d}x^2} = j\frac{\omega\varepsilon_{eff}}{d_1 d\sigma}V$$





1D: conclusie

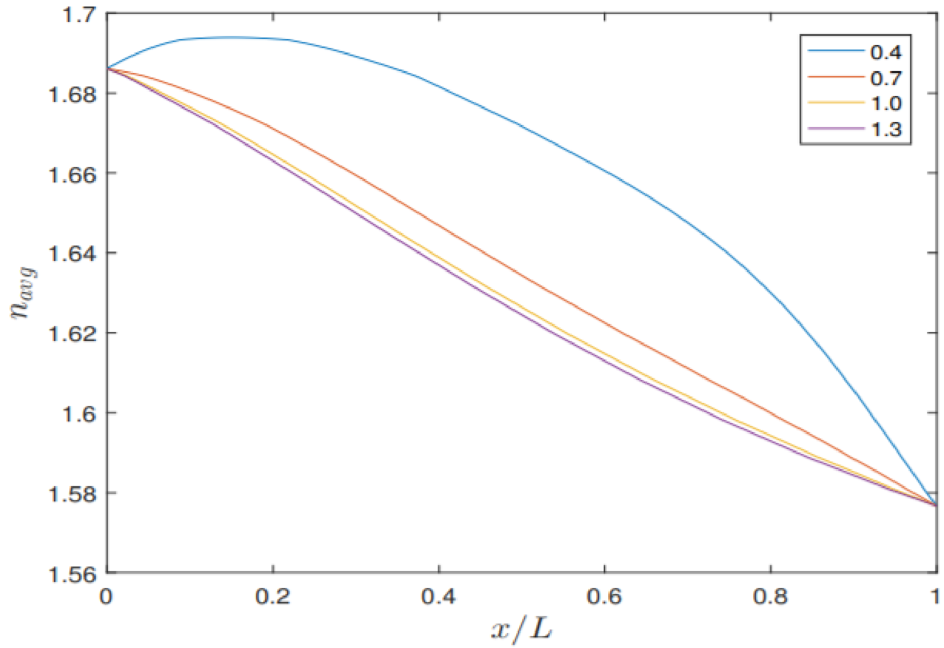
Meerdere frequenties:

$$\frac{\mathrm{d}^2 V_1}{\mathrm{d}x^2} = j\frac{\omega_1 \varepsilon_{eff}}{d_1 d\sigma} V_1$$

$$\frac{\mathrm{d}^2 V_2}{\mathrm{d}x^2} = j\frac{\omega_2 \varepsilon_{eff}}{d_1 d\sigma} V_2$$

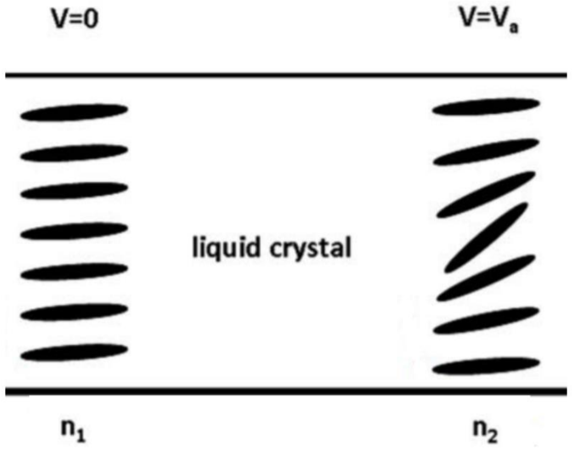
$\theta(deg)$	$V_1(0)(V)$	$V_1(L)(V)$	x_{c1}/L	$V_2(0)(V)$	$V_2(L)(V)$	x_{c2}/L
0.5	1.06	1.32	1.00	0.00	0.00	0.97
1.0	1.06	1.57	1.00	0.00	0.01	1.04
1.5	1.03	1.88	1.00	0.00	0.03	1.07
2.0	1.00	2.22	1.00	0.00	0.02	1.47
2.2	0.98	2.21	1.00	0.00	0.03	1.44

Eén frequentie:

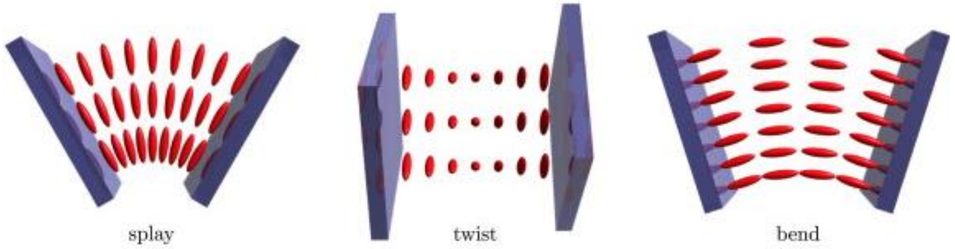


2D simulatie

z - afhankelijkheid



Complex microscopisch gedrag



$$-\nabla \cdot (\overline{\overline{\varepsilon}}\, \nabla V) = 0$$

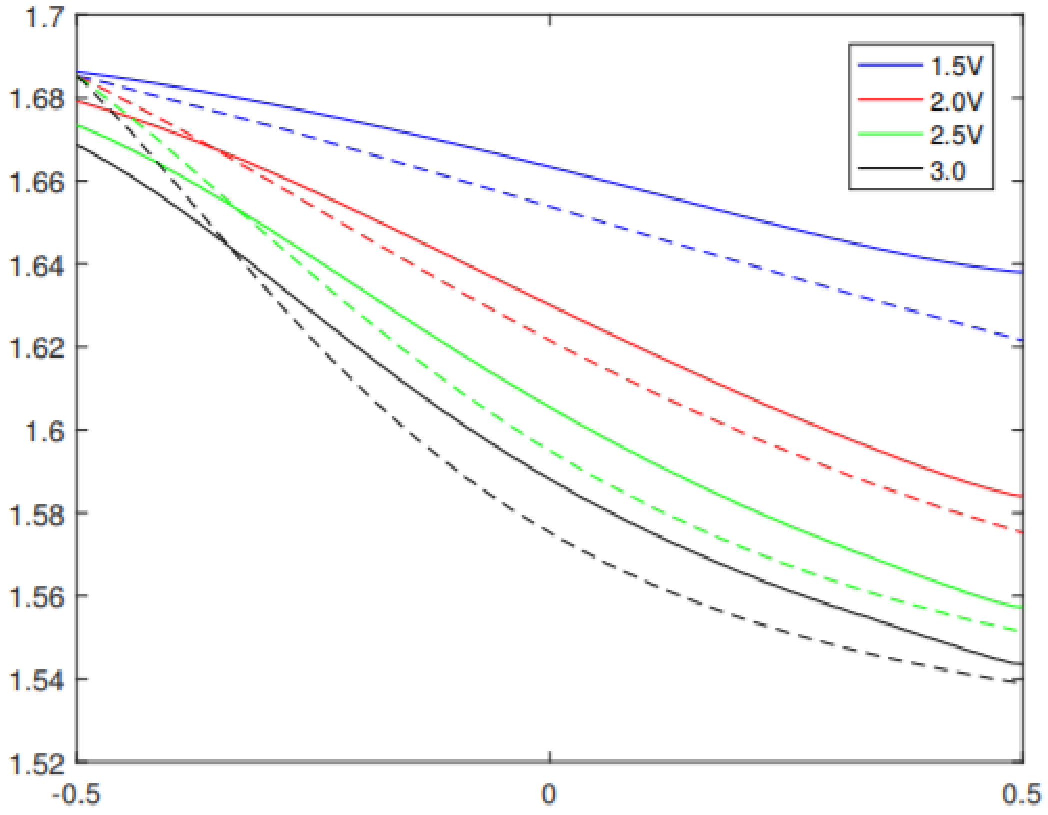
$$-K\nabla^2\theta = \frac{1}{2}\Delta\varepsilon\left(-\sin(2\theta)E_x^2 + \cos(2\theta)E_xE_z + \sin(2\theta)E_z^2\right)$$

2D: Conclusie

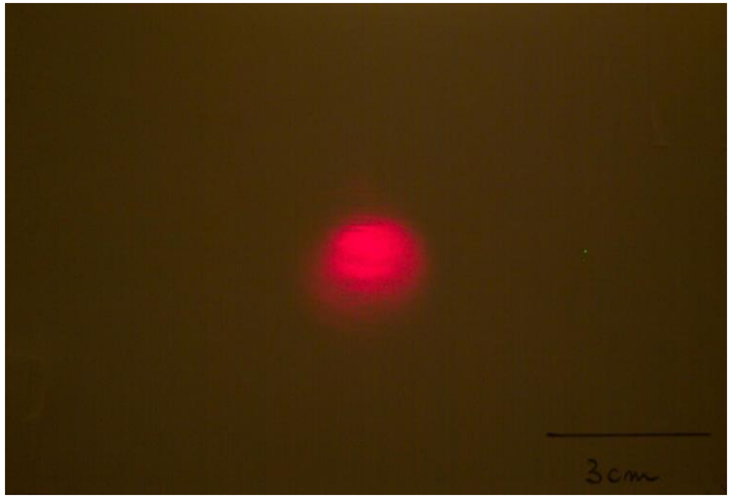
Rekenkundig veel intensiever

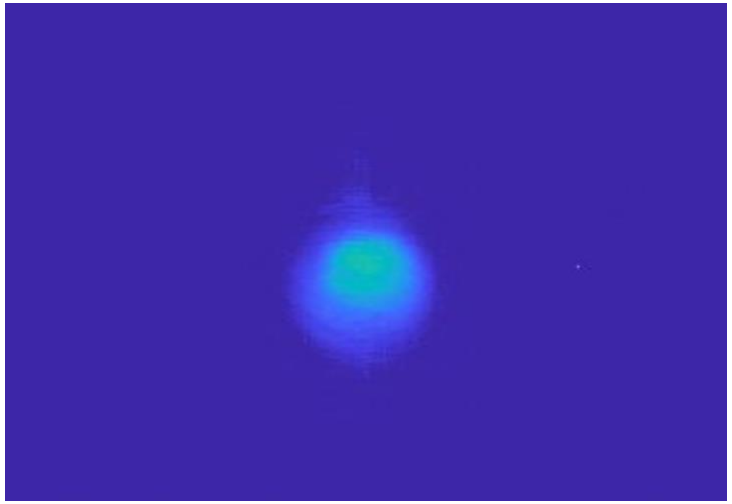
Trend gelijkaardig aan 1D simulatie

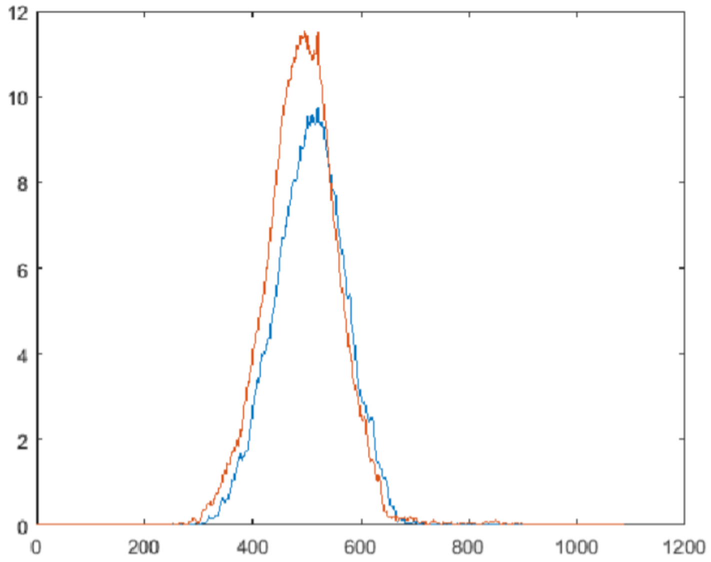
Algemeen: hogere brekingsindex



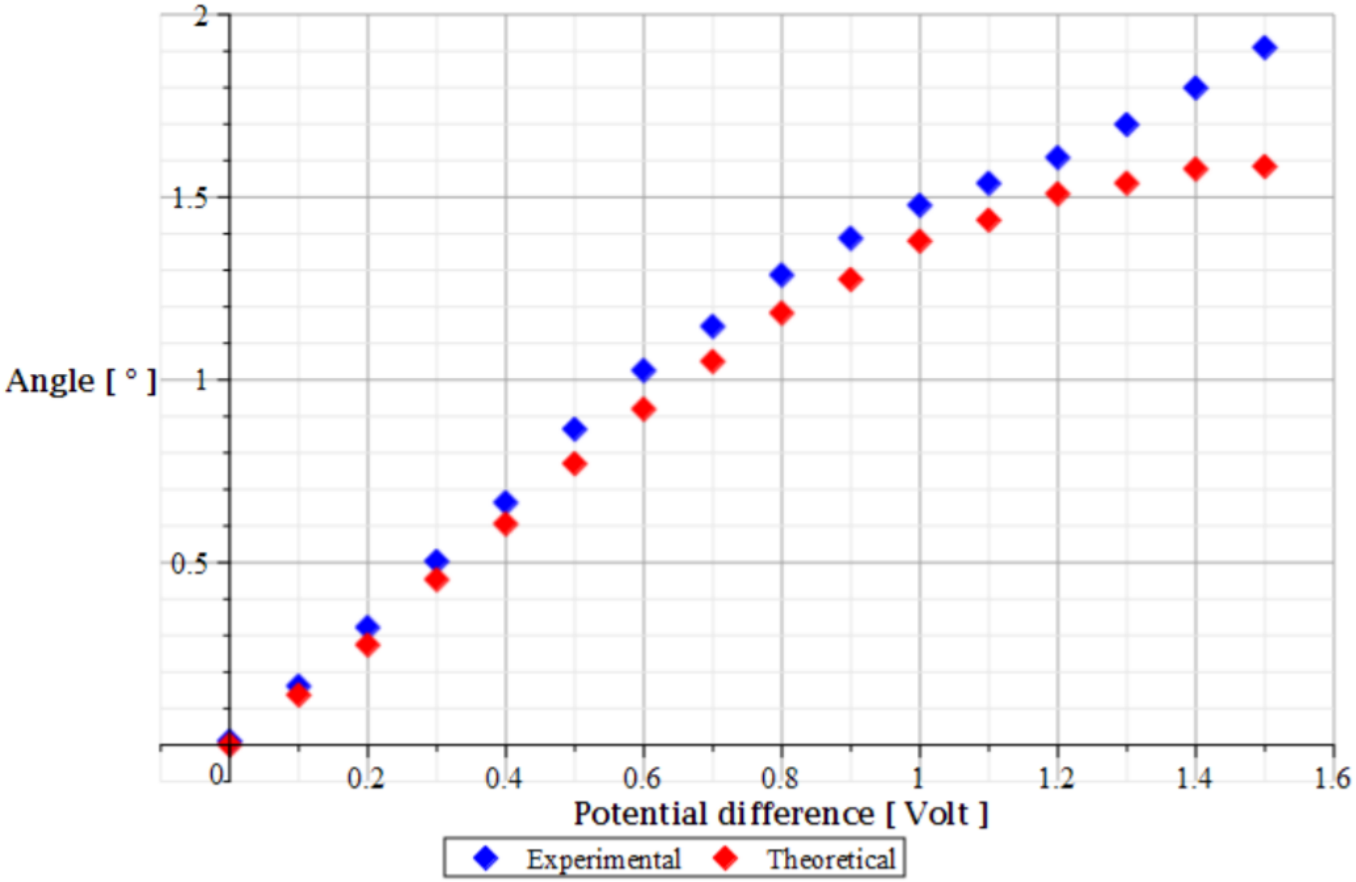
Experimentatie





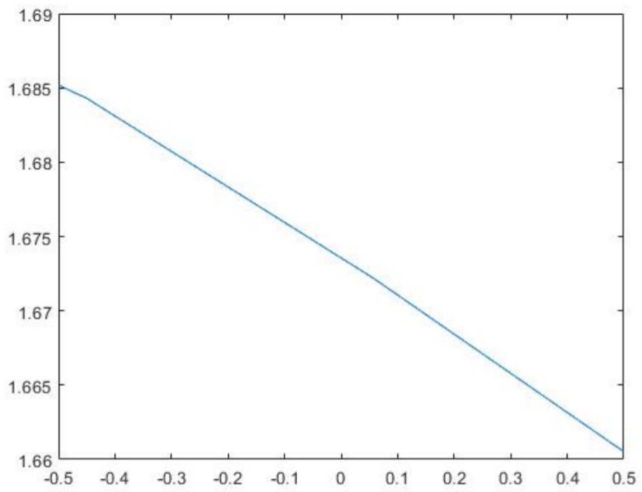


Experimentele resultaten

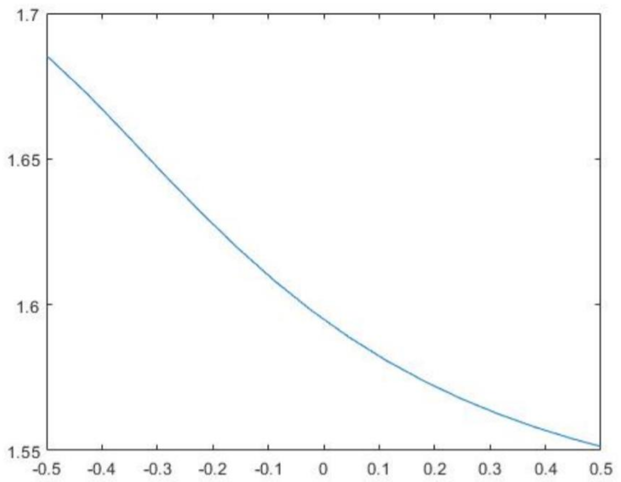


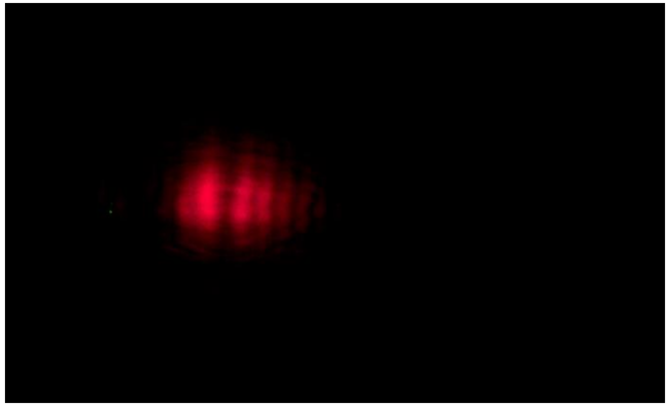
Experimentele resultaten

$\Delta V = 0.2\, Volt\ RMS$

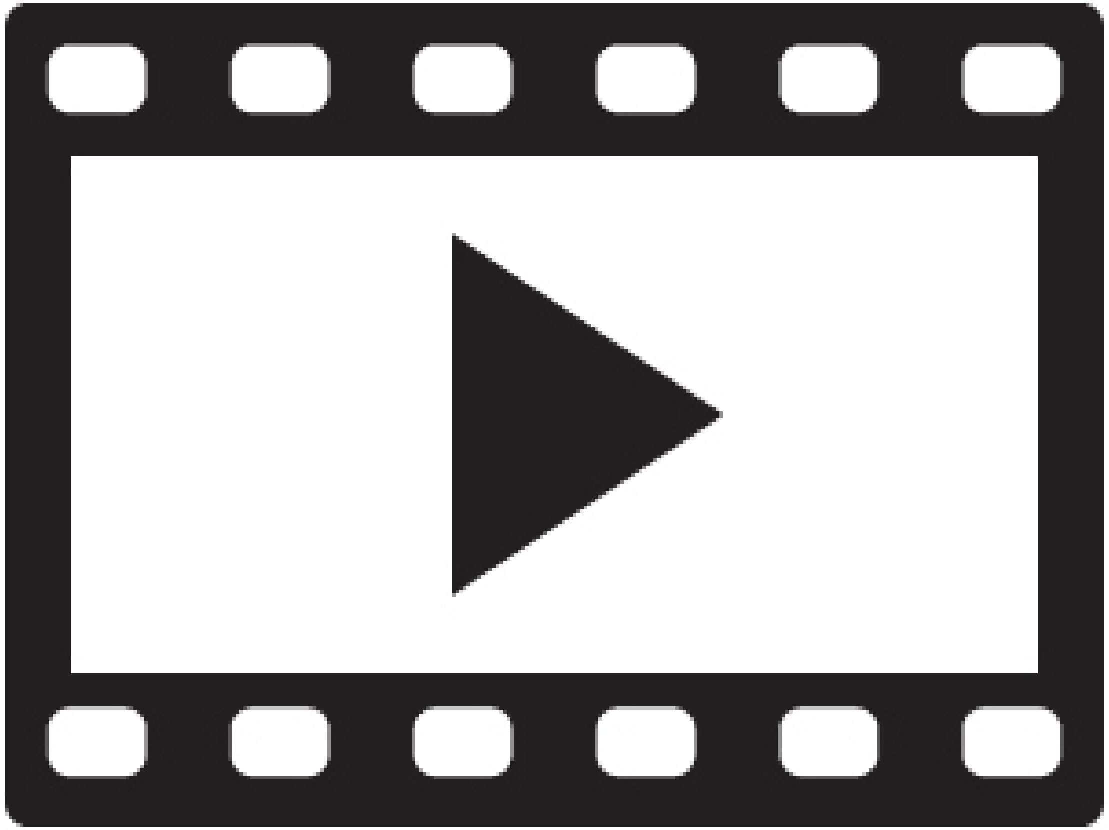


$\Delta V = 1.5\, Volt\ RMS$





Filmpjes



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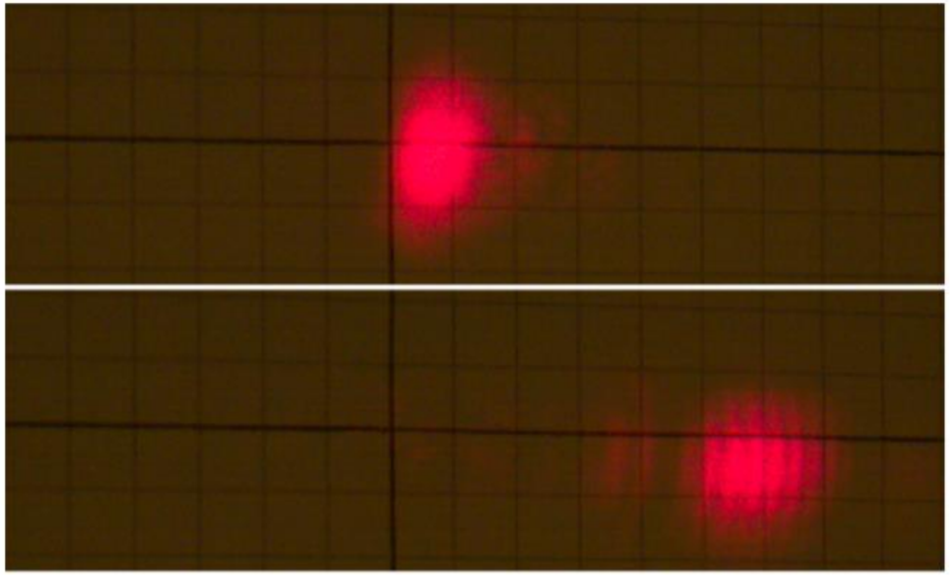
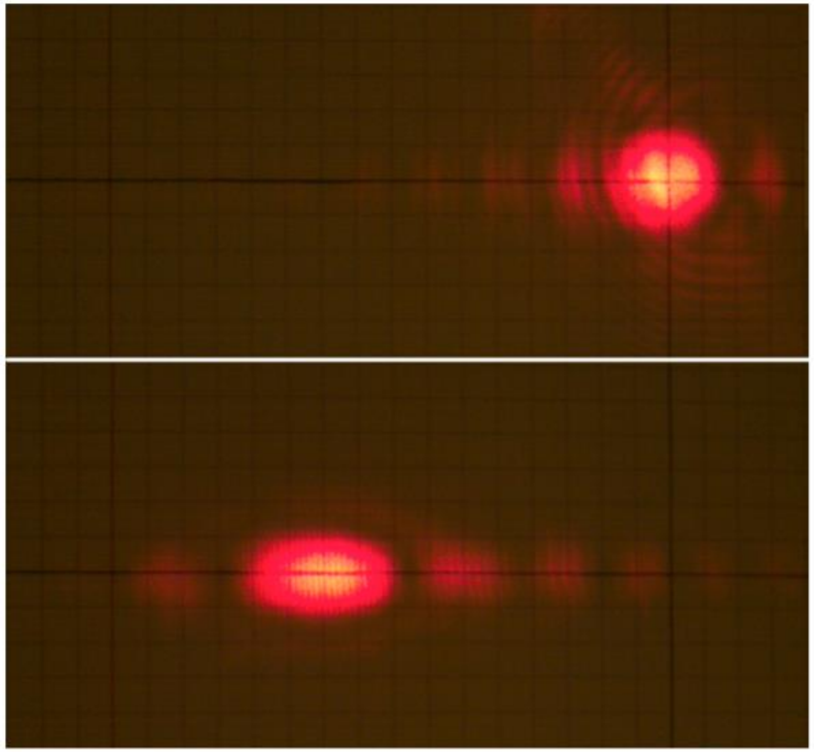
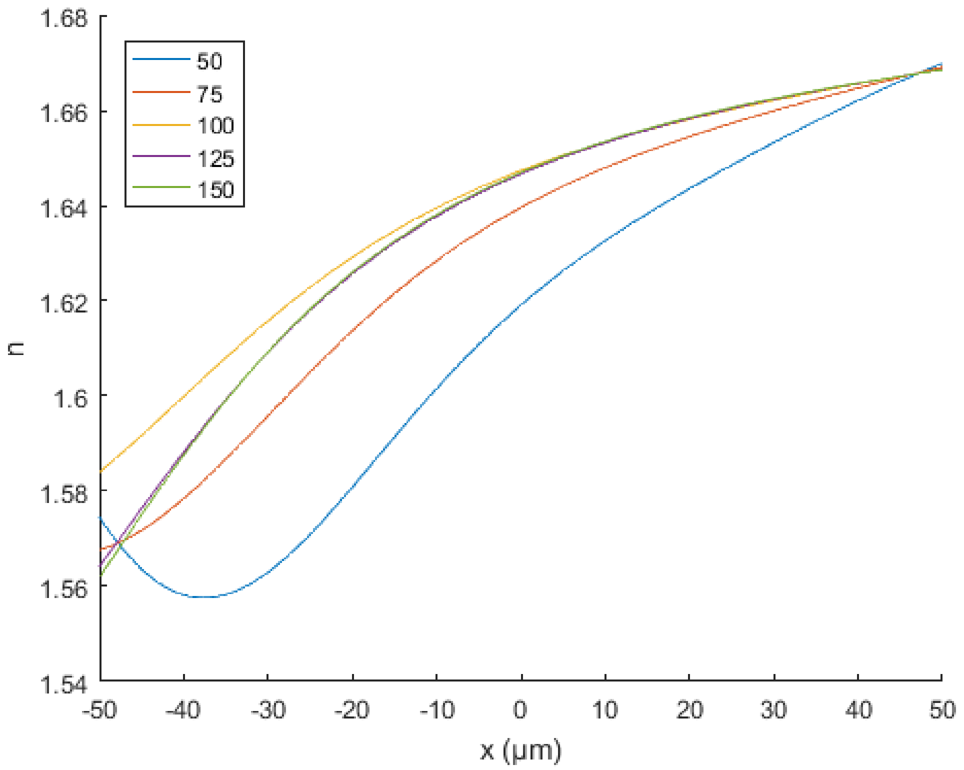




Extra Slides

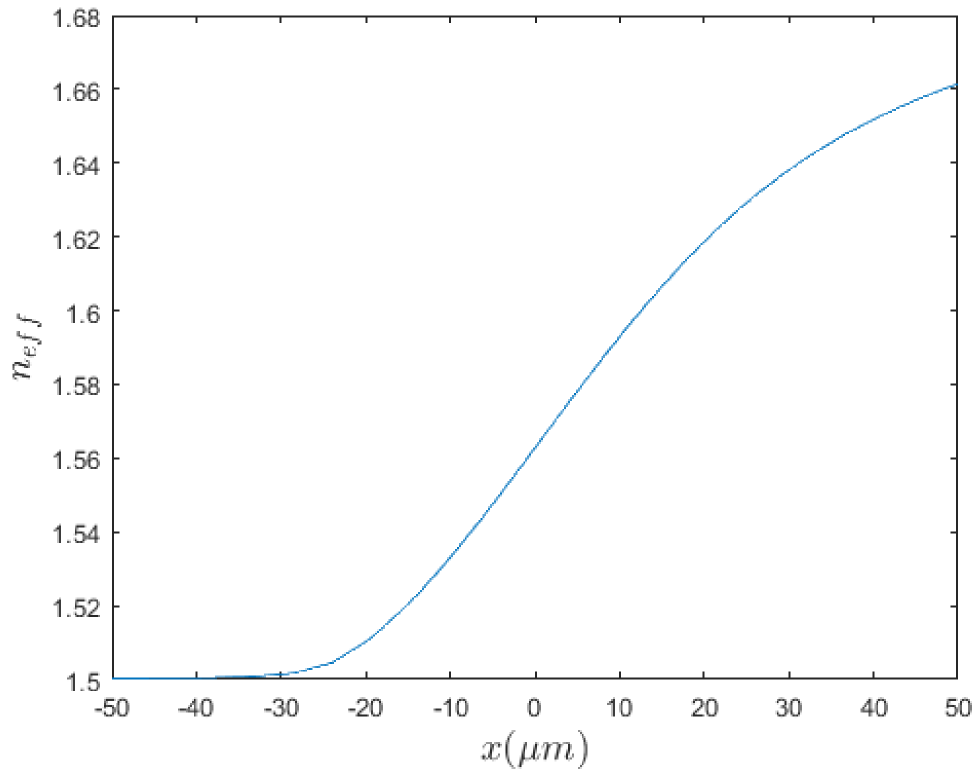
(Gemiddelde) brekingsindex



- Duidelijk niet lineair
- Mogelijke oplossing:
  - Invoeren extra parameters en optimaliseren

Optimalisatie

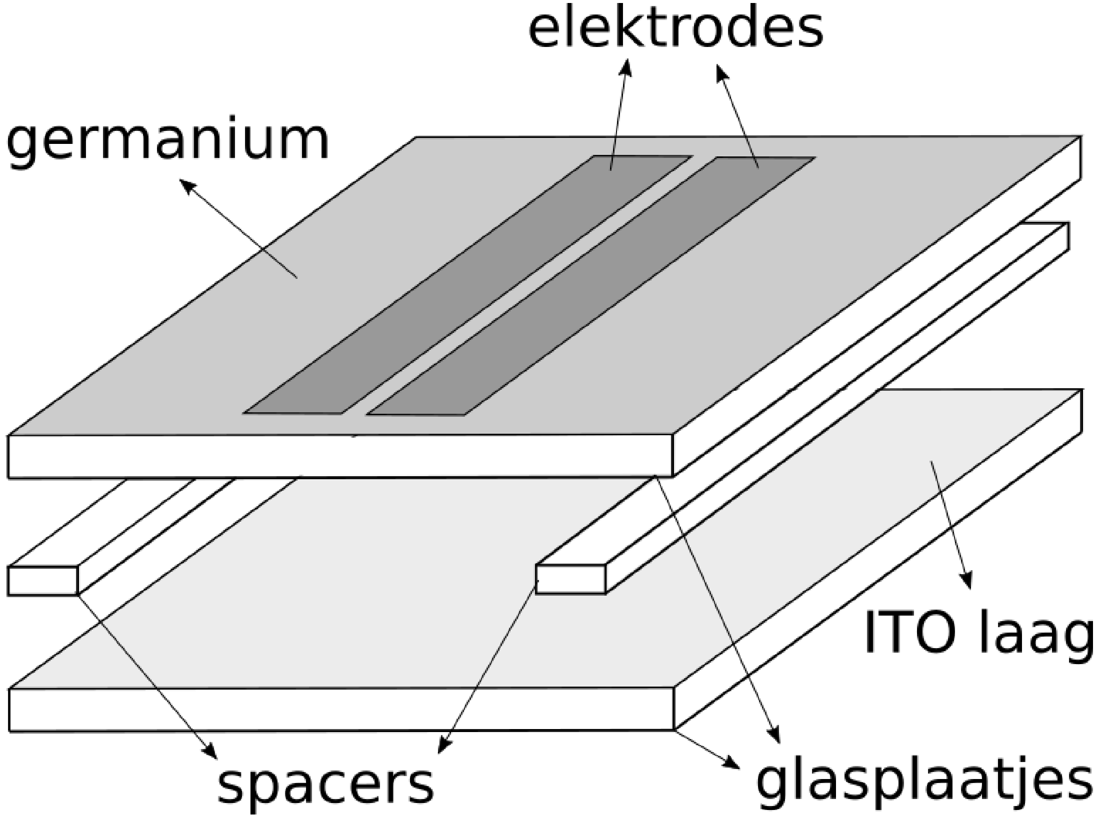
- Aanleggen meerdere frequenties
- Minimaliseren kostenfunctie: divergentie/stuurhoek
  - Moeilijk algoritmisch
  - Voorlopig trial and error
- Slechts beperkt gebied lineair



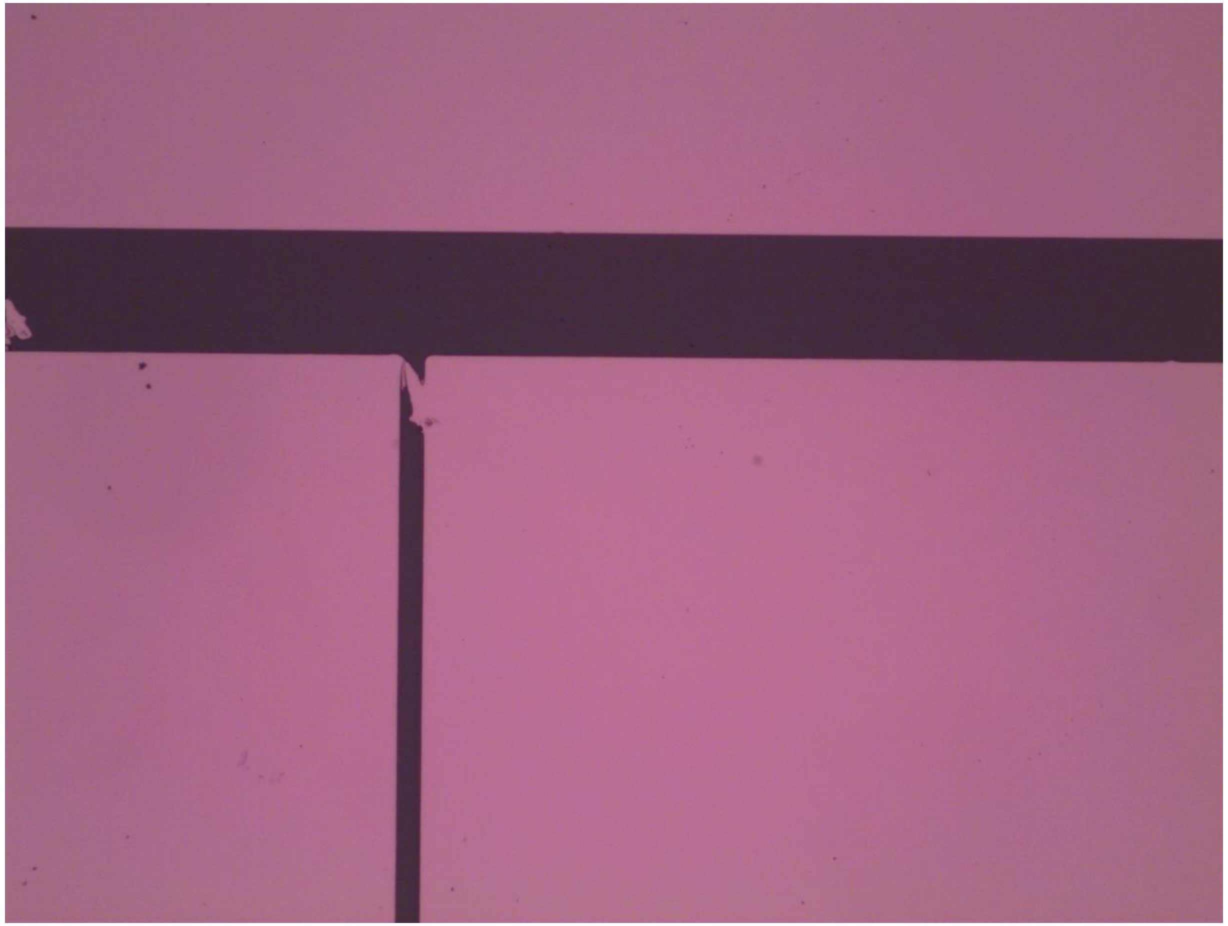
Cleanroom

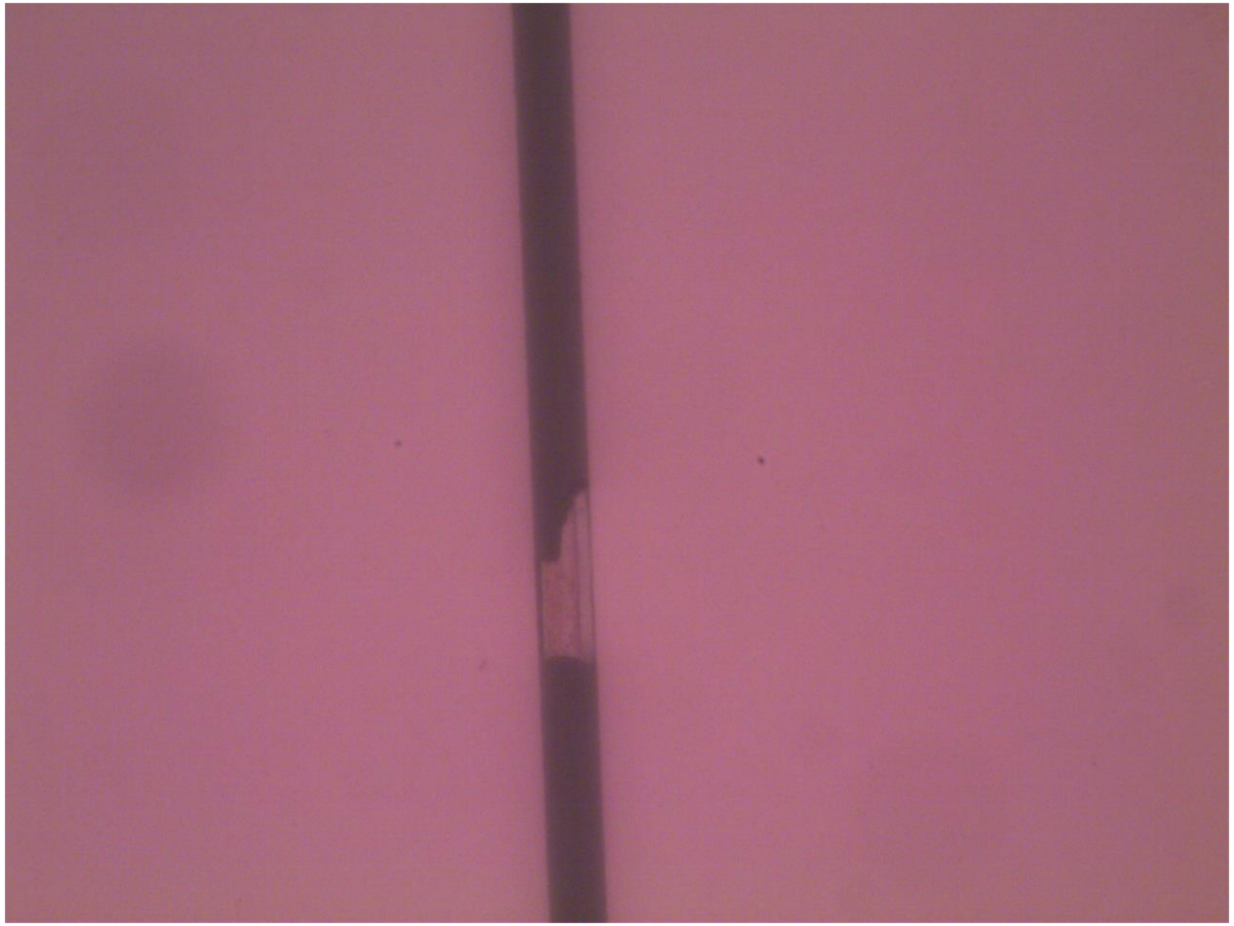
Productie Sample

1. Glassubstraat met geleidende ITO-laag
2. Elektrodes: lithografie
3. Zwak geleidende laag: sputtering germanium
4. Uitlijningslaag: spincoating nylon
5. Vloeibaar kristal: capillaire werking



MICROSCOOP

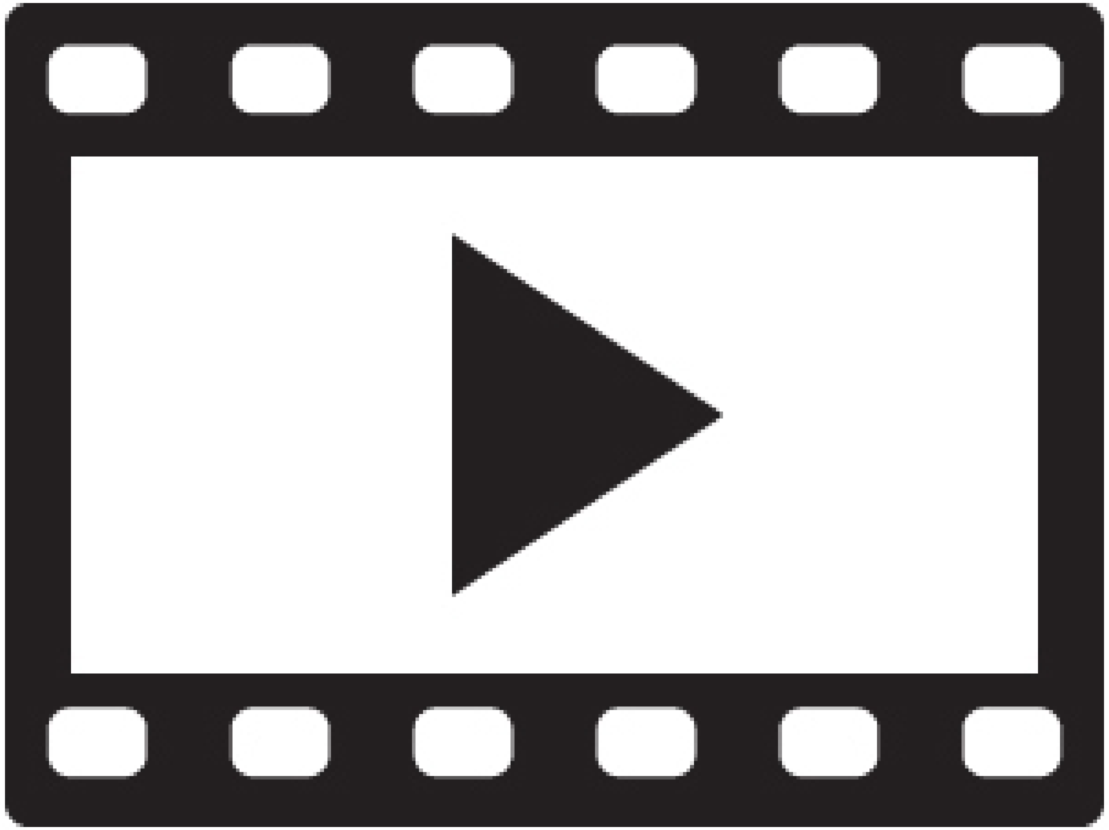




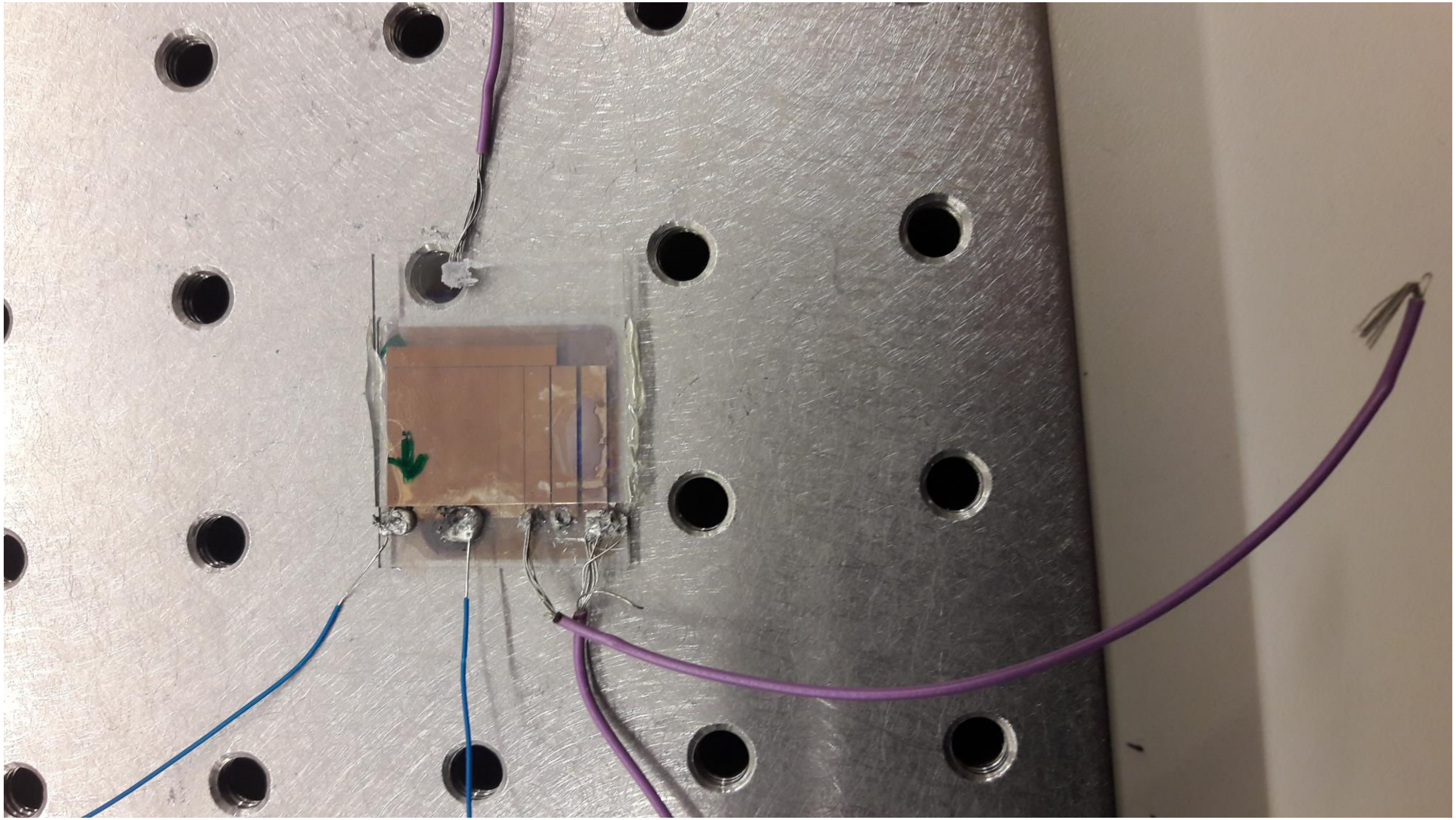
Planning toekomst

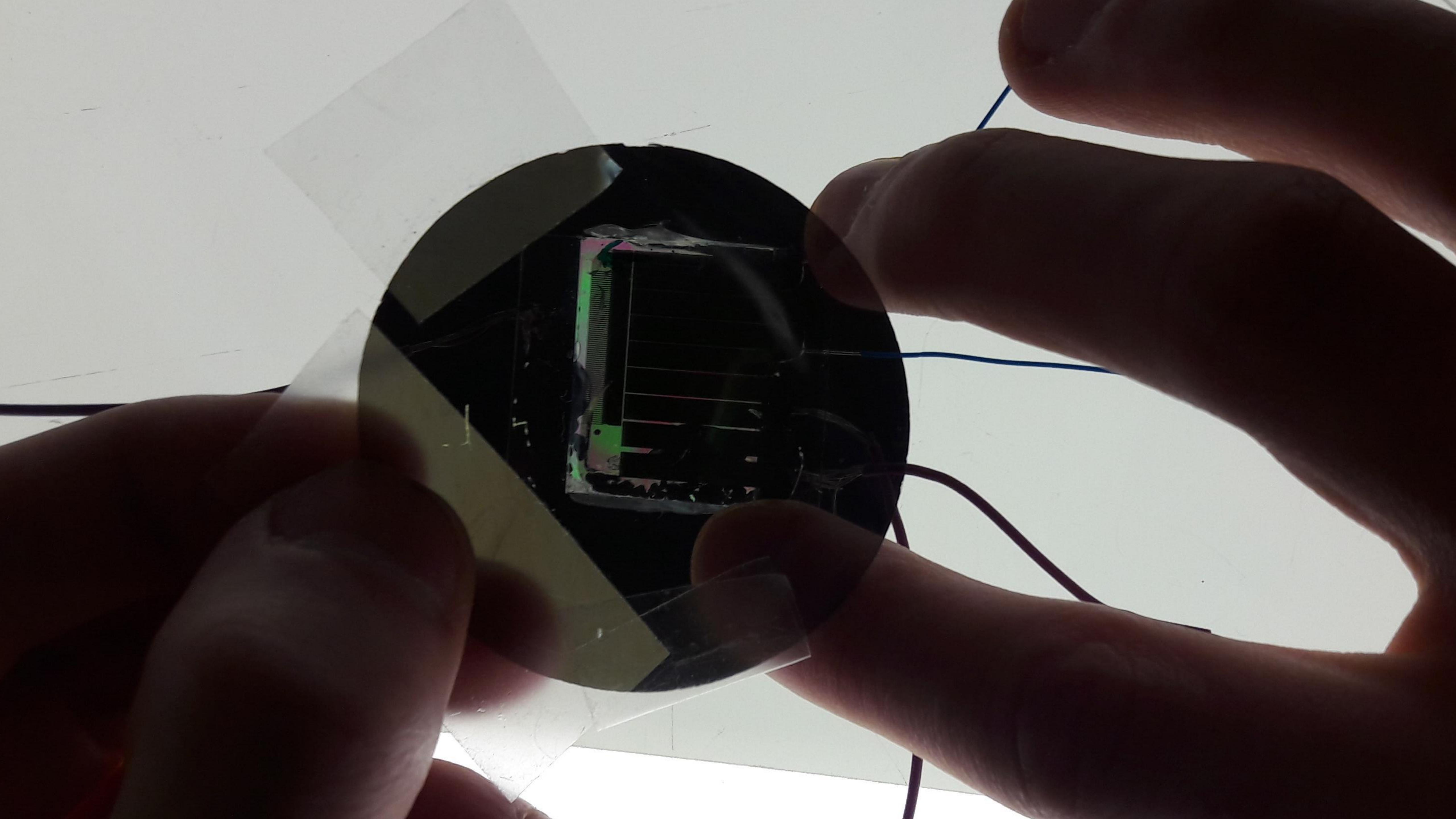
- Moeilijkheden sample oplossen
  - Lijm, UV-lamp kapot?
  - Tussentijd: optimalisatie, 2D
- Experiment vergelijken met theorie
  - Revisie
  - Gegeven sturing realiseren

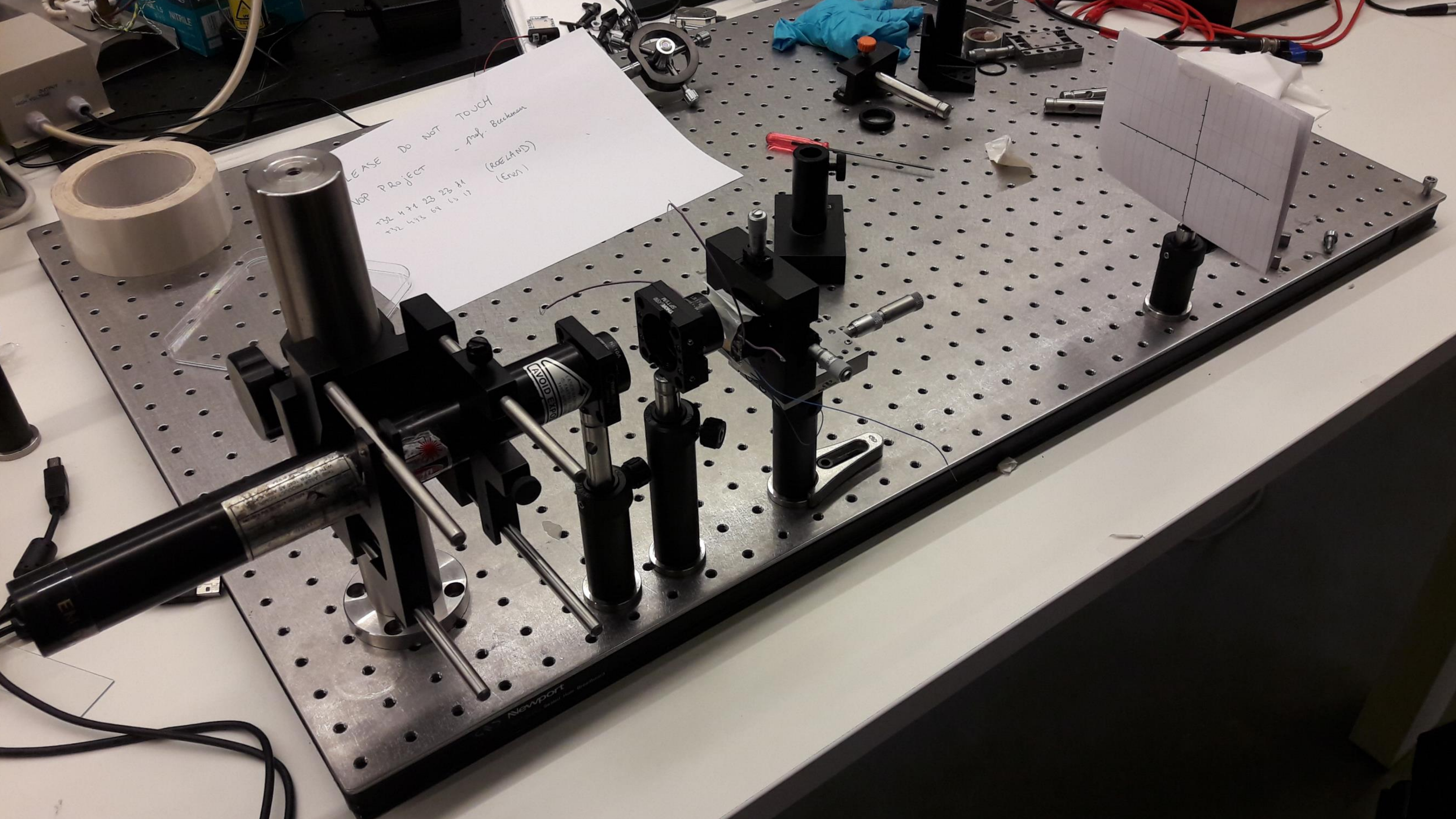
Filmpje



Extra slides (voor eventuele vragen toe te lichten)



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