Return electrode optimisation in the organic electrolytic photocapacitor

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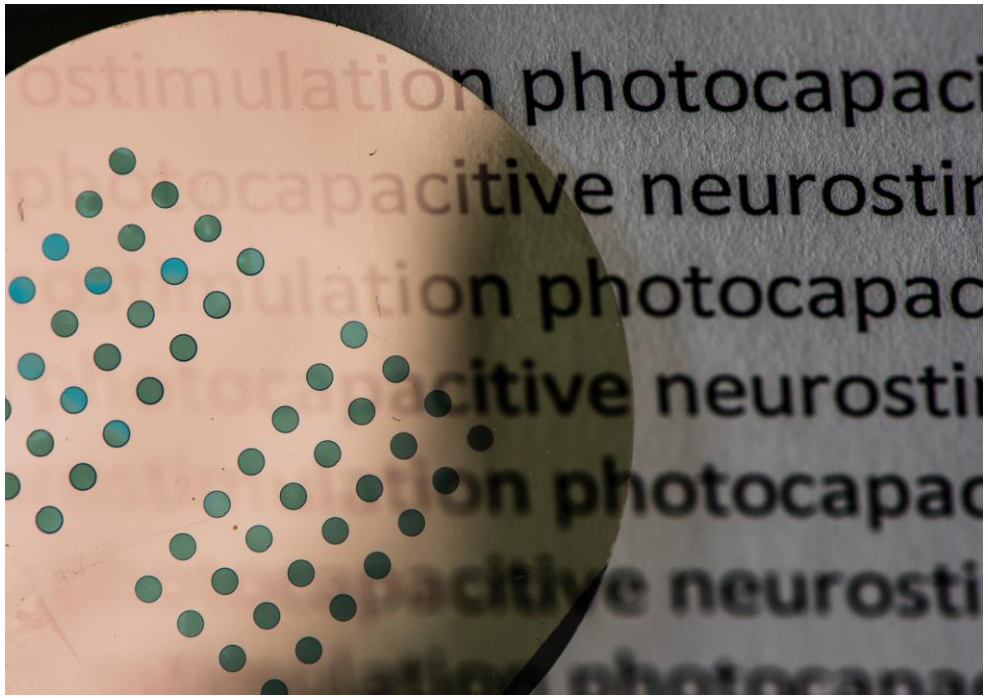

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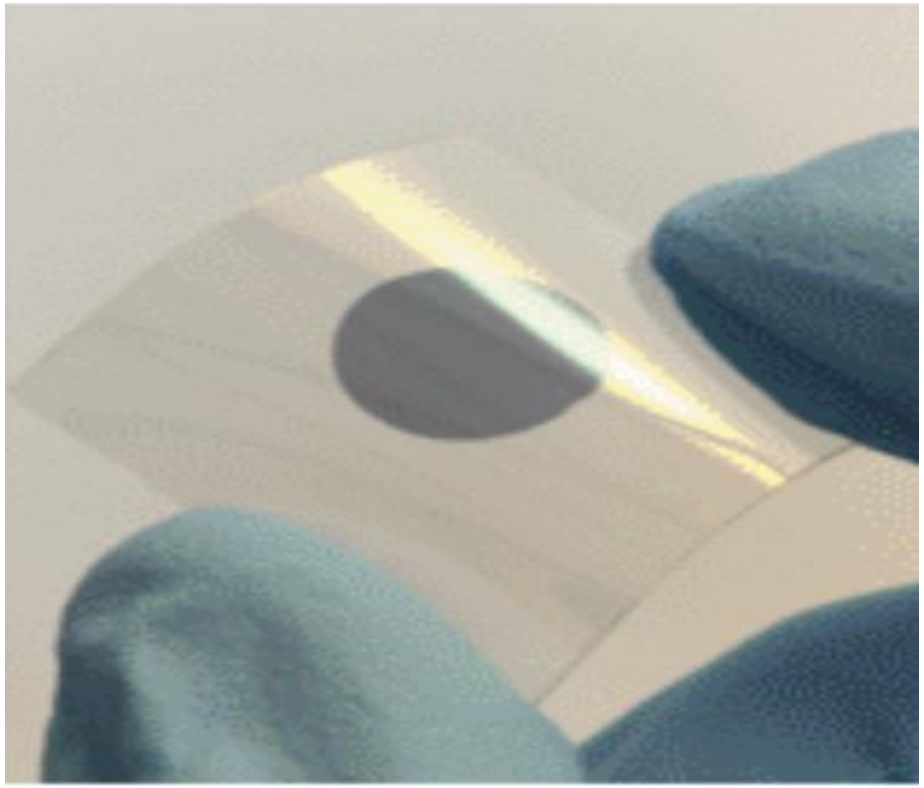
Introduction - What is OEPC?



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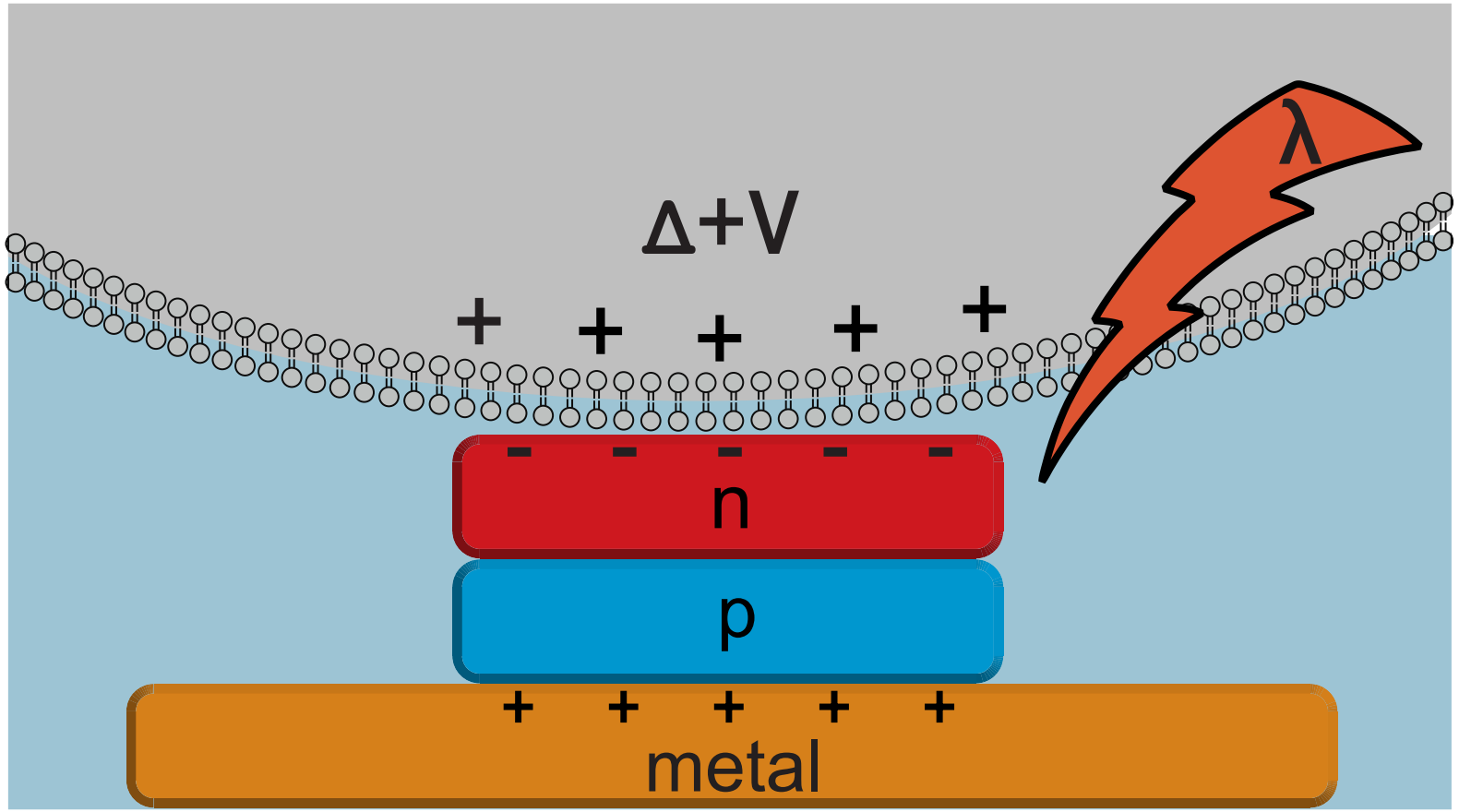
- electronic devices
- light stimulation
- manipulation of electrophysiological processes
- wireless, light sensitive version: organic electrolytic photocpacitor (OEPC)

Introduction – What is OEPC?

- ~ 80 nm thick trilayer: return electrode + p-n organic semiconducting nanocrystal bilayer immersed into electrolytic solution
- photoinduced charge transfer between the p-n layer
- accumulation of charges creates a bilayer with the surrounding electrolyte
- transductive electric potential → localised change of membrane potential

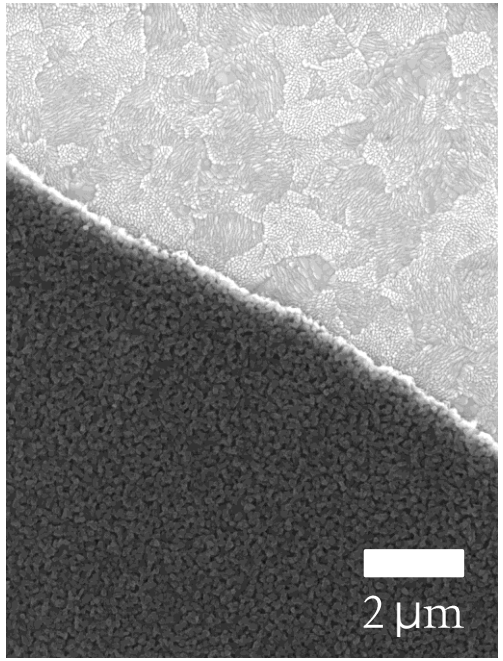
Introduction - What is OEPC?



cell membrane

extracellular cell

Introduction - What is OEPC?



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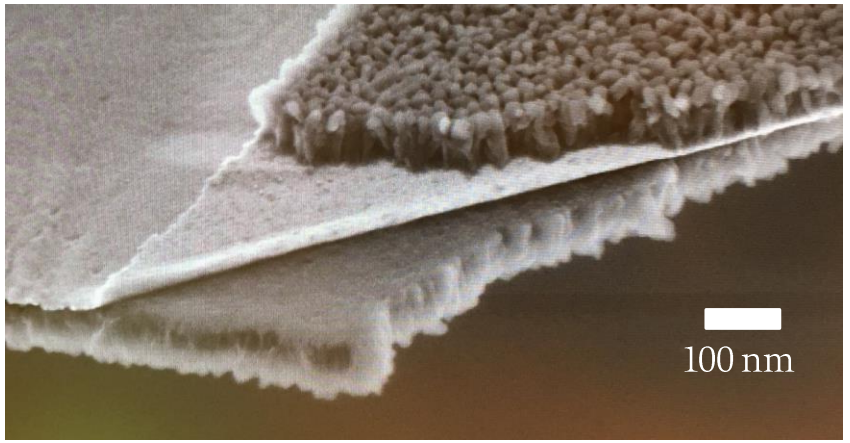
Why use organic materials?

- less invasive
- non-toxic and compatible for the biological tissue
- extremely thin layers (nanometric dimensions)
- more stable and long lasting – suited for non-dry conditions



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Introduction - Ion currents

ion current in the electrolyte

capacitive

- ideal OEPC
- RC circle

faradaic

- generated by reduction or oxidation reaction

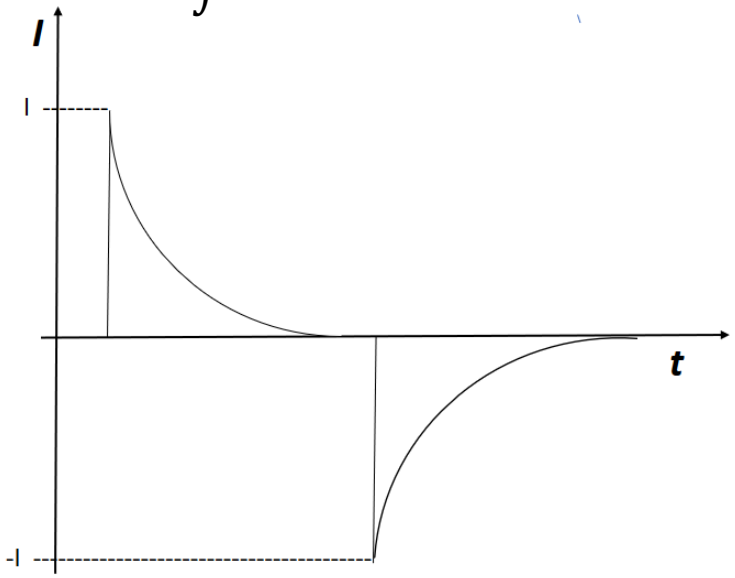
mixed

- real OEPC
- part of ions undergo electrochemical reactions

Introduction - Ion currents

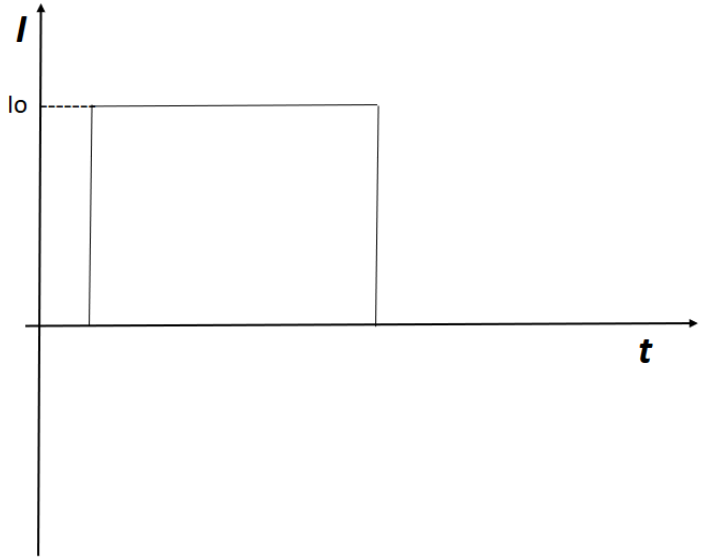
capacitive current

$$\int Idt = 0$$



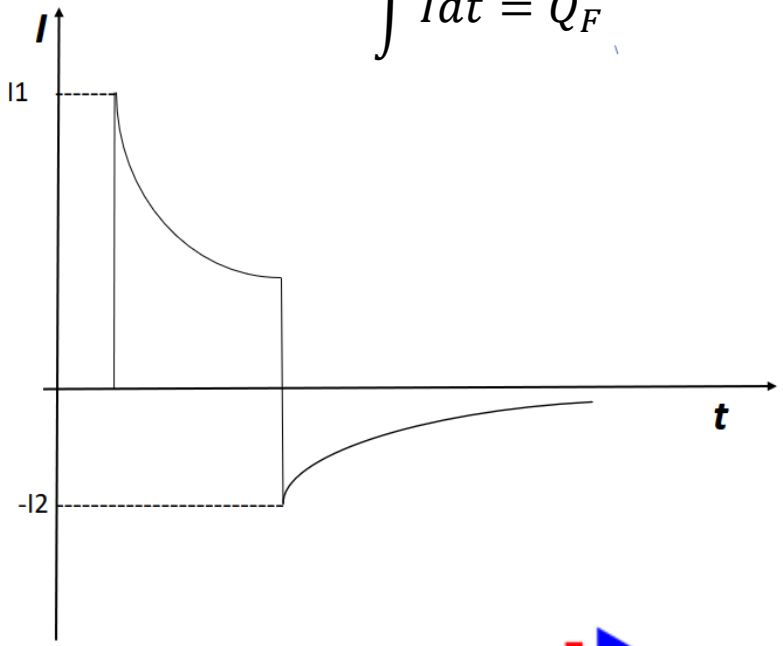
faradaic current

$$\int Idt = I_0 \Delta t = Q_F$$

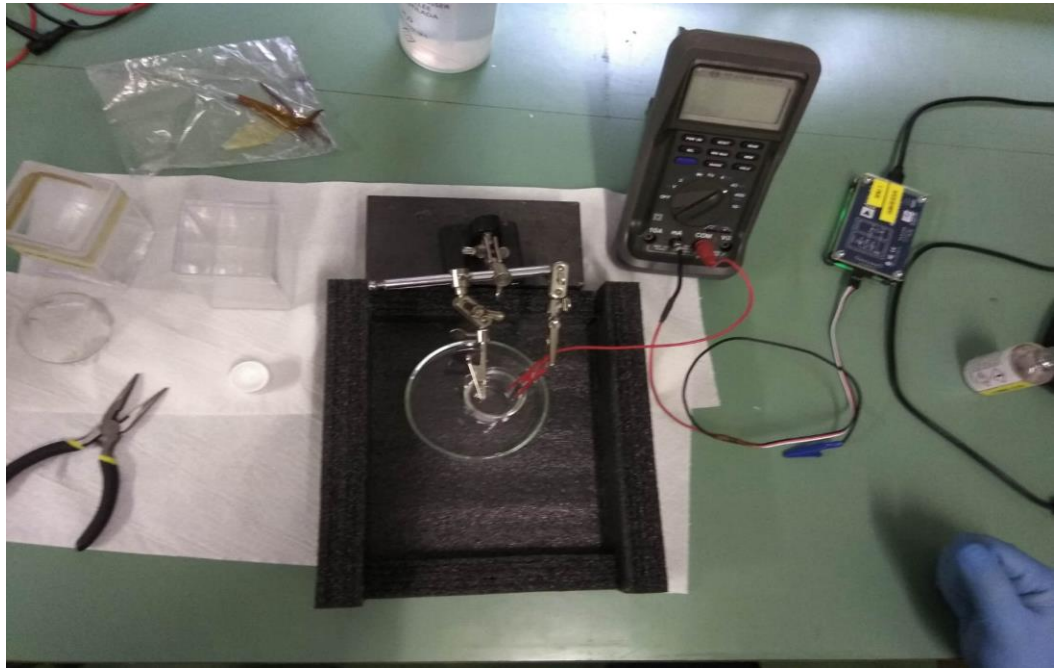


mixed current

$$\int Idt = Q_F$$

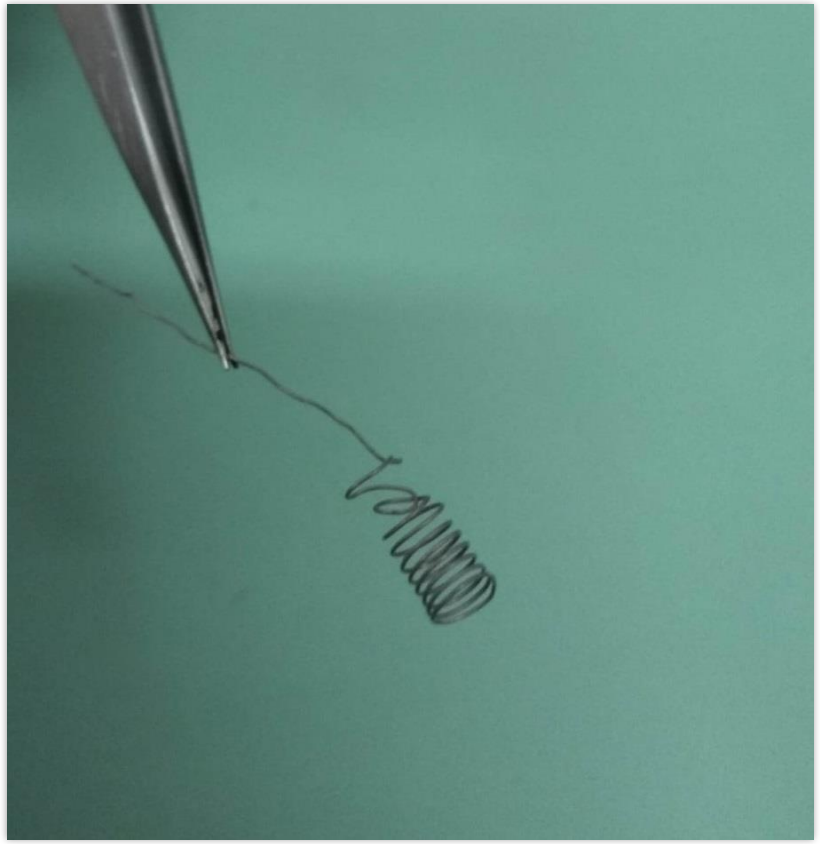


Experimental setup

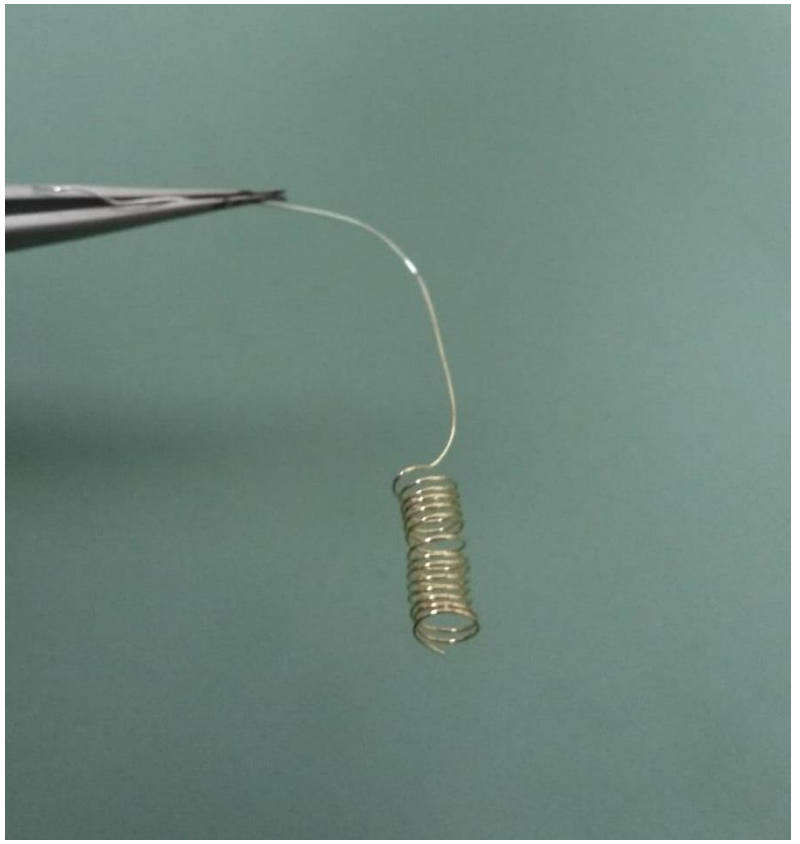


- return electrodes:
  - Ag/AgCl
  - Au
- prepared in the lab:
  - silver wire immersed into NaClO
  - electroplating
- organic semiconductor layer:
  - H_2PC (p-type) + $PTCDI$ (n-type) + Au + Parylene C + PDMS + glass
- light source: LED λ = 660 nm
- electrolyte: 0.1 M KCl

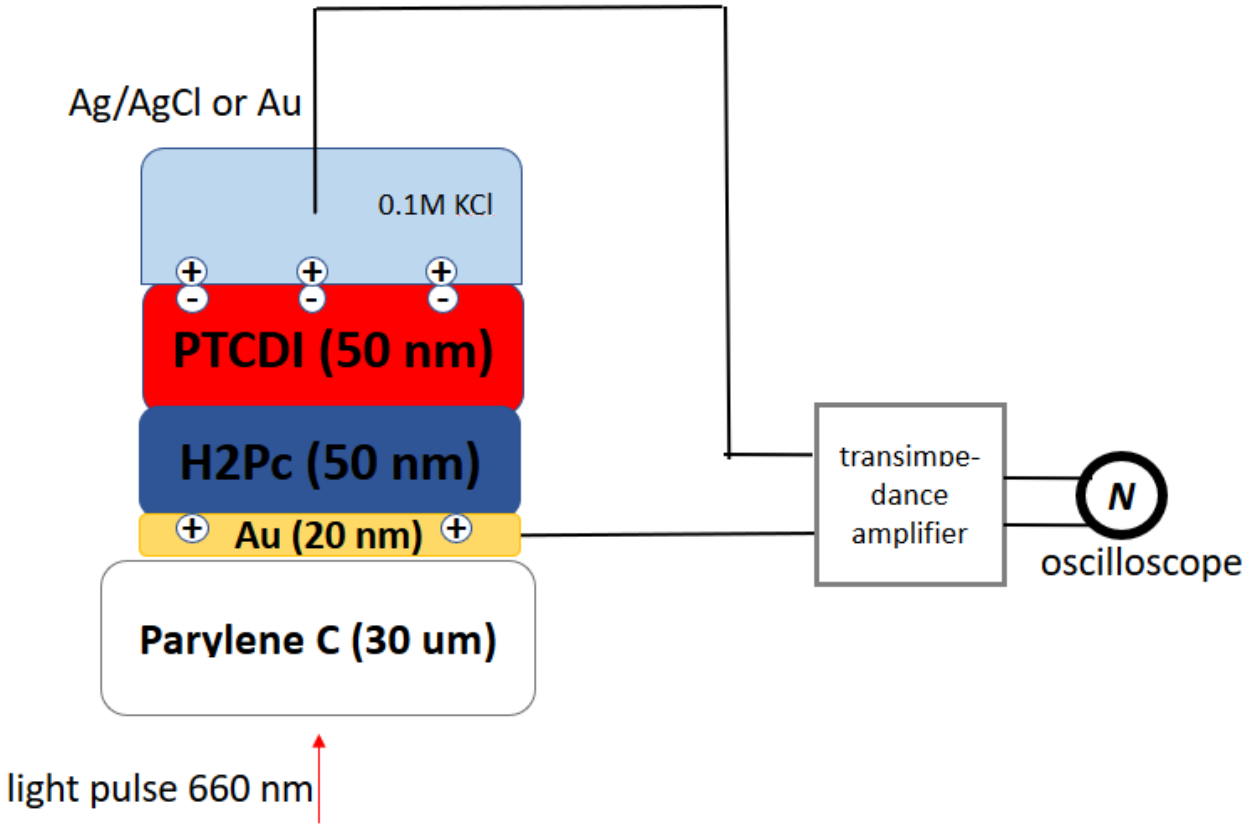
Experimental setup



return electrodes



Experimental setup

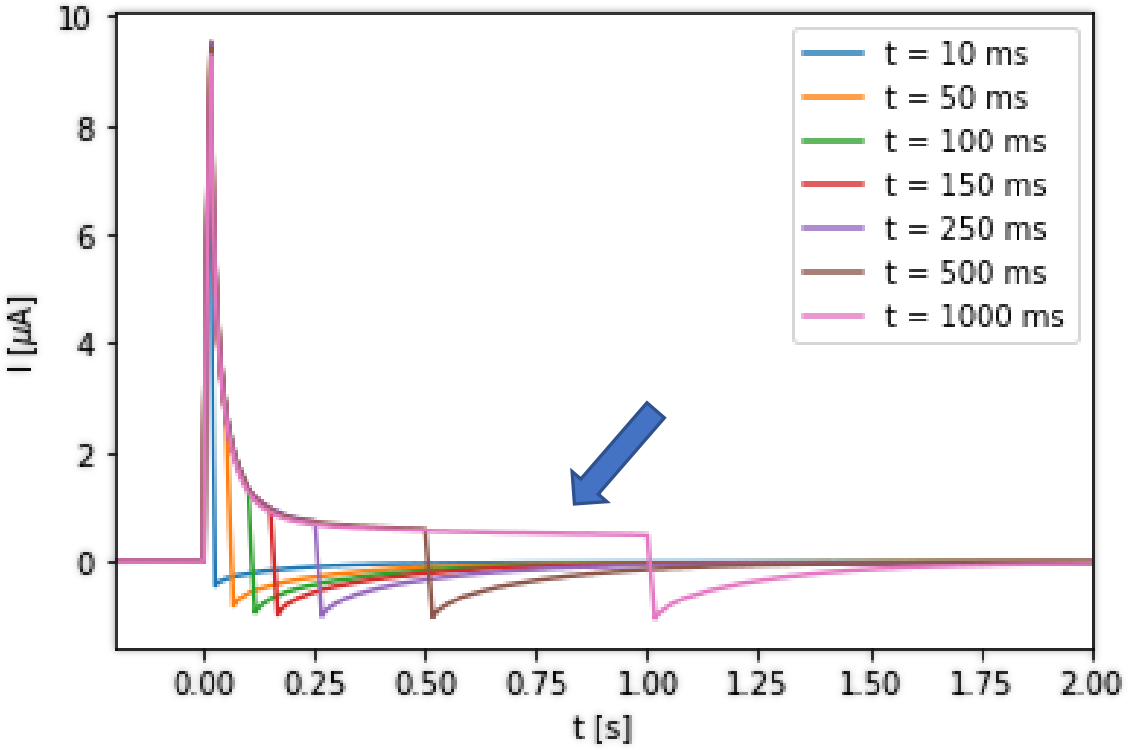


Experimental setup

- 4 pulse intensities ($10 - 35\ mW\,cm^{-2}$)
- 15 pulse durations - $100\ \mu s$ – $1\ s$ with 4 seconds inbetween
- current - time data for 2 OEPCs

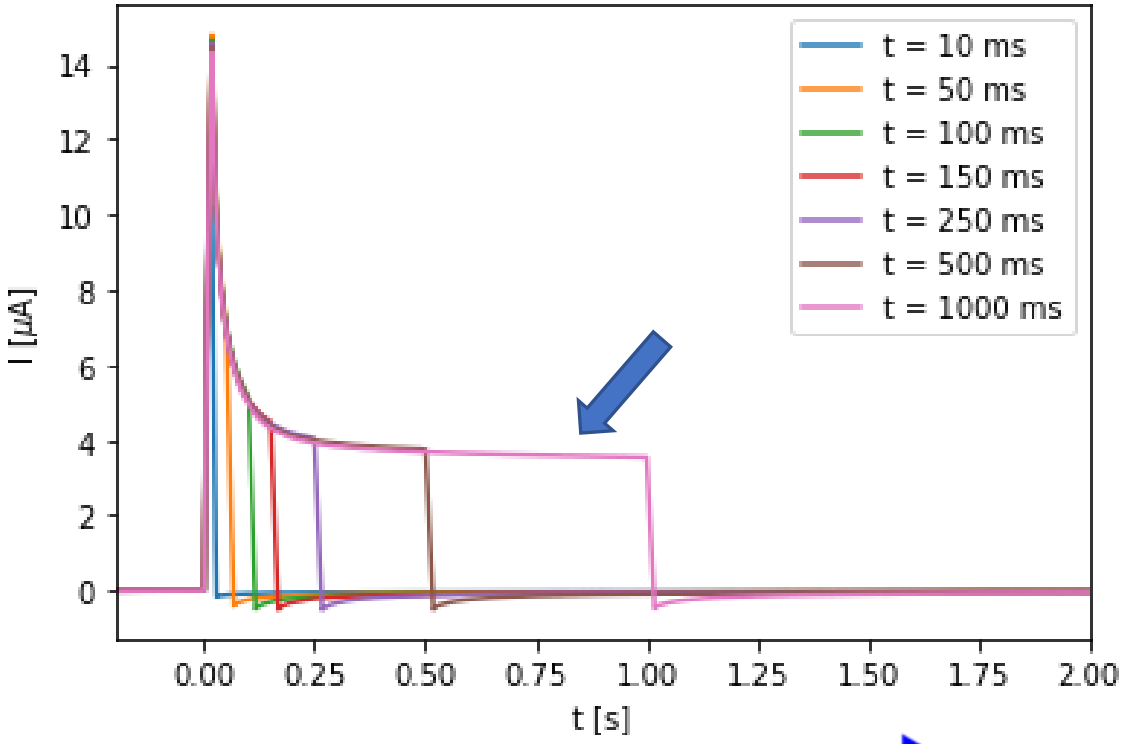
} 120 .csv files to analyse

Results



Au – longer pulses

$i = 35\ mW\,cm^{-2}$

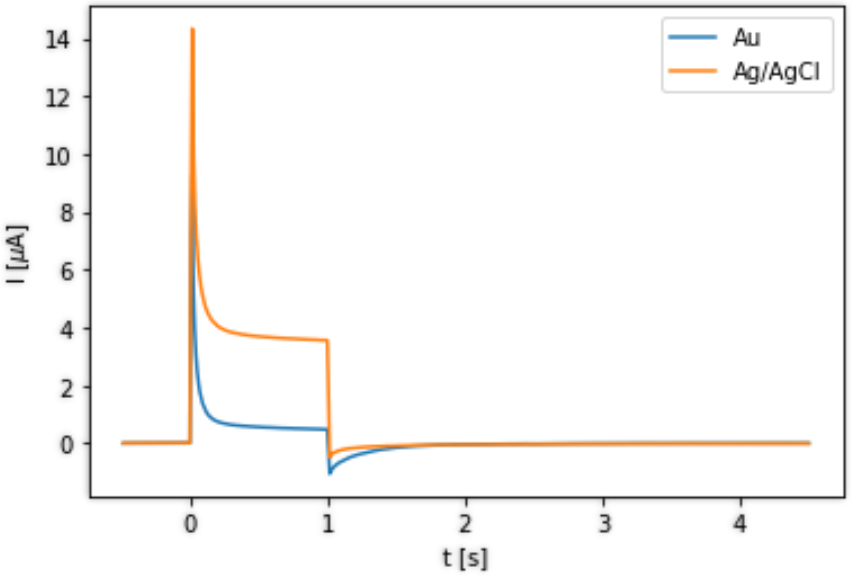


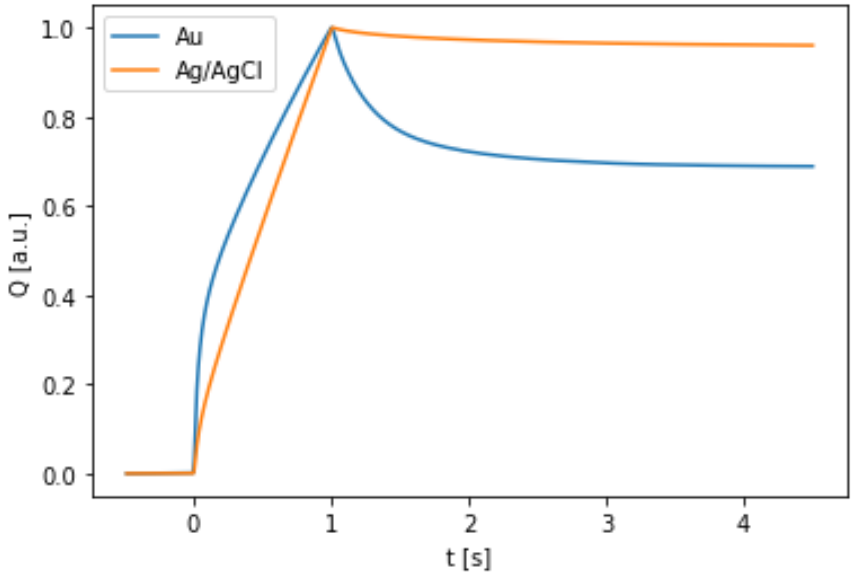
Ag/AgCl – longer pulses

$i = 35\ mW\,cm^{-2}$

Results

$t = 1\ s$
$i = 35\ mW cm^{-2}$



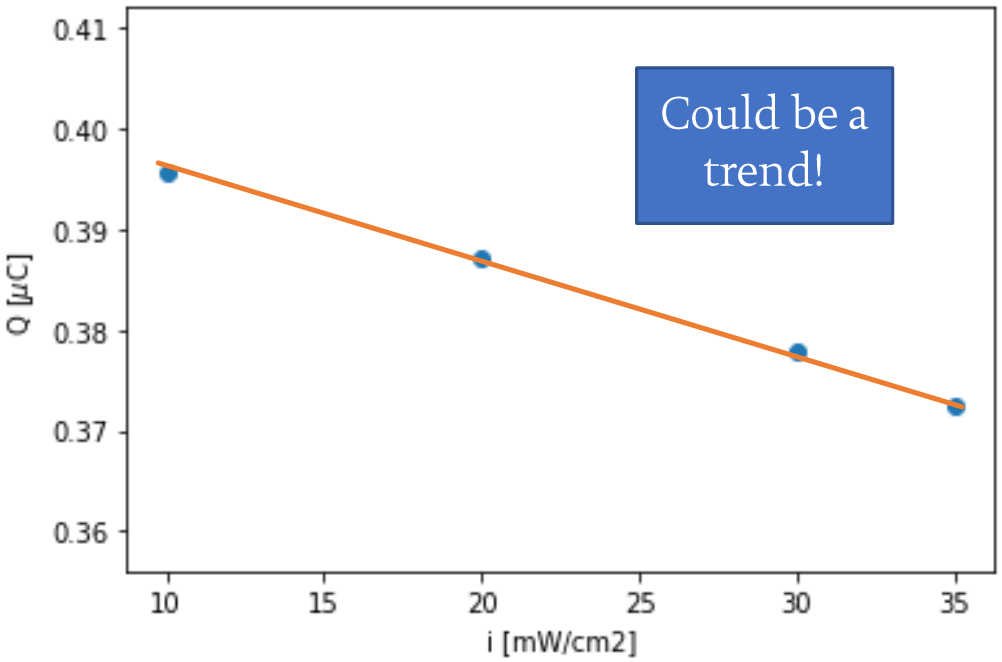


RC constants:

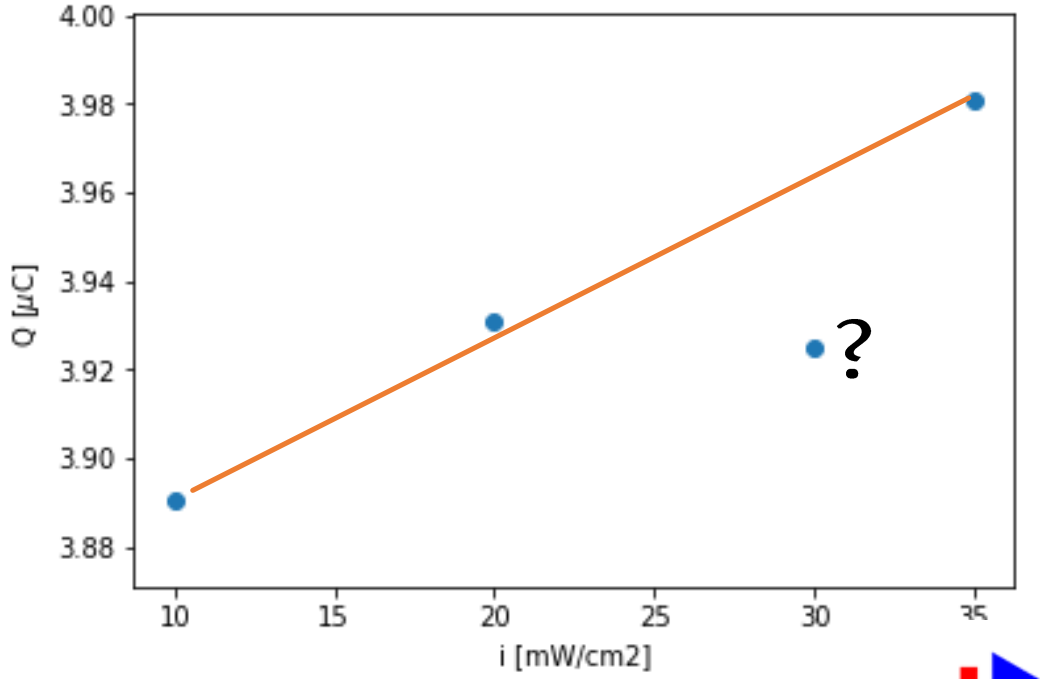
- Au: $\tau = (31 \pm 6)\ ms$
- Ag/AgCl: $\tau = (40 \pm 7)\ ms$

Results

- What about faradaic charge and light intensity dependence?



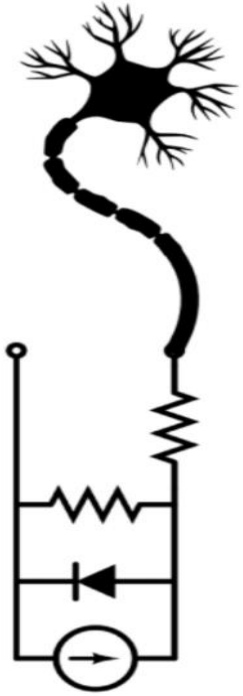
Au $t = 1\ s$



Ag/AgCl $t = 1\ s$

Conclusion

- both OEPCs show mixed behaviour (capacitive and faradaic)
- fully non-capacitive for shorter pulses
- Au return electrode has more capacitive behaviour than Ag/AgCl
- faradaic charge ↔light intensity analysing (indication of a trend)
- much space for improvement:
  - use new (unused) organic samples
  - make more measurements for different intensities
  - better experimental conditions (reduce external light)
  - prepare and compare other return electrodes (rhodium, paladium...)
  - understand physical and chemical phenomena



Thank you for your attention!