TiO_2 TEMPLATED MULTILAYER FILMS USED AS HIGH EFFICIENCY PHOTOELECTRODE IN LIQUID OR SOLID DSSCs

Jennifer DEWALQUE
University of Liege
Belgium

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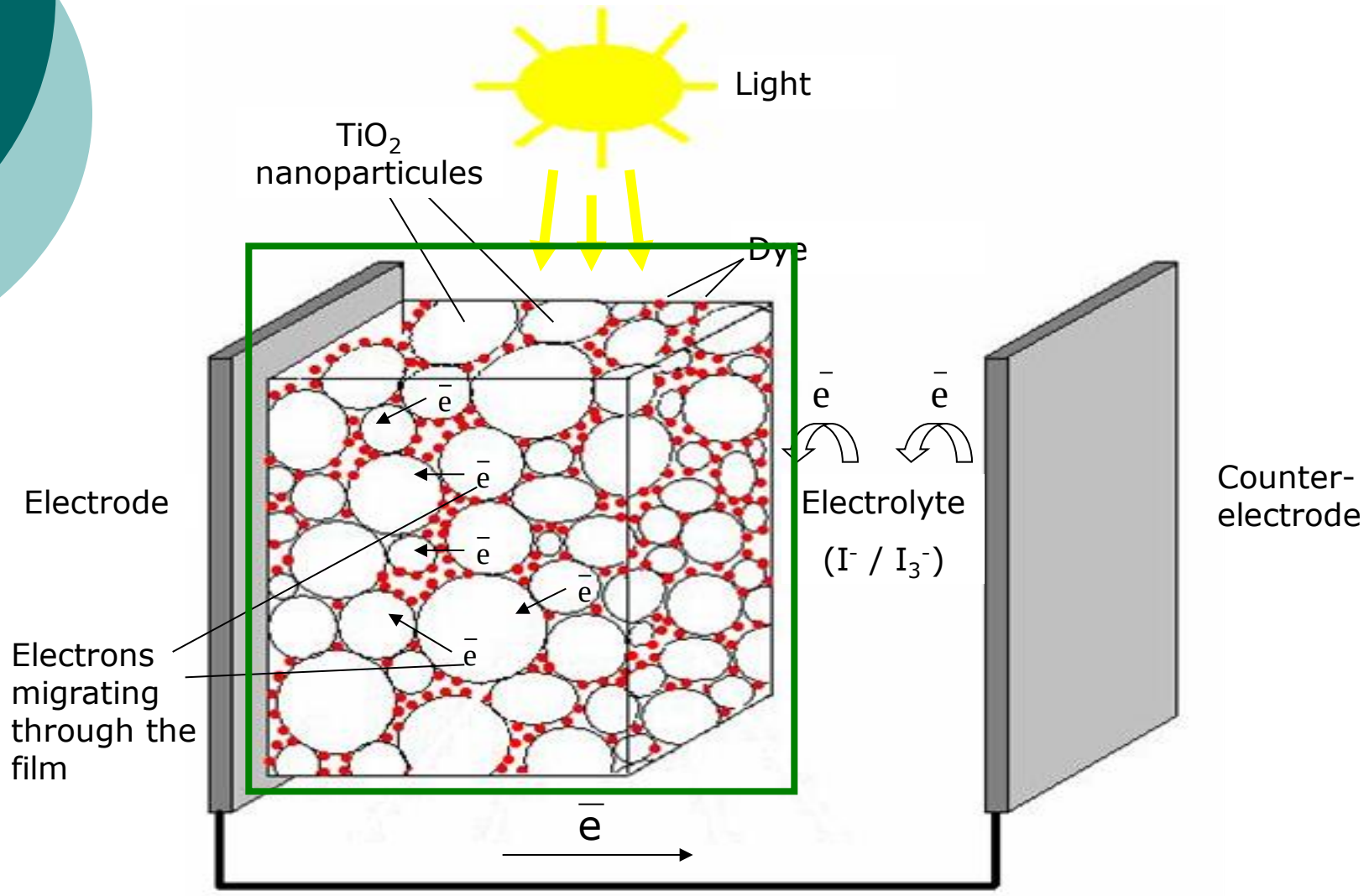
GREEn Mat

Overview

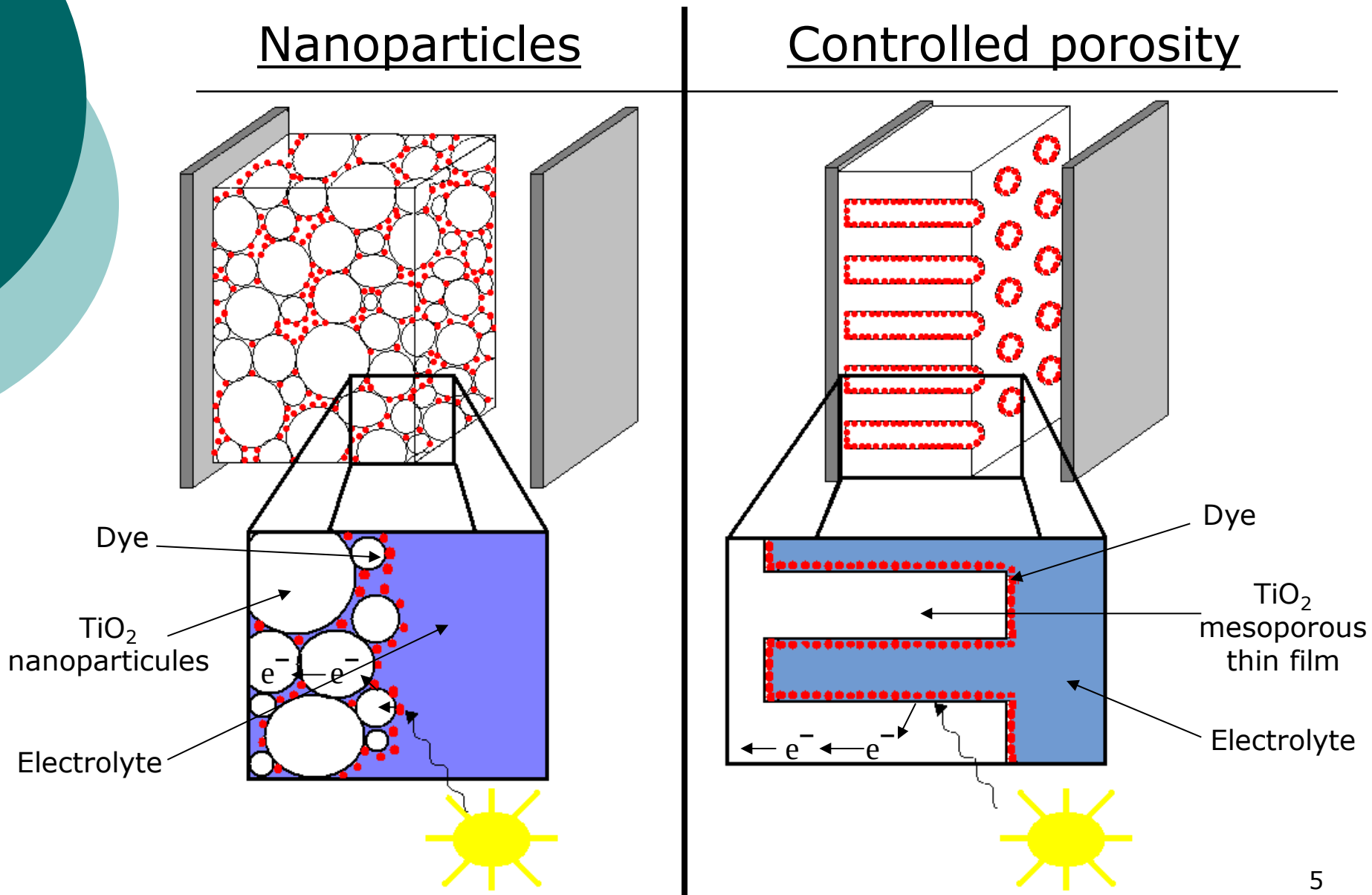
- **Introduction**
- **Film preparation and characterization**
  - Synthesis route
  - Single layer films
  - Multilayer deposition process
- **PV evaluation**
  - Liquid-state DSSCs
  - Solid-state DSSCs perspectives
- **Conclusions and perspectives**

Introduction

Dye-sensitized solar cell



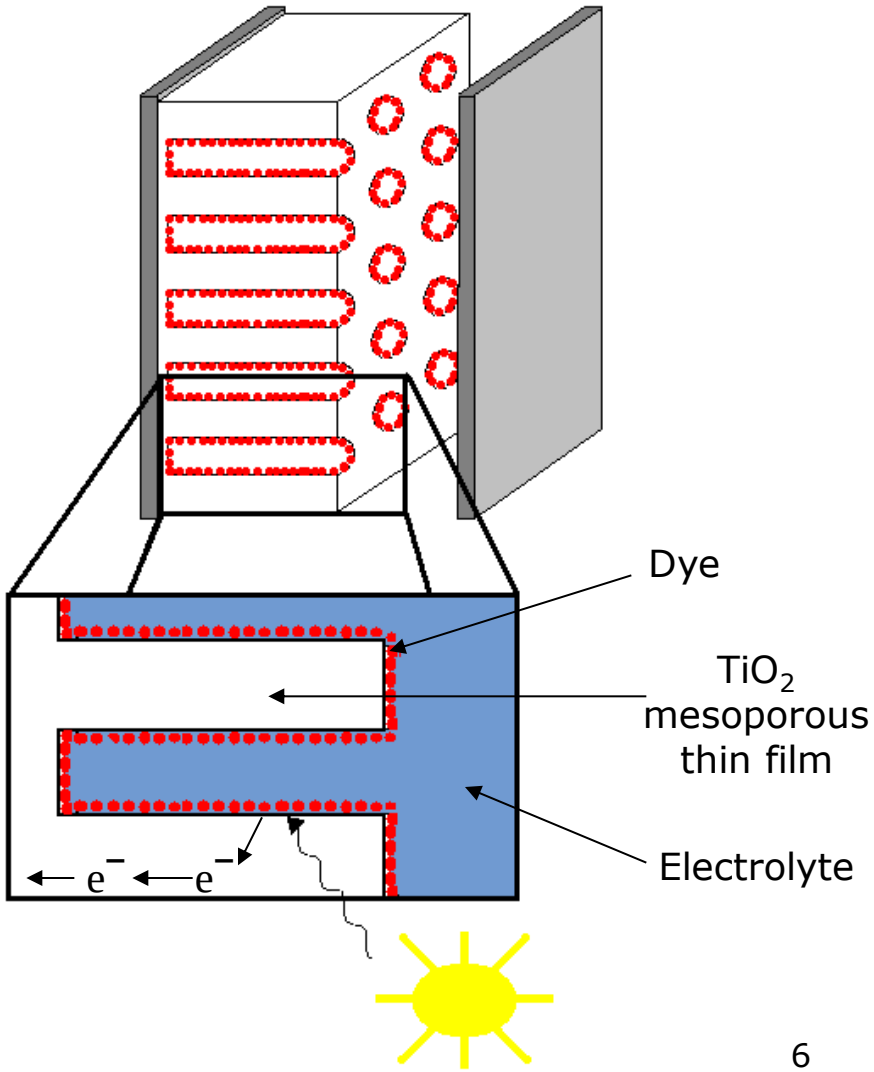
Advantages of controlled porosity



Advantages of controlled porosity

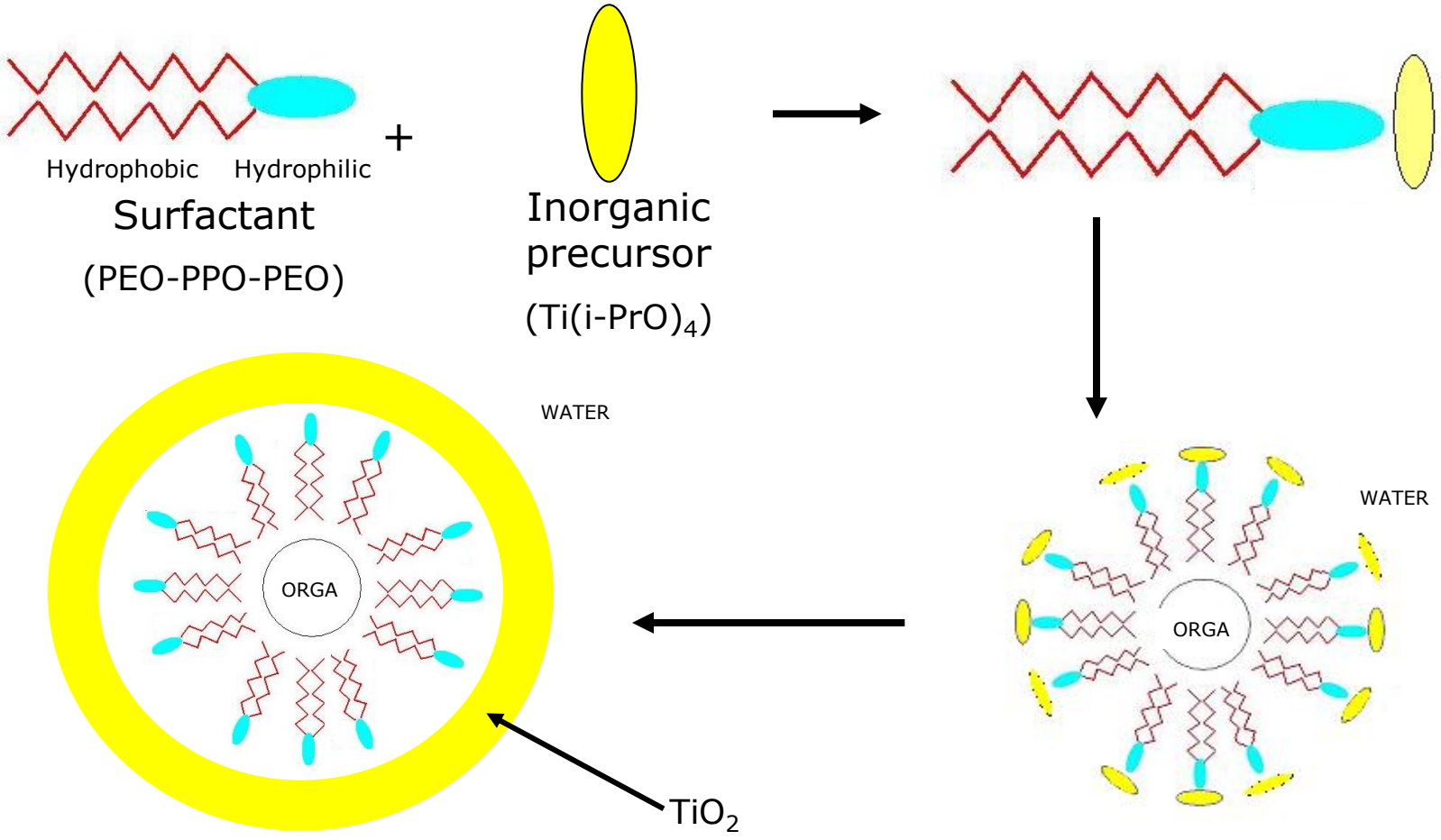
- ✓**Higher surface area**
- ✓**Better pores accessibility**
- ✓**Easier electrons transfer**

Controlled porosity

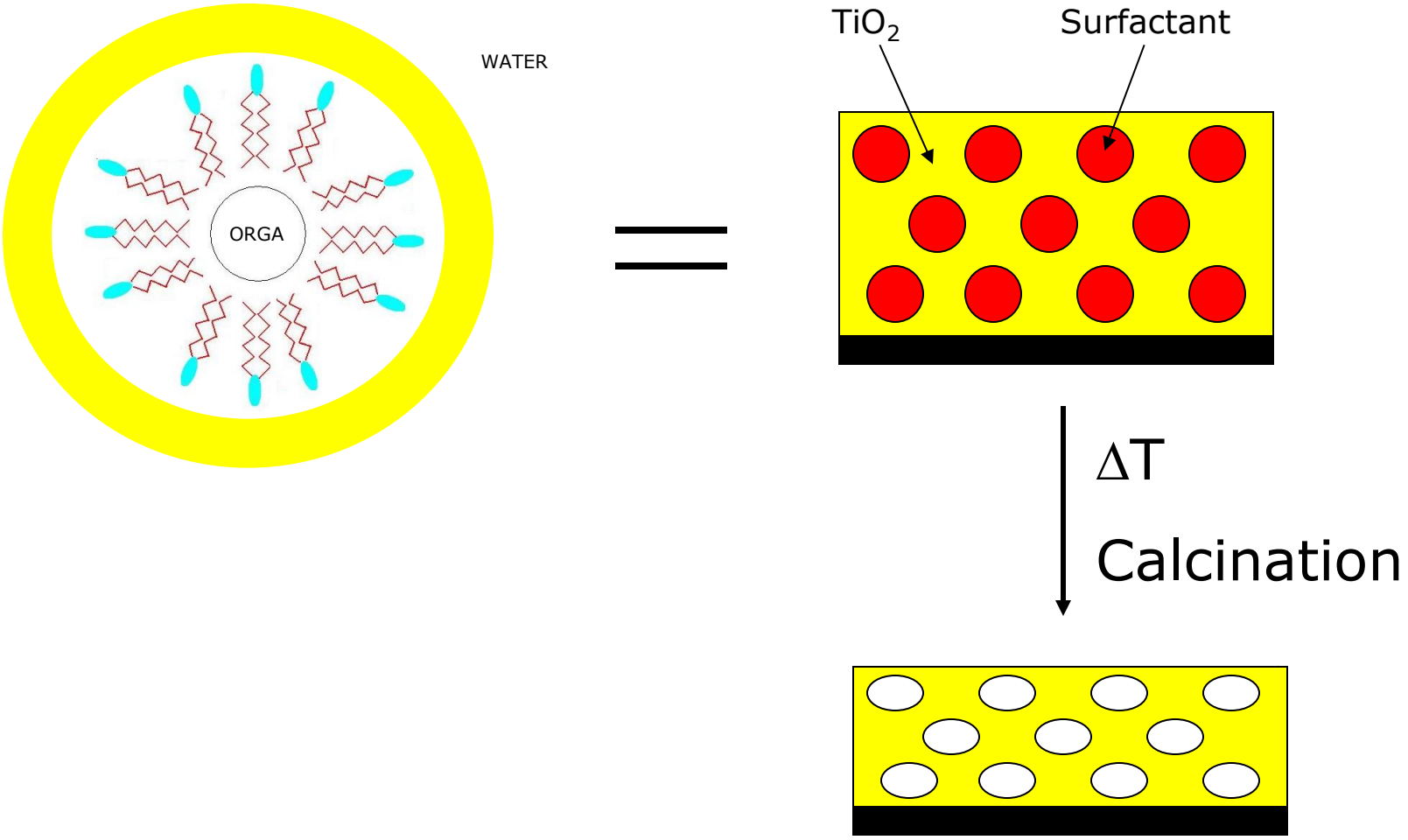


Film preparation and characterization

Synthesis route: Templating

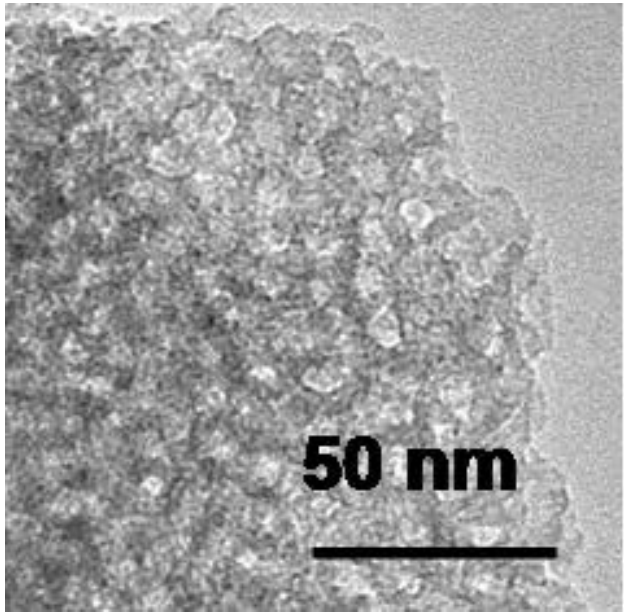


Elimination of the surfactant and film crystallization



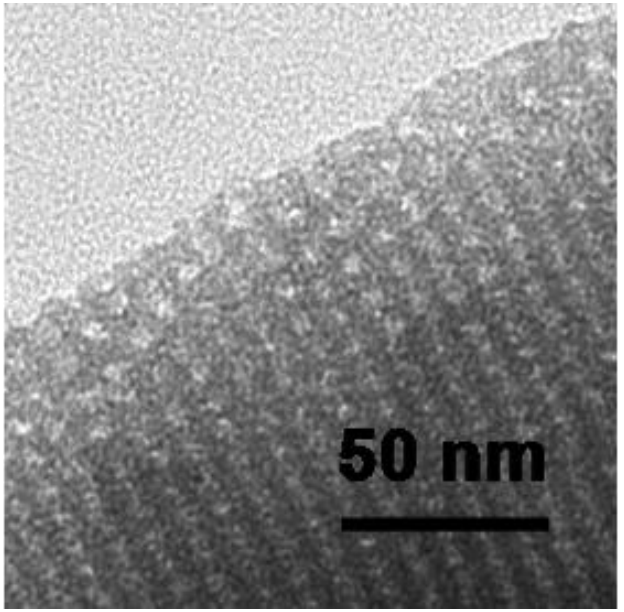
Film microstructure: influence of the relative humidity (RH)

Low RH



Wormlike Mesostructure

High RH



Gridlike Mesostructure

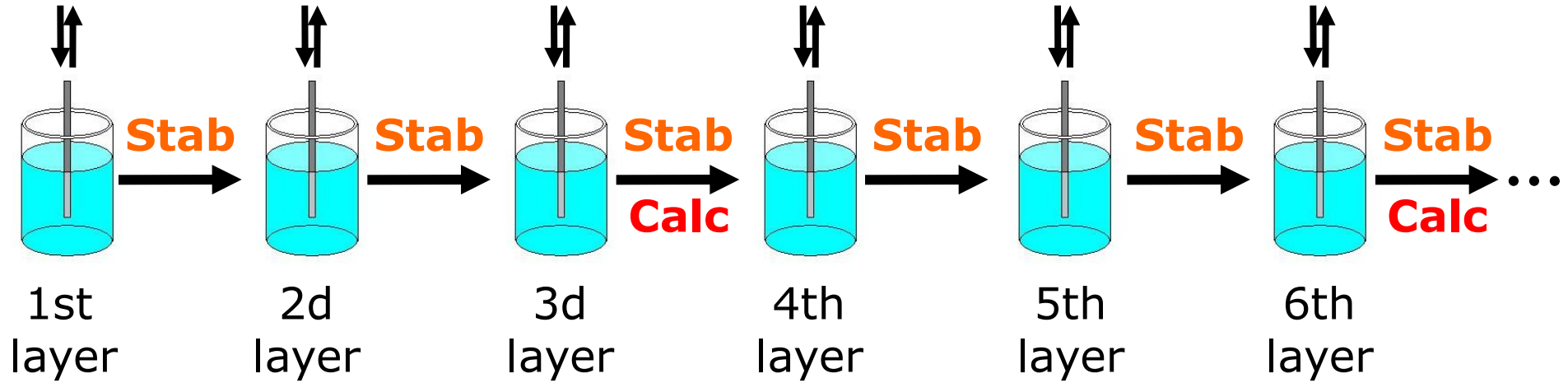
Henrist C. et al; *Micro Meso Mat*, **2009**, *117* (1–2), 292

Templated single layer films limitation

- Very small thickness (few hundred nm)
- Low content in photoactive material

How to increase the film thickness?

Multilayer deposition process



- Stabilization (**Stab**) ➔ Film **condensation**
- Calcination (**Calc**) ➔ Film **crystallization** and **surfactant degradation** (each µm ~3 layers)

Dewalque J. et al; *Thin Solid Films, in press*

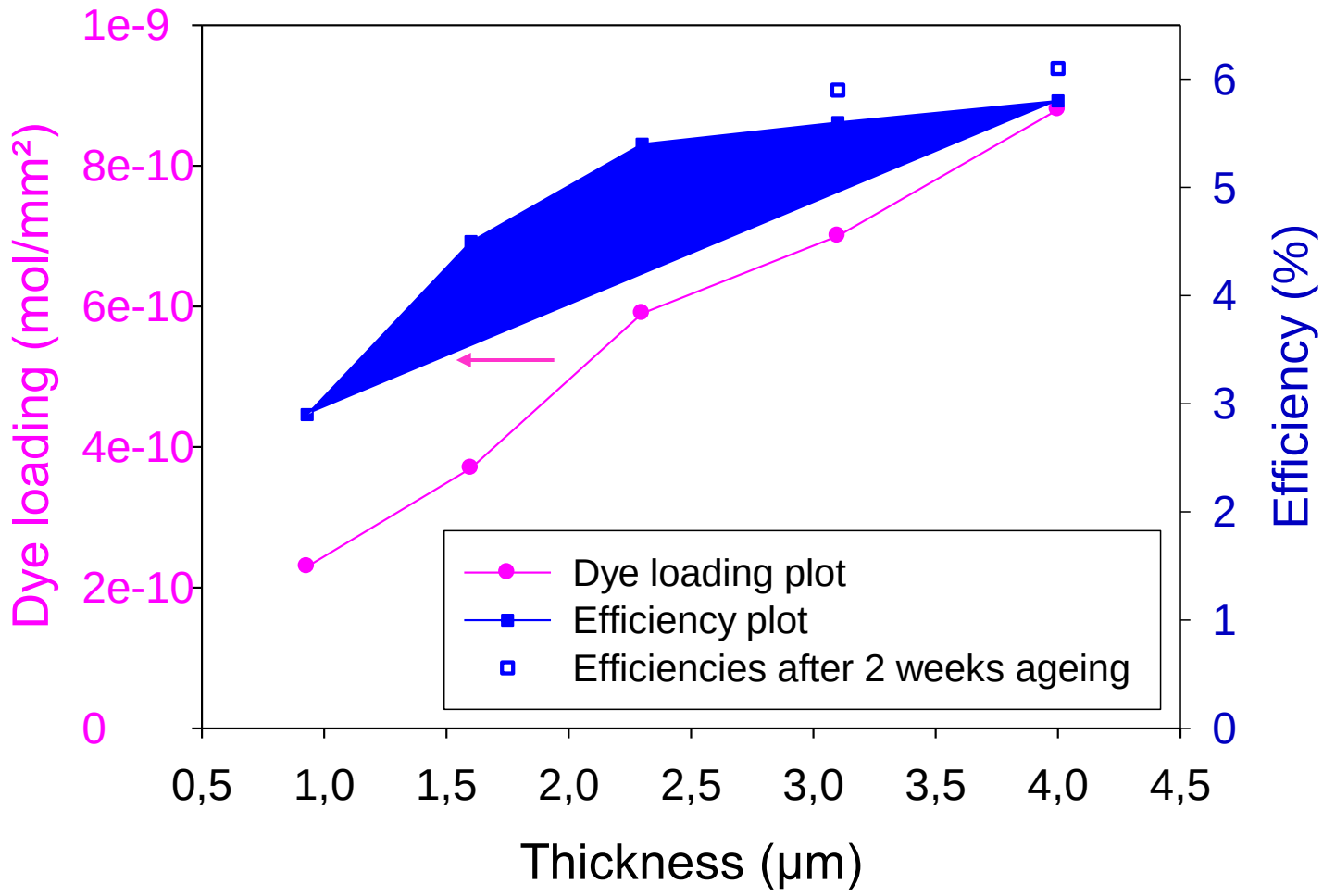
1µm-thick films characterization

Film microstructure	Surface area ($m^2\ cm^{-3}$)	Dye loading ($mol\ mm^{-2}$) for N719 dye
Wormlike	211	3.3×10^{-10}
Gridlike	176	3.0×10^{-10}

Increase of the wormlike film thickness ➔ PV evaluation

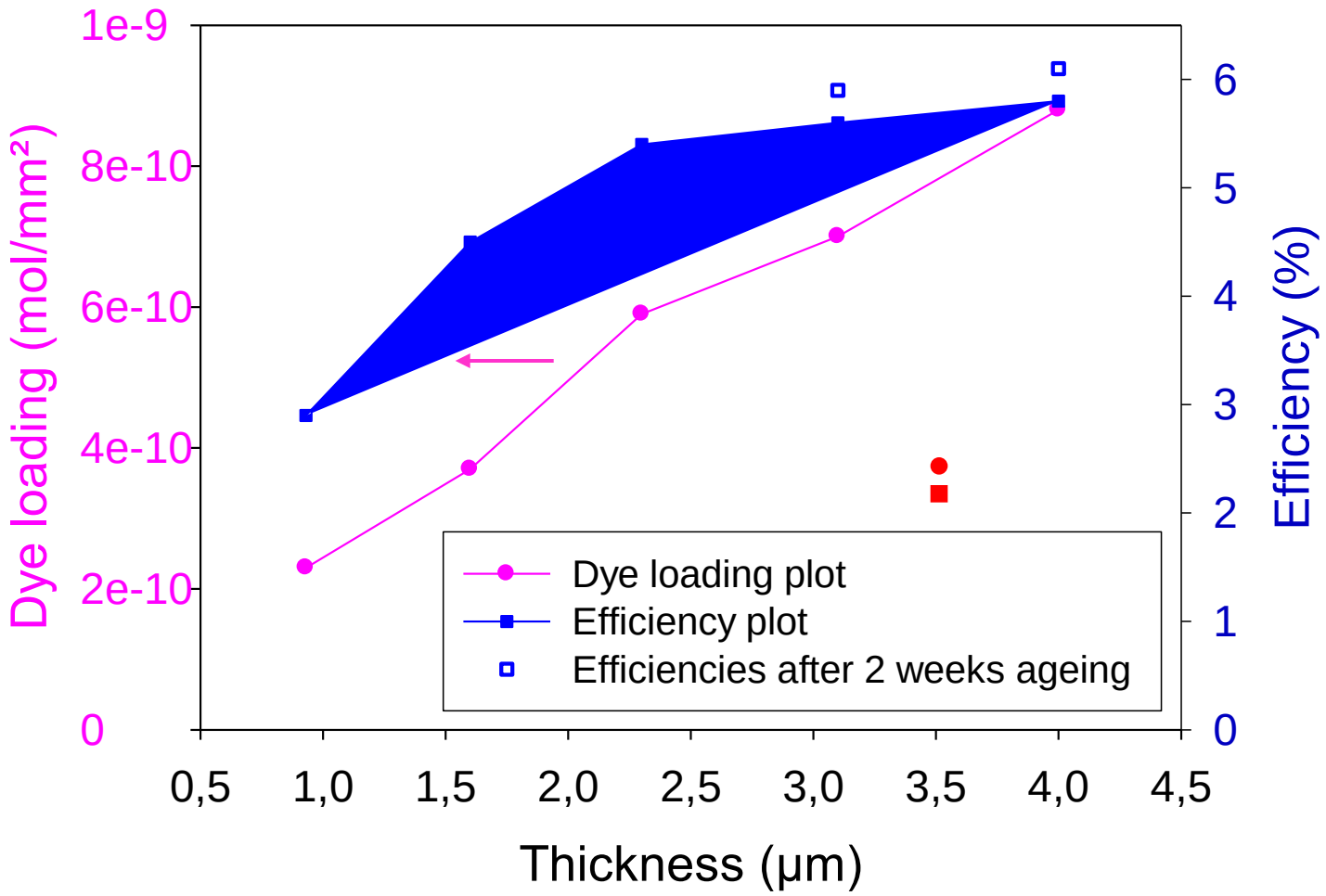
PV evaluation

PV evaluation in liquid-state DSSCs, with N719 dye



Dewalque J. et al; *J Mater Chem*, **2011**, *21*, 7356

PV evaluation in liquid-state DSSCs, with N719 dye



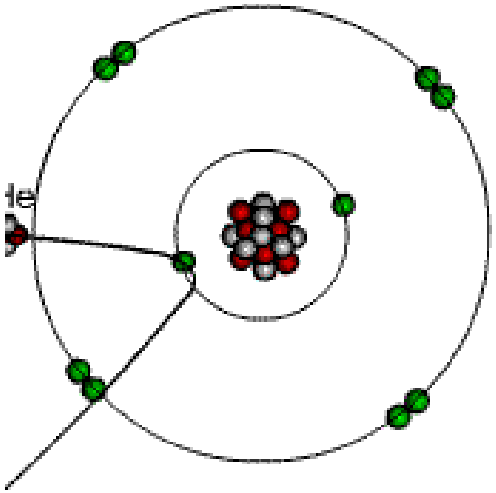
Dye loading (●) and efficiency (■) for a reference nanoparticles film (3.5 µm thick)

Potential use in solid-state DSSCs

- High dye loading ➔ overcoming of the film thickness limitation
- Limiting factor = pore filling of the solid electrolyte

➔ Pore filling characterized by Rutherford Backscattering Spectrometry (RBS)

RBS overview



- The energy of backscattered particles depends:

  (i) on the target atoms

  and

  (ii) on their distance from the surface

➔ Atomic profile of the layer

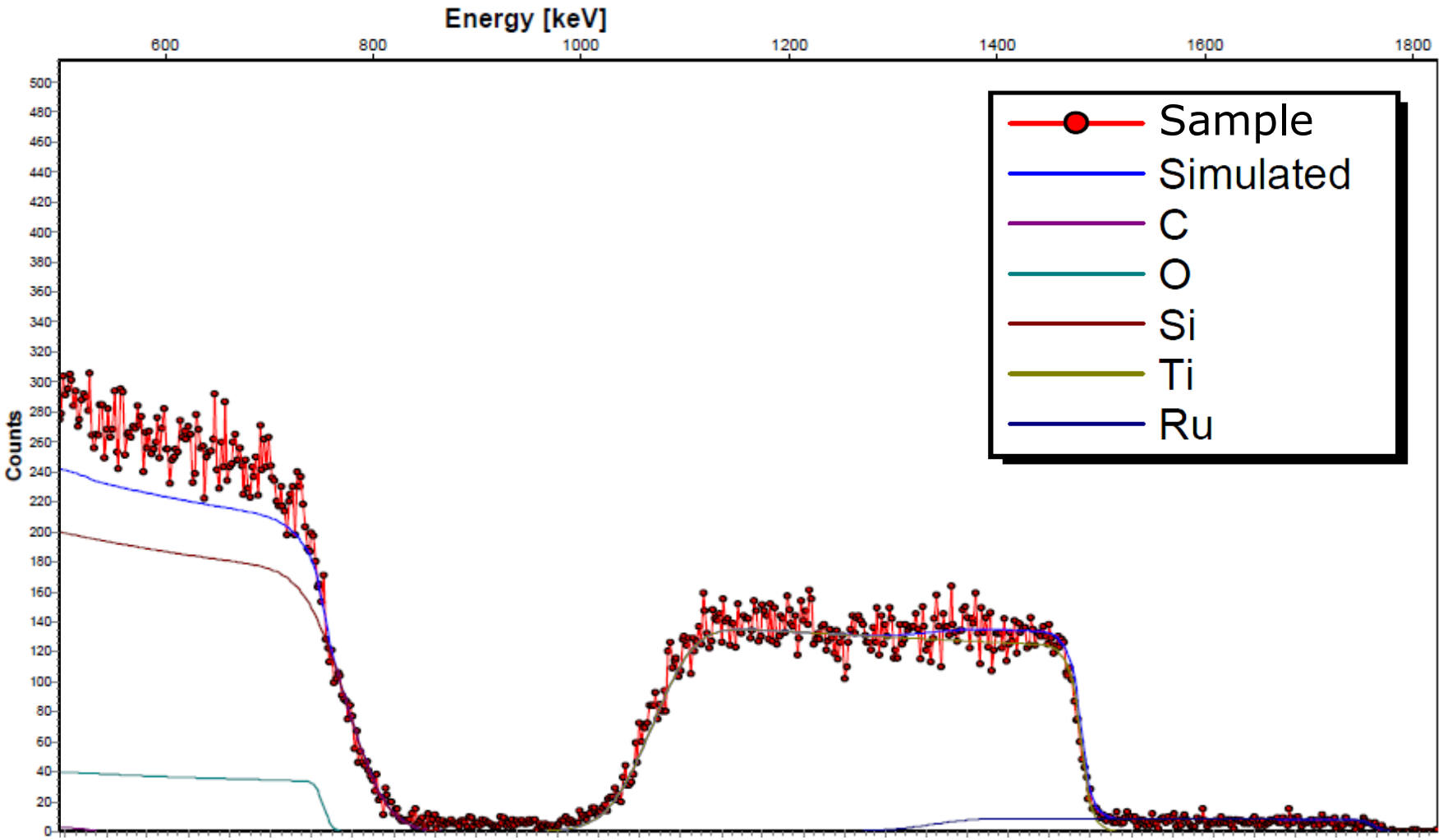
(up to several microns)

Analysis of a RBS spectrum

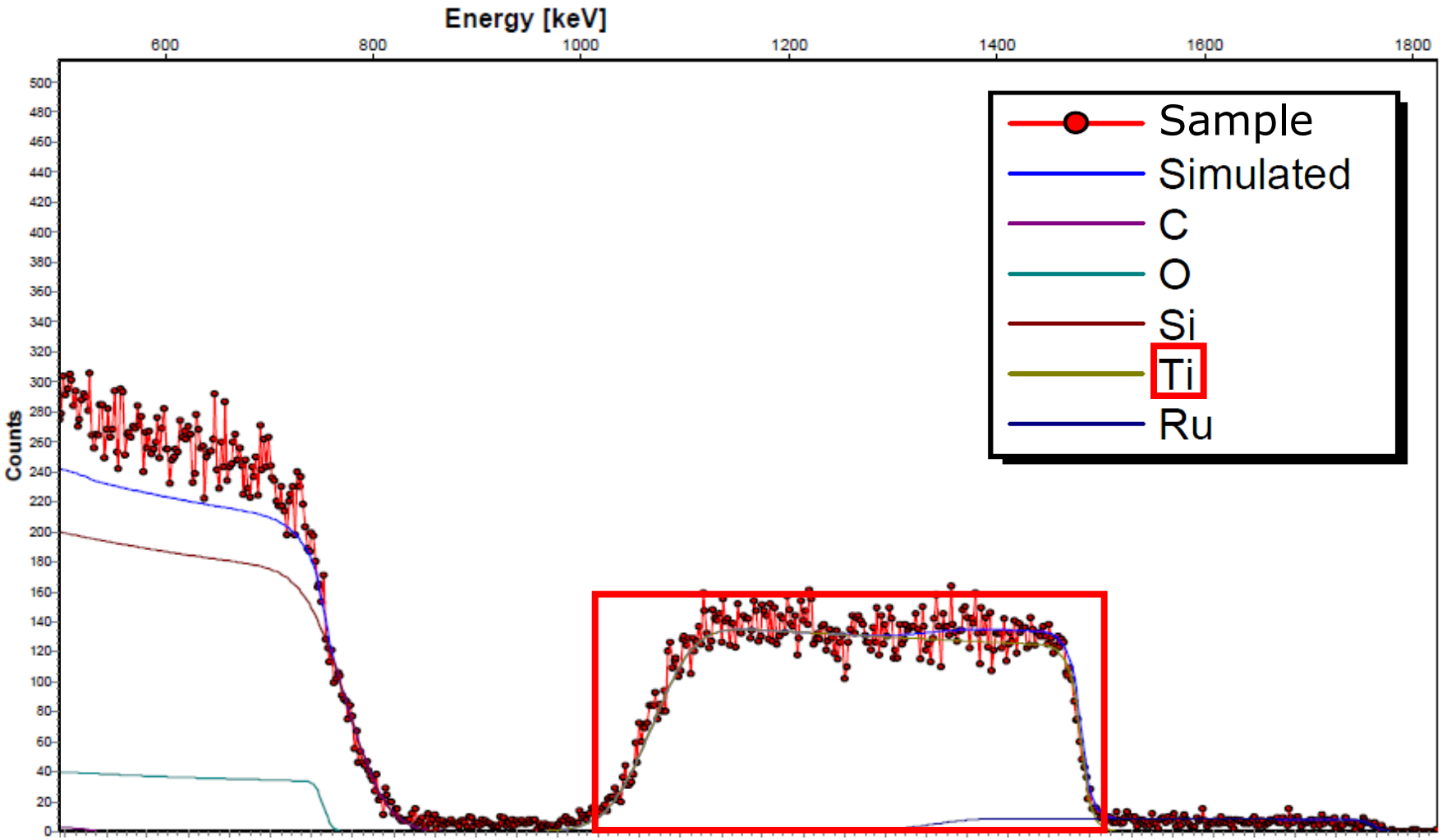
- Position of the peak ↔ element/overlayer
- Peak height ↔ atomic concentration
- Peak width ↔ thickness/density of the layer
- Multistep peak ↔ inhomogeneity in the layer atomic composition

➔ This can be correlated to the pore filling

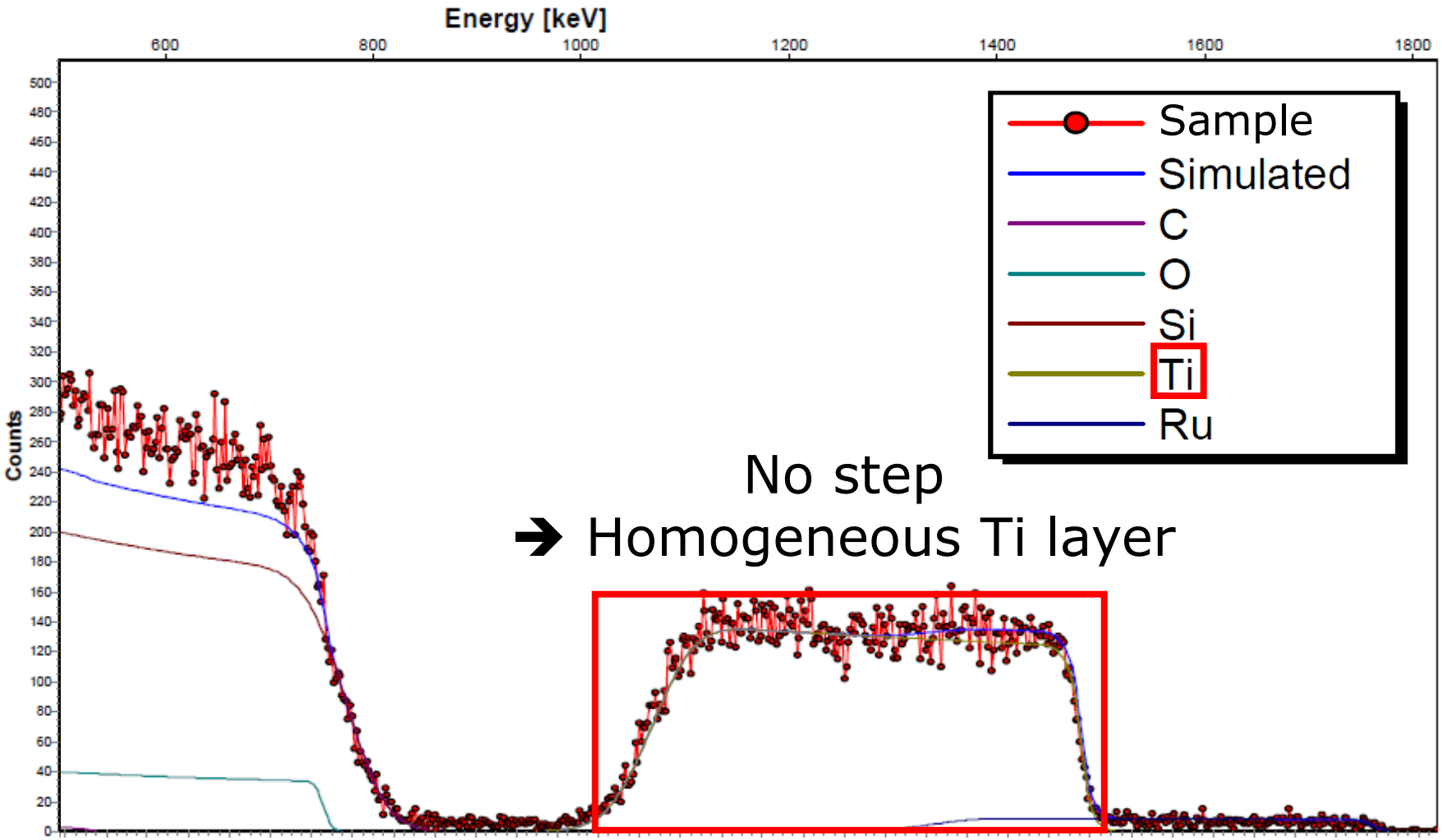
Without electrolyte



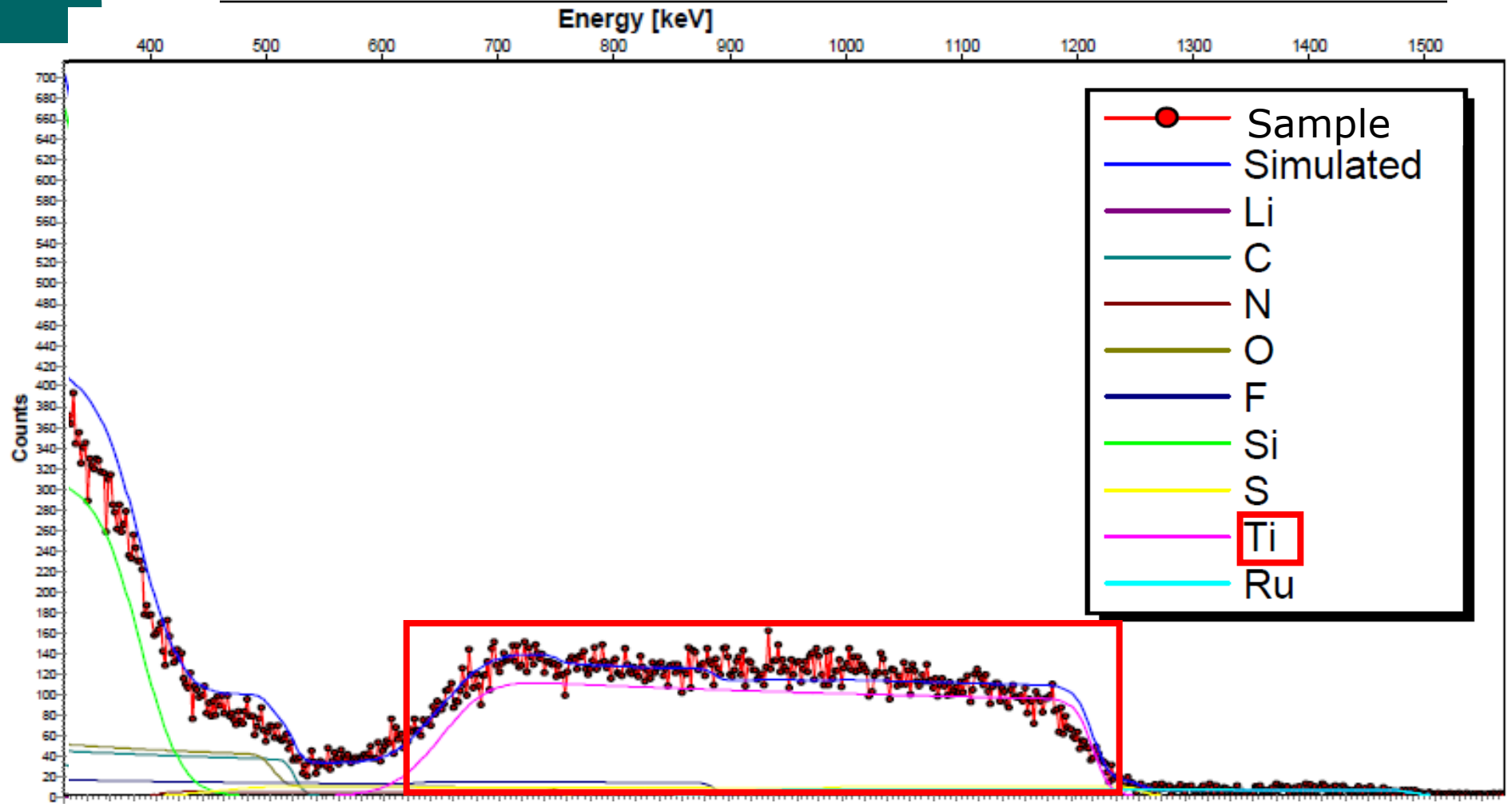
Without electrolyte



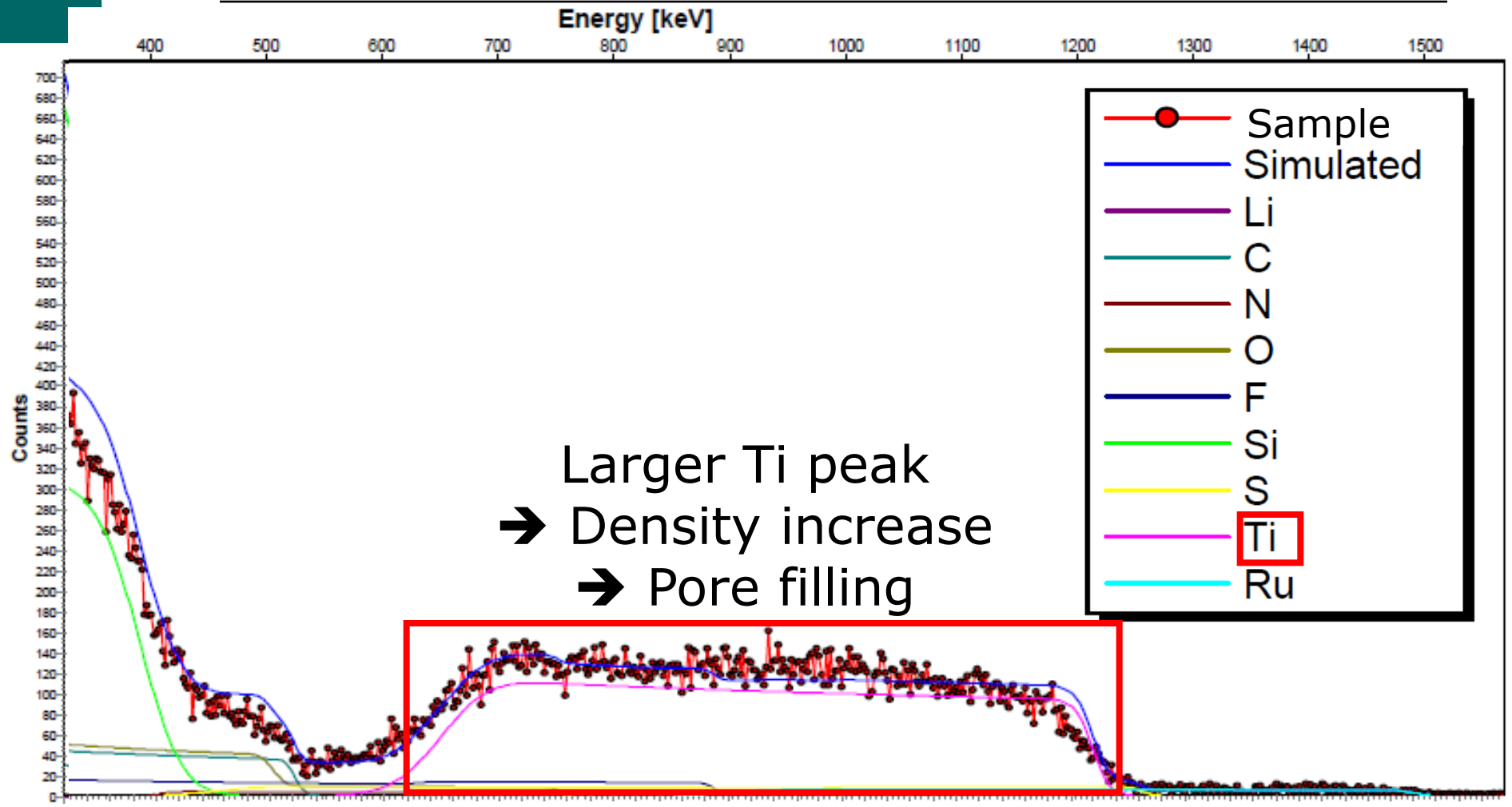
Without electrolyte



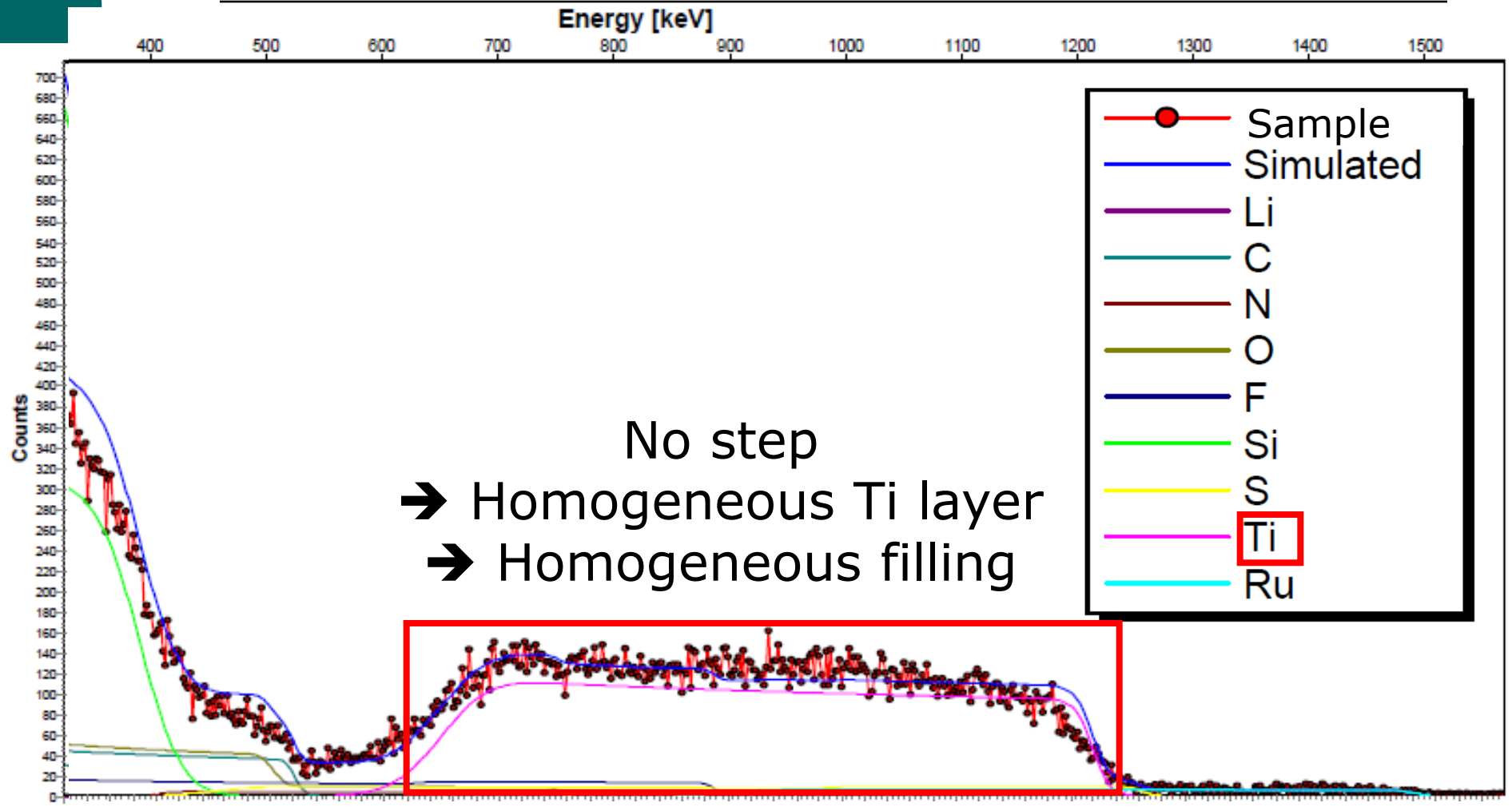
With electrolyte



With electrolyte



With electrolyte



Conclusions and perspectives

Conclusions and perspectives

- Tuning of the film mesostructure by templating
  ➔ controlled porosity
  ➔ high surface area
- Need of a multilayer deposition process to increase the film thickness
  ➔ pores accessible along with the multilayer deposition
  ➔ linear increase of dye loading
- Promising PV efficiencies of templated films in liquid-state DSSCs (6.1%)
- Good pore filling with solid electrolyte
  ➔ promising perspectives in solid-state DSSCs

Thank you for your attention

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