TiO_2 MESOPOROUS THIN FILMS ACTING AS PHOTOELECTRODE IN DYE-SENSITIZED SOLAR CELLS

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MRS Fall Meeting

Boston, 2008

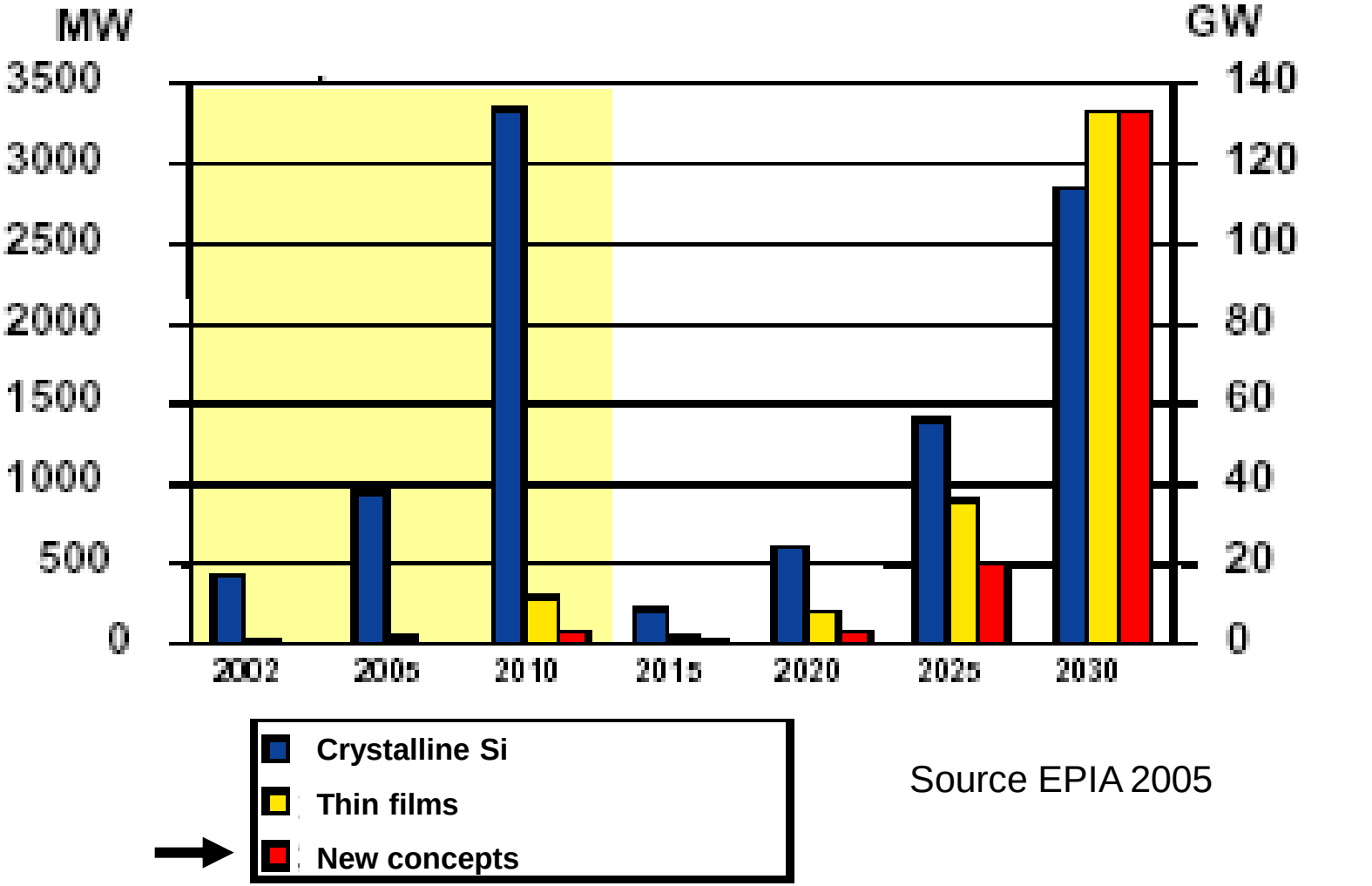
Overview

Overview

- Introduction
  - The dye-sensitized solar cell
  - The TiO_2 thin film
- Film preparation
- Results
  - Influence of the mesostructure
  - Increase of thickness
- Summary and perspectives

Introduction

Technology perspectives in Europe

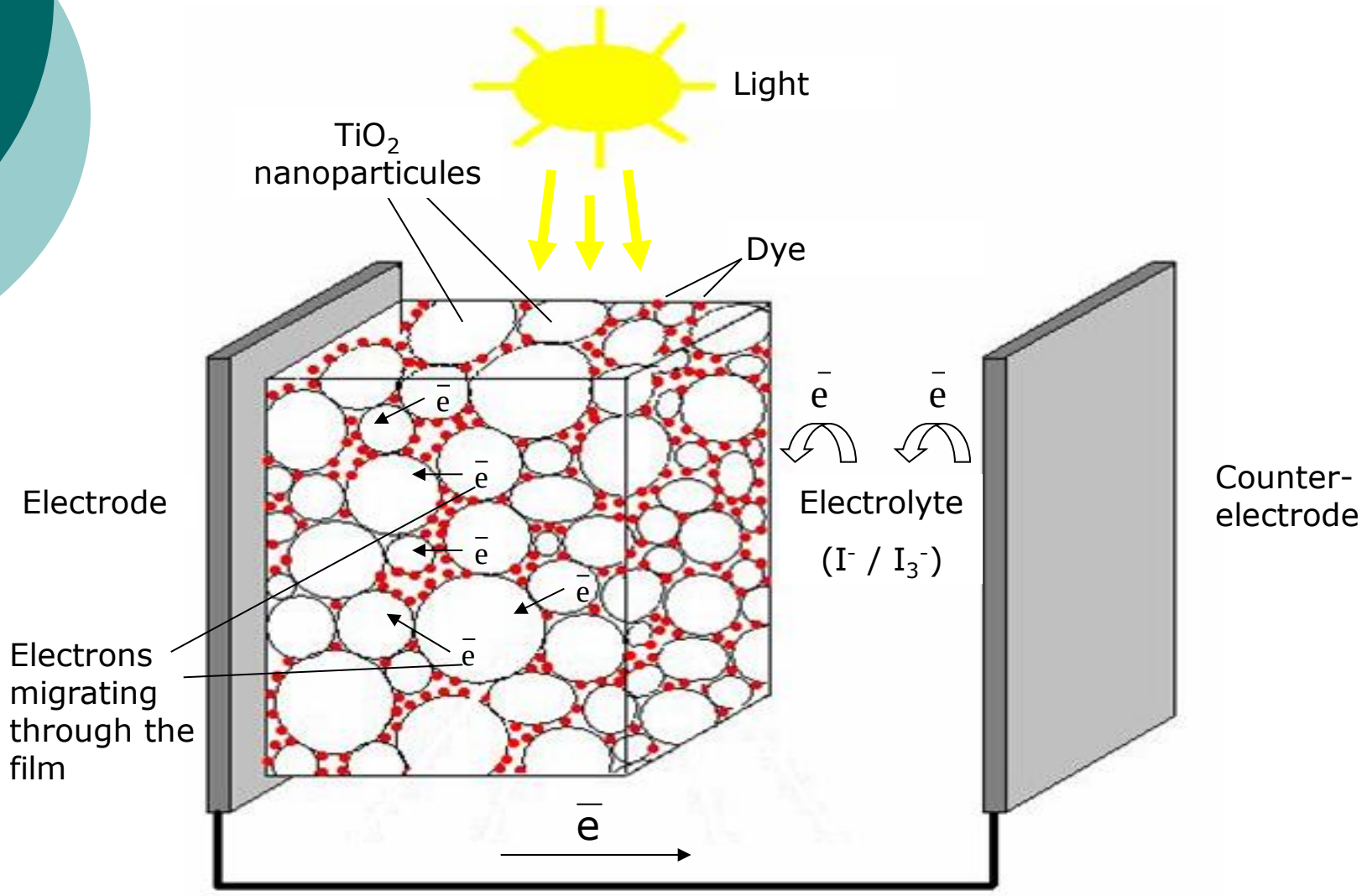


Source EPIA 2005

Dye-Sensitized Solar Cell

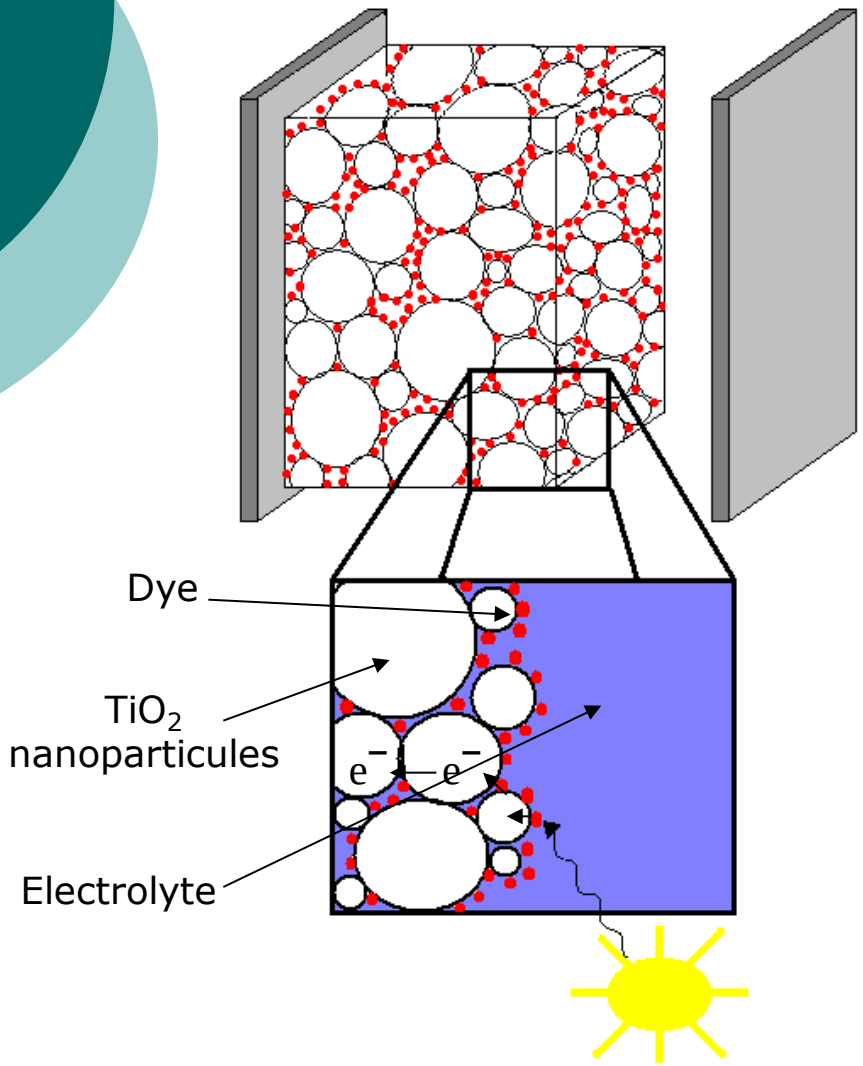
- Main components: Semi-conductor oxide (TiO_2) + organic dye
- Discovery in 1991 by M. Grätzel

Dye-sensitized solar cell

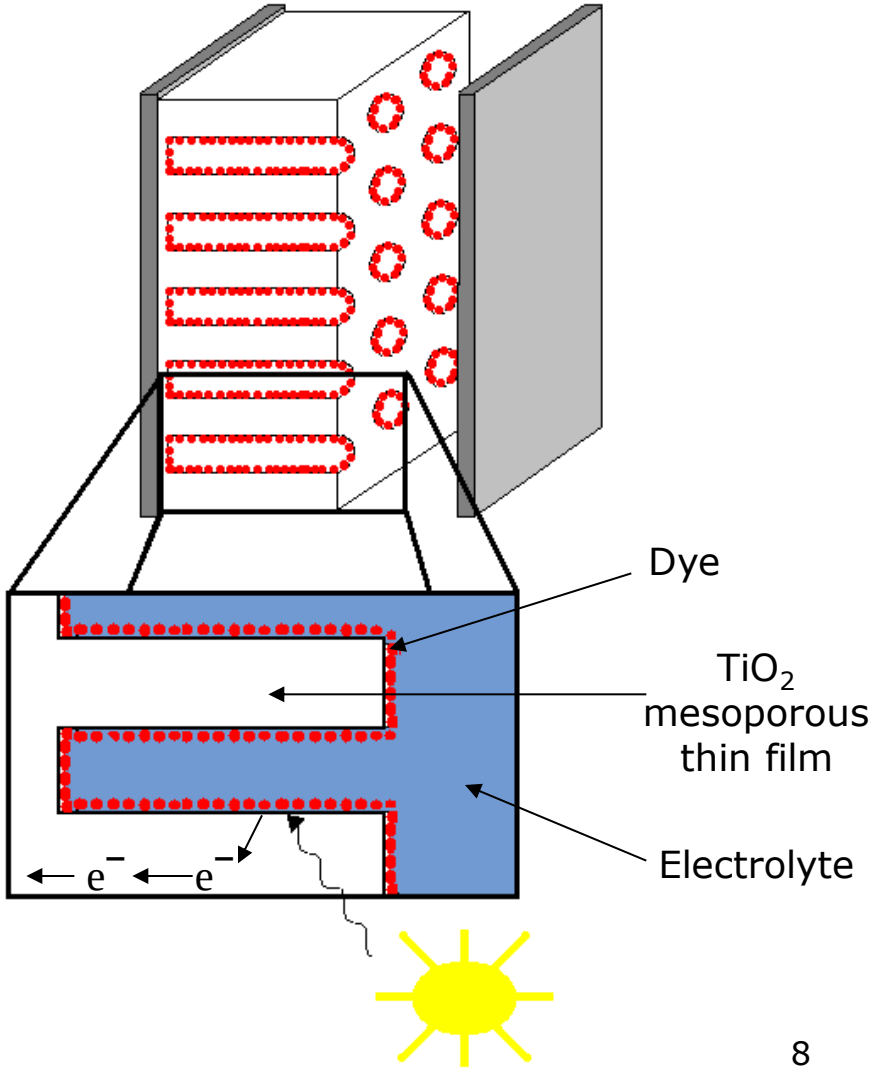


New concept: controlled porosity

Dye-sensitized solar cell



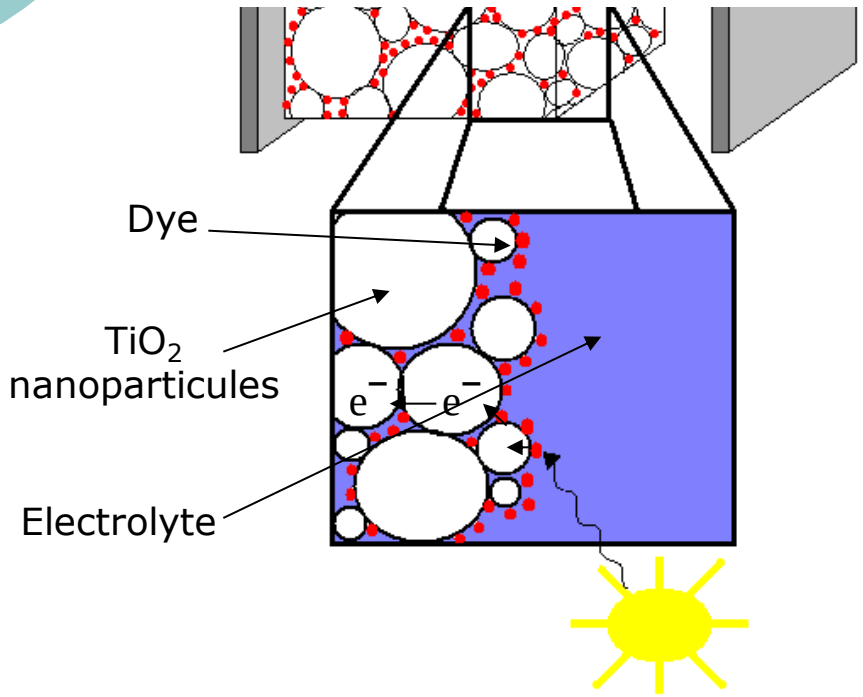
New concept



New concept: controlled porosity

Dye-sensitized solar cell

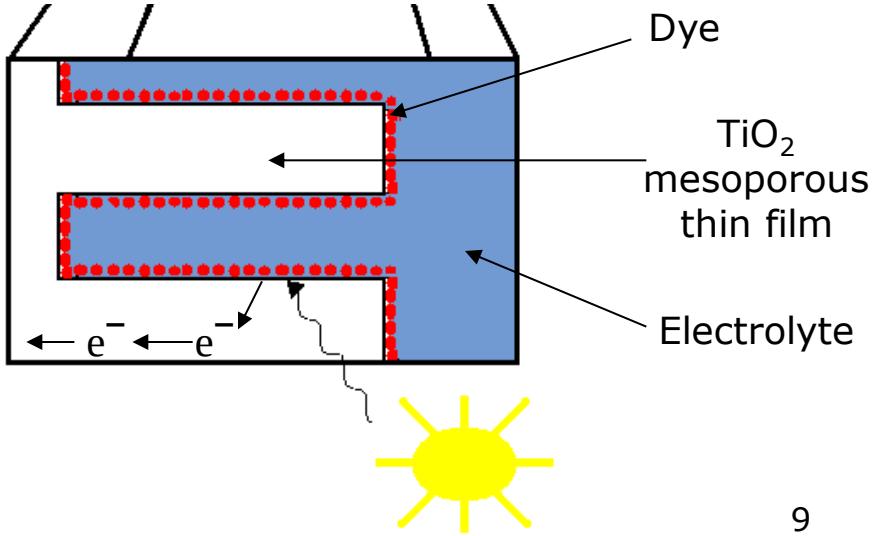
Electrons transfer more fastidious



New concept

Higher surface area

Electrons transfer easier

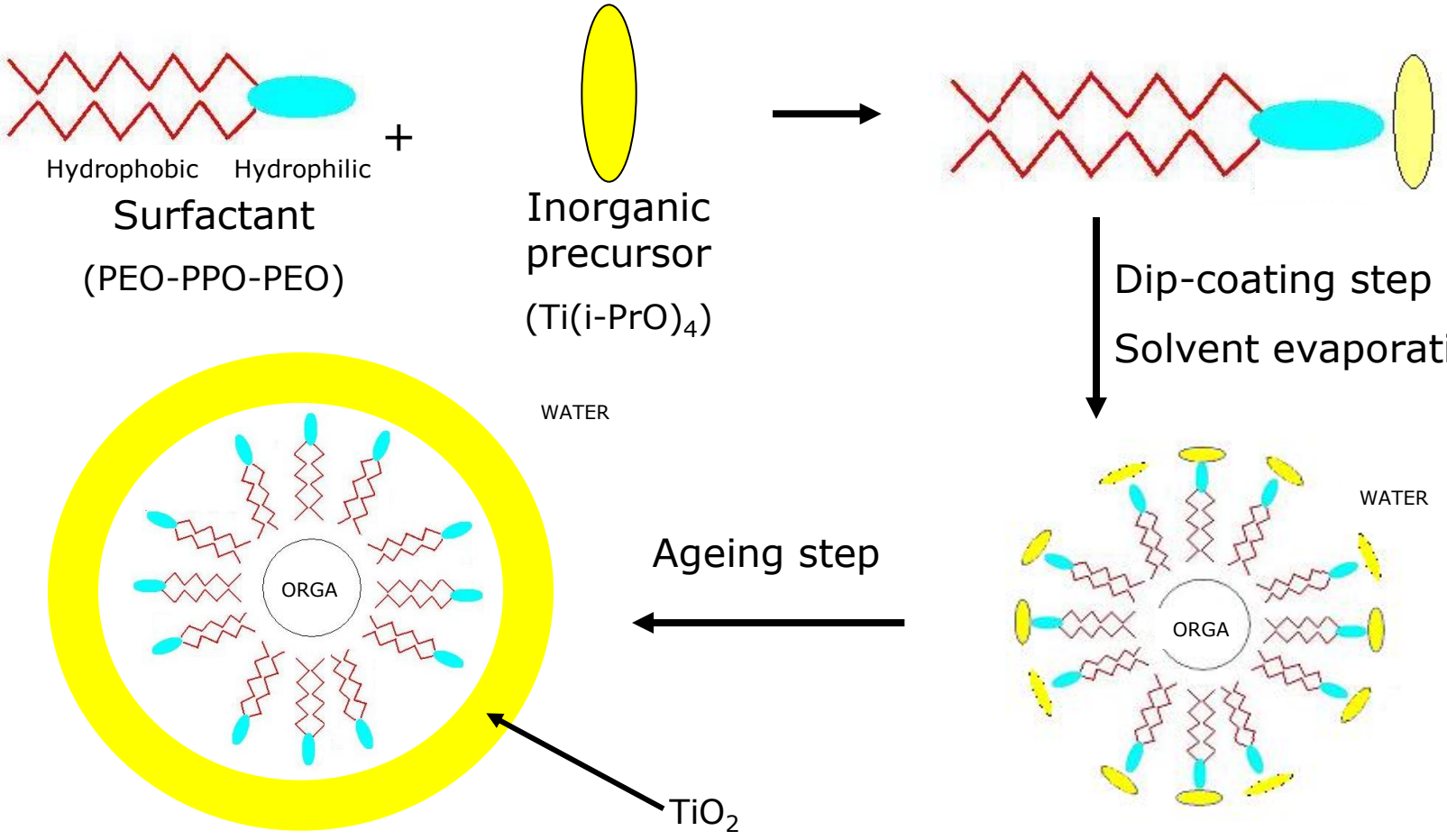


The TiO_2 layer requirements

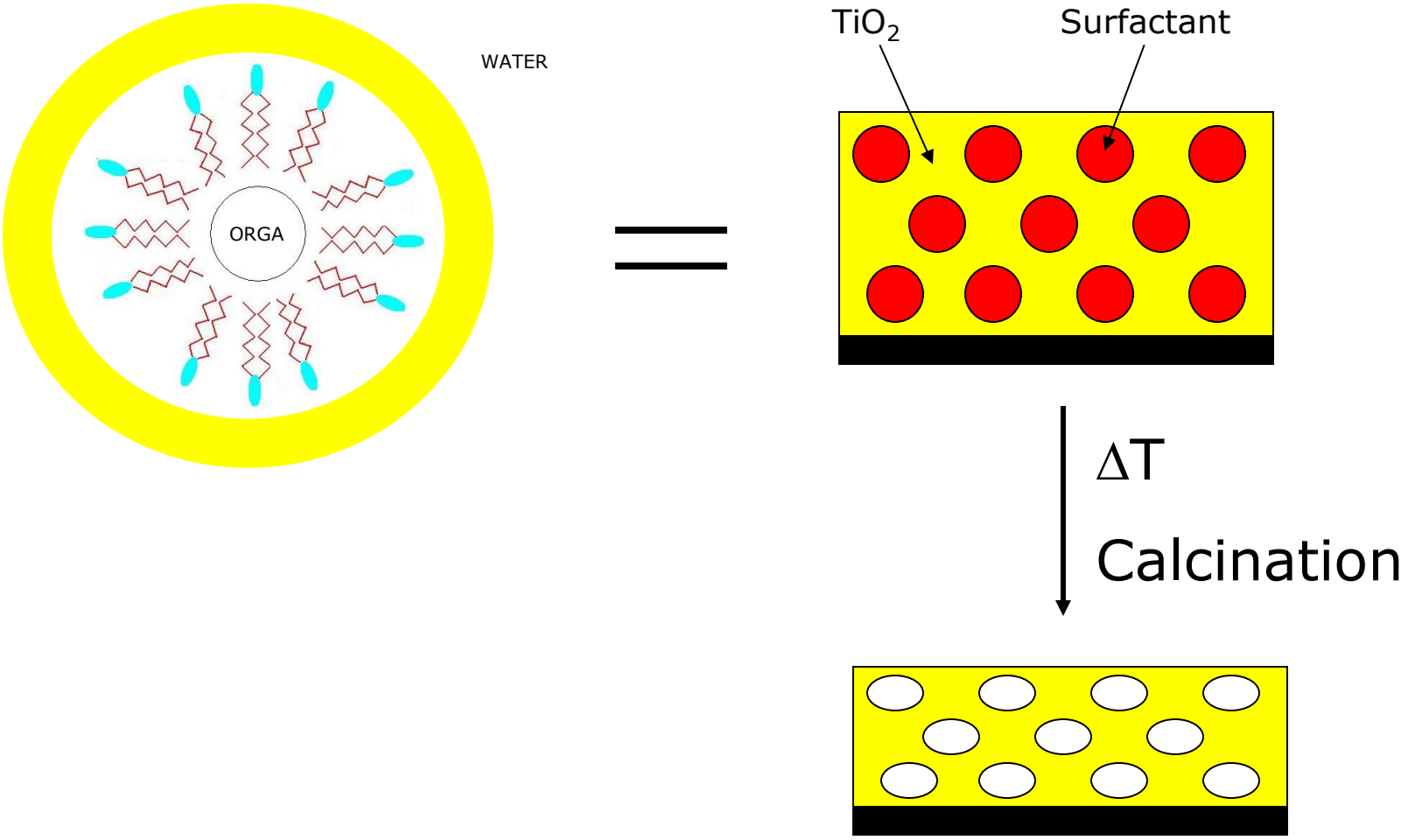
- Good electronic properties ➔ TiO_2 anatase
- High surface area ➔ mesoporosity
- Accessible pores for a better dye filling
- Thermal and structural stability

Film preparation

Synthesis route: Templating



Elimination of the surfactant and film crystallization



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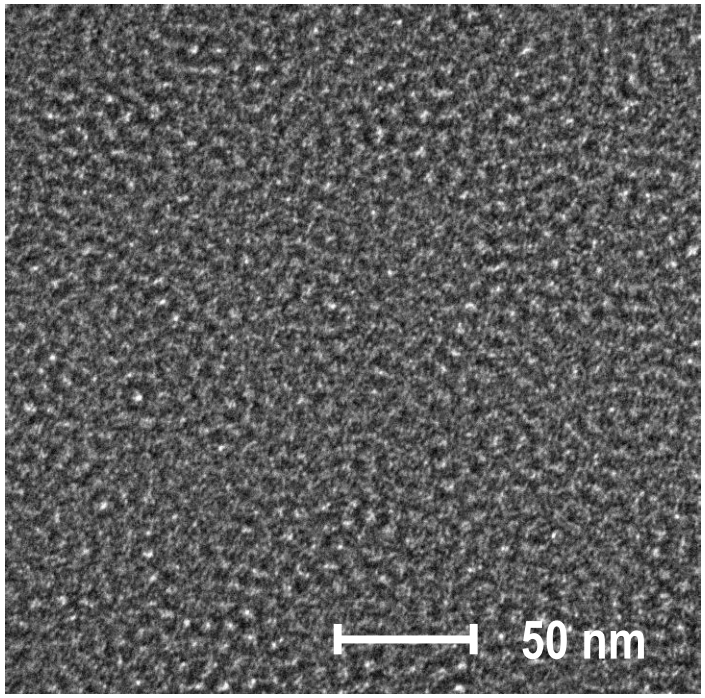
Results:

Microstructural and electrochemical characterization

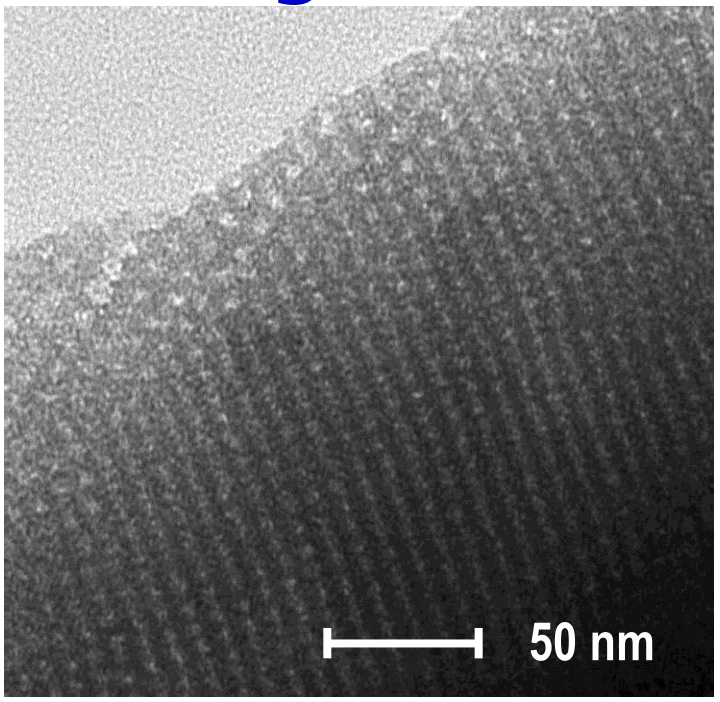
TEM
Influence of the relative humidity

low RH



Wormlike
mesostructure

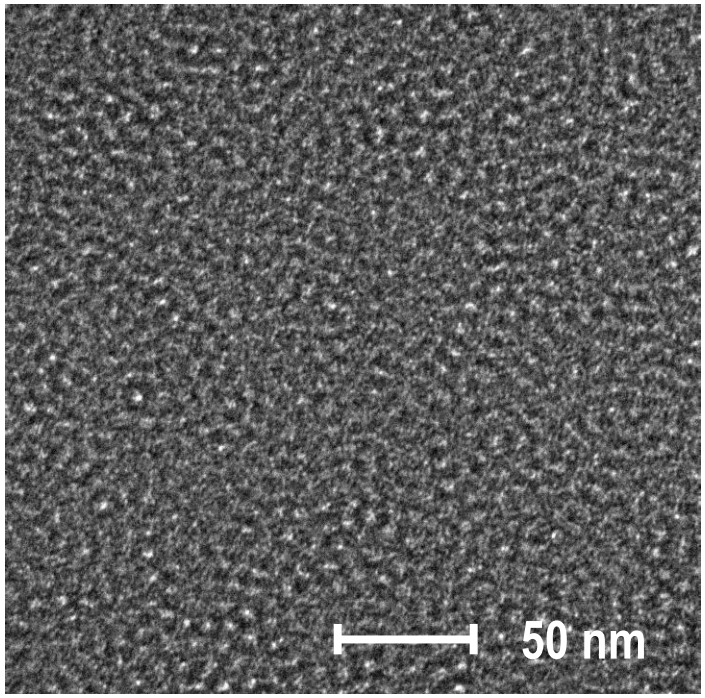
high RH



Gridlike
mesostructure

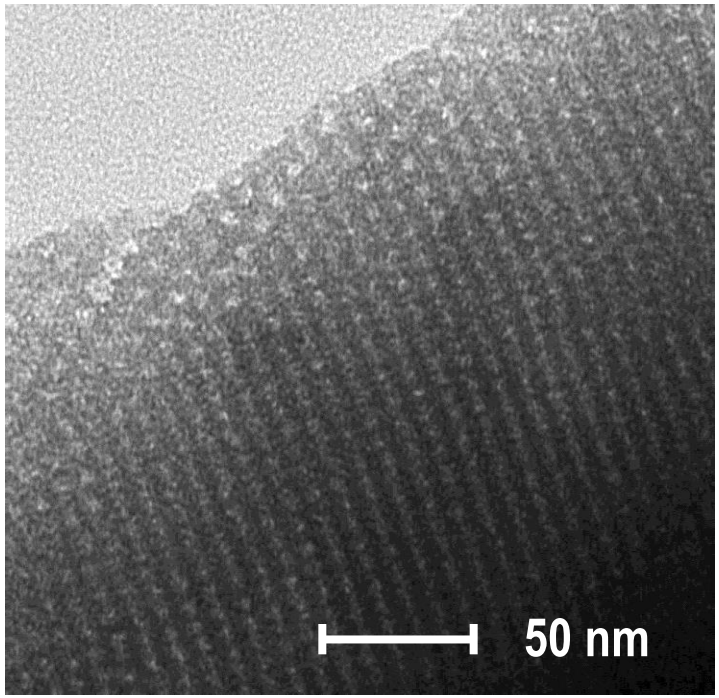
Percentage of porosity

Wormlike



45%

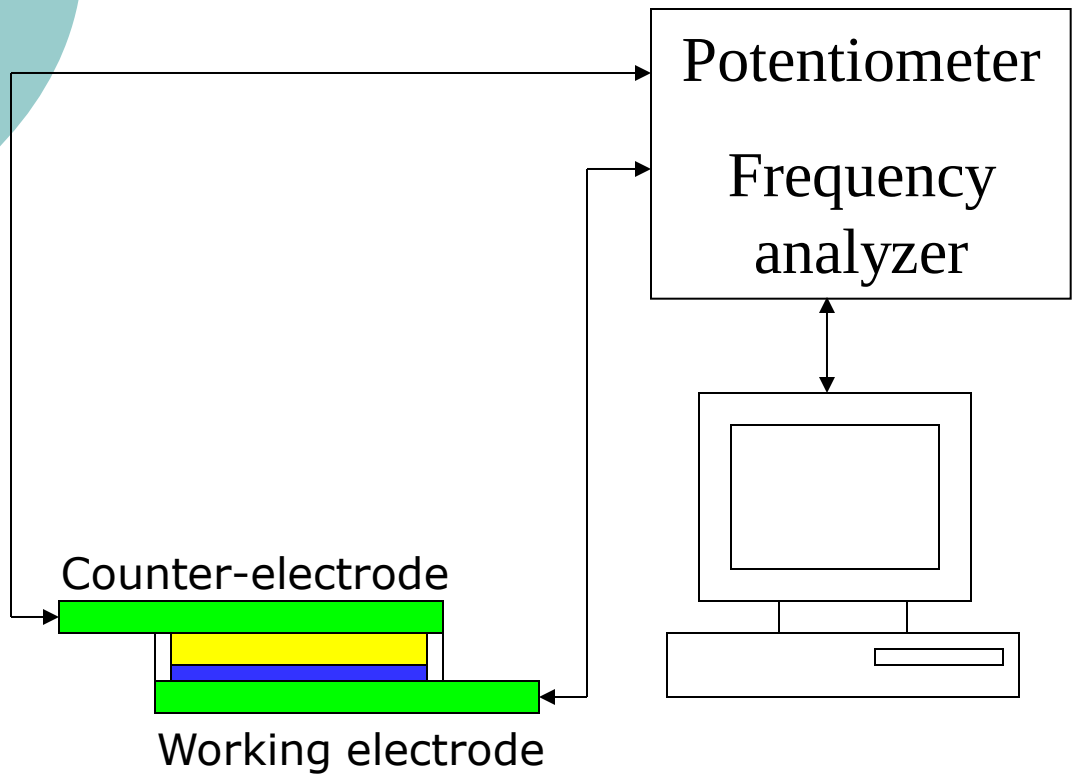
Gridlike



39%

Electrochemical Impedance Spectroscopy (EIS)

Determination of the film conductivity



° Working electrode :

TiO_2 anatase on TCO glass

° Counter-electrode :

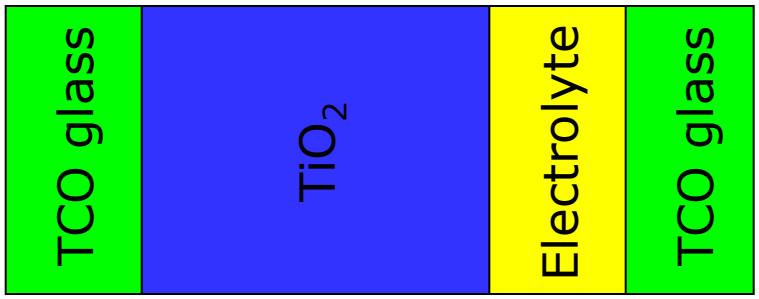
TCO glass

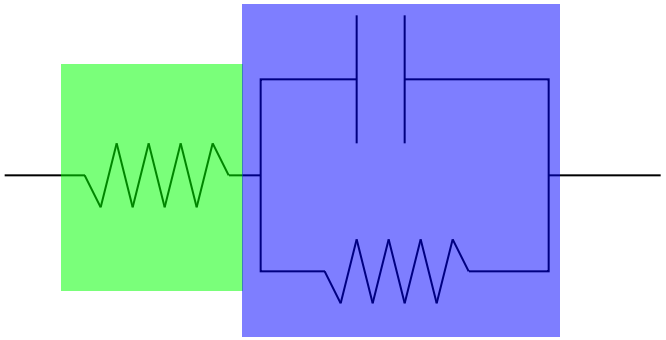
° Electrolyte :

KI 0,1M / I_2 0,01M (EG)

° Sealing

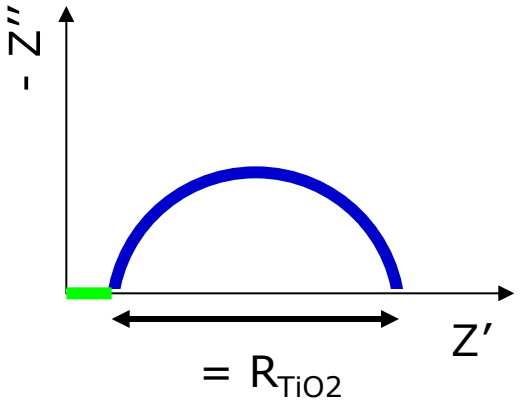
Equivalent circuit



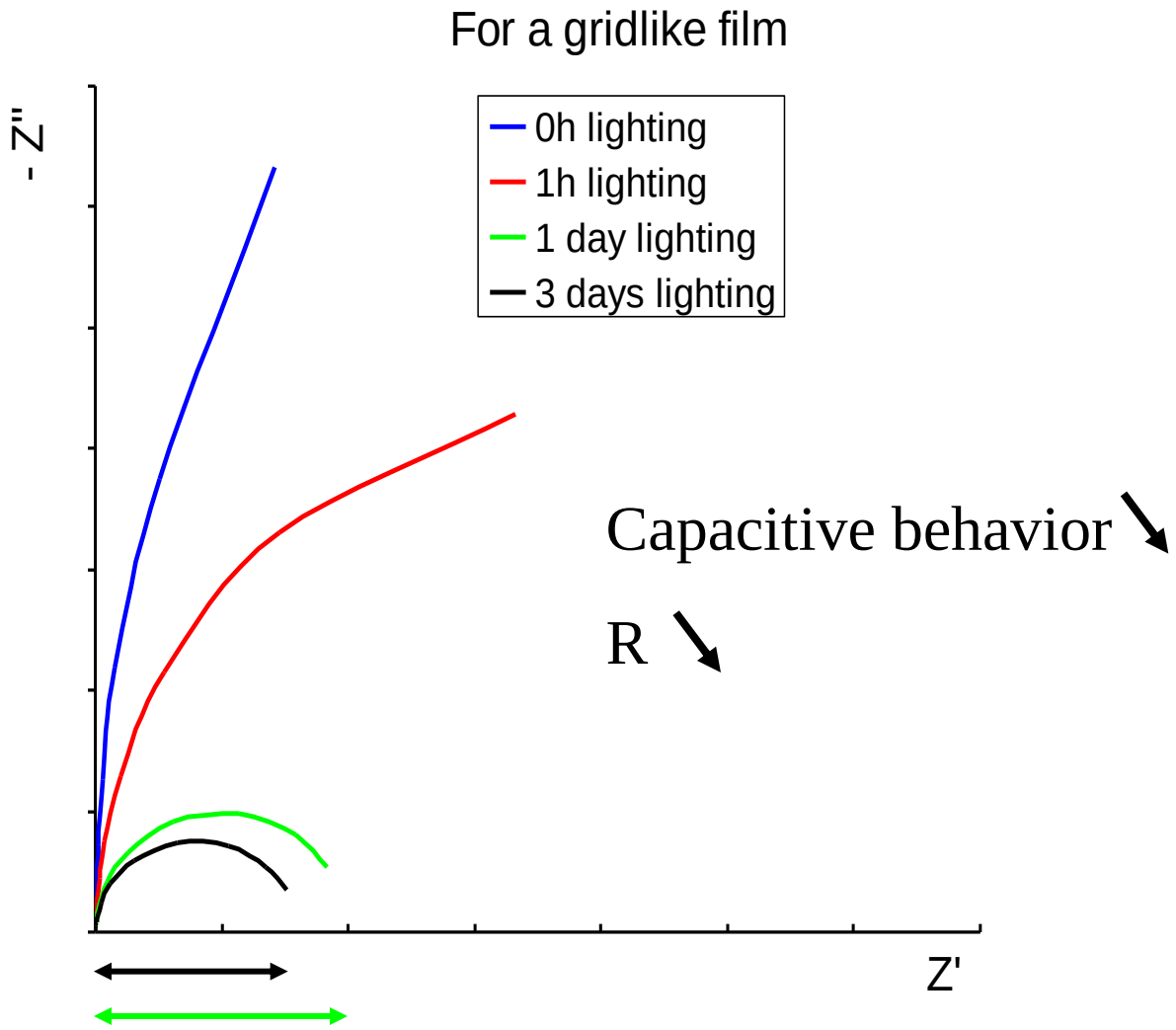


Upon lighting

Nyquist plot

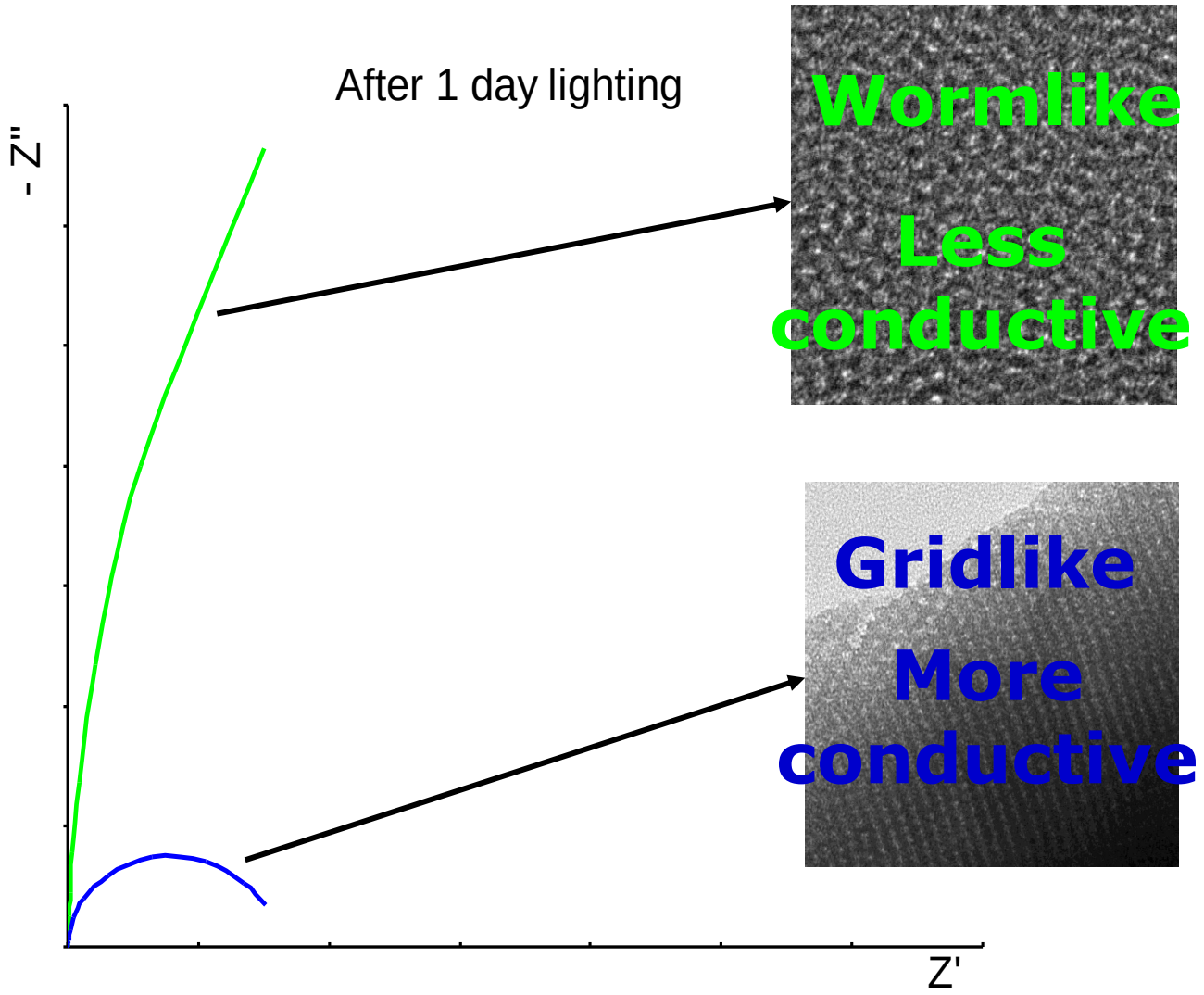


Response of the film upon lighting



EIS

Influence of the film mesostructure

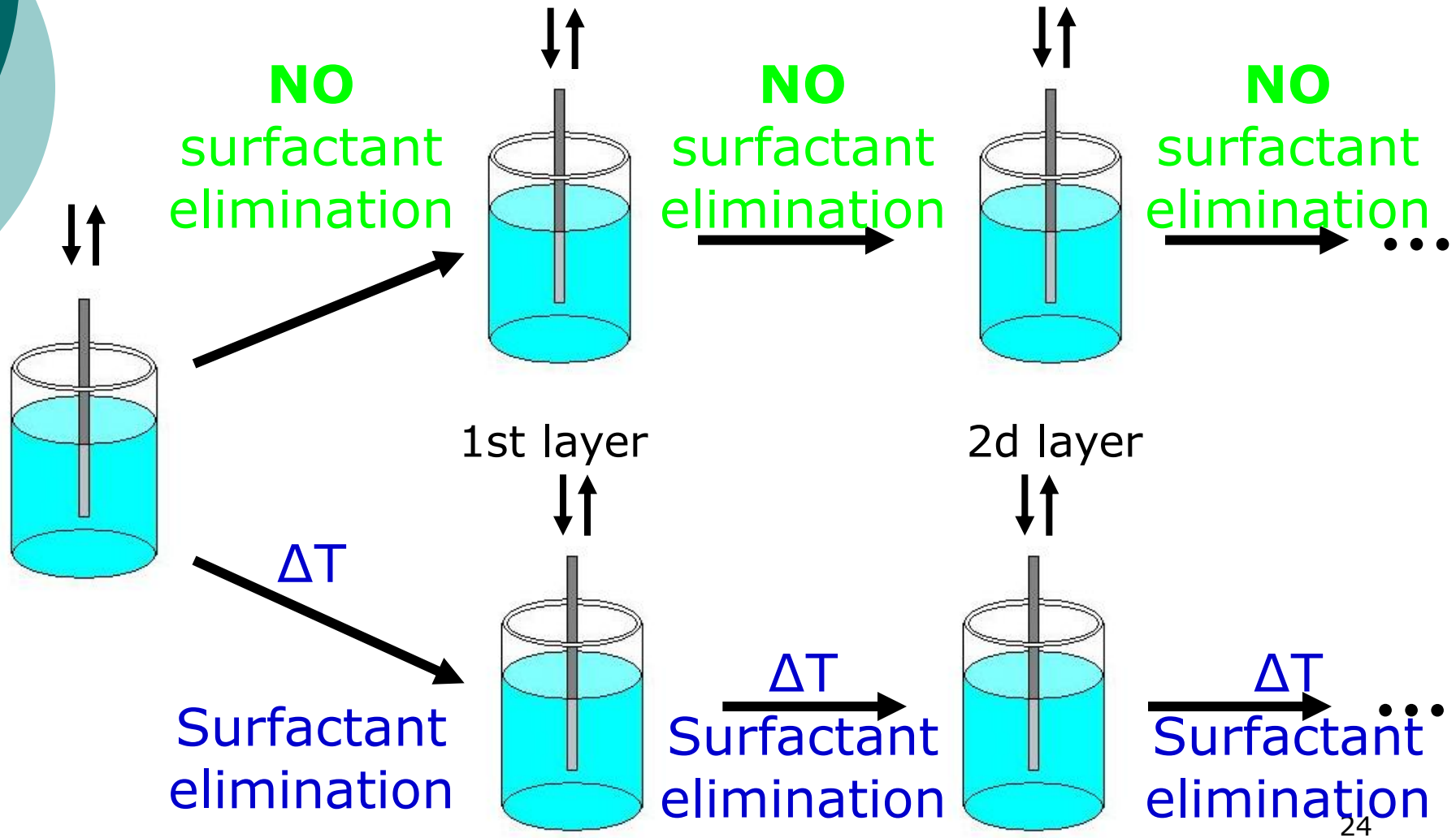


Today's limitation

- Very small thickness of the films (approx. 100 nm)
- Low content in photoactive material

How to increase the thickness?

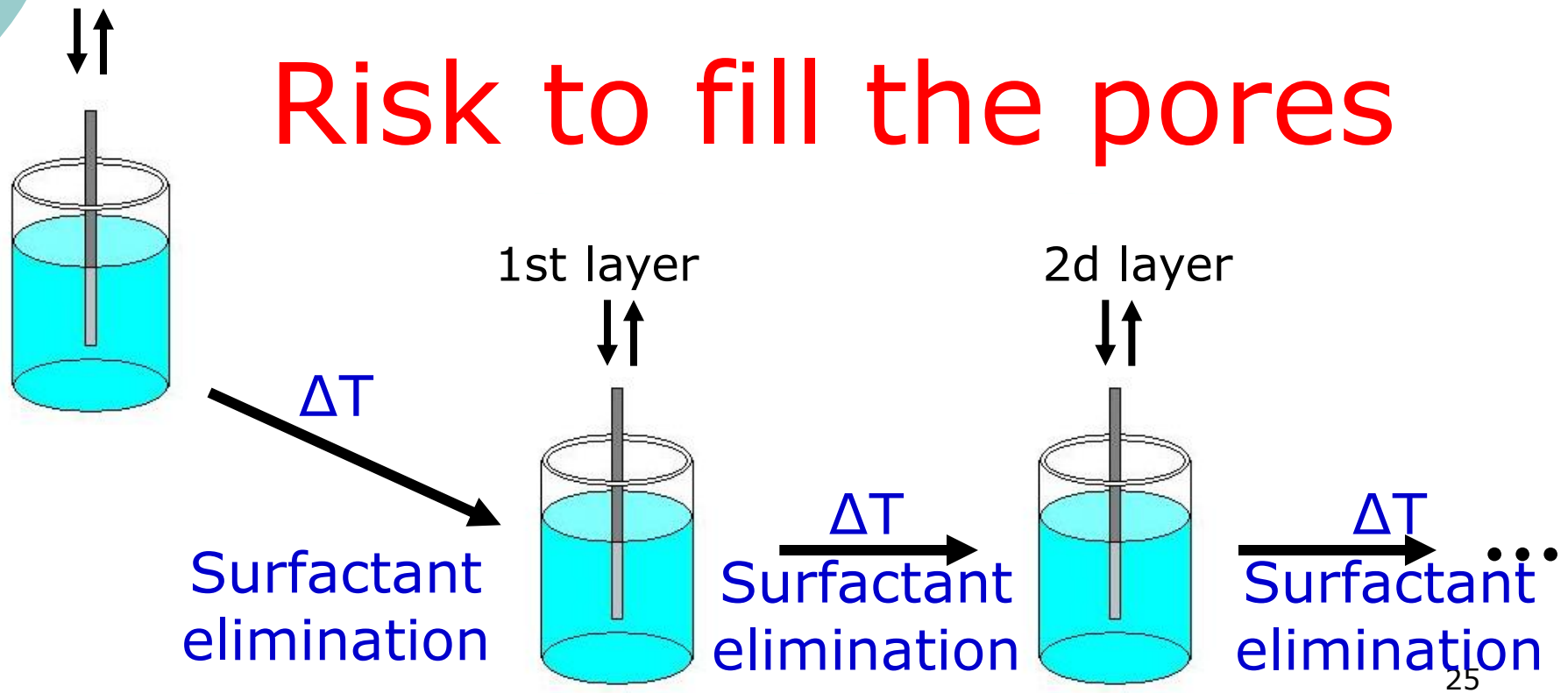
Multilayer deposition process



Multilayer deposition process

WARNING

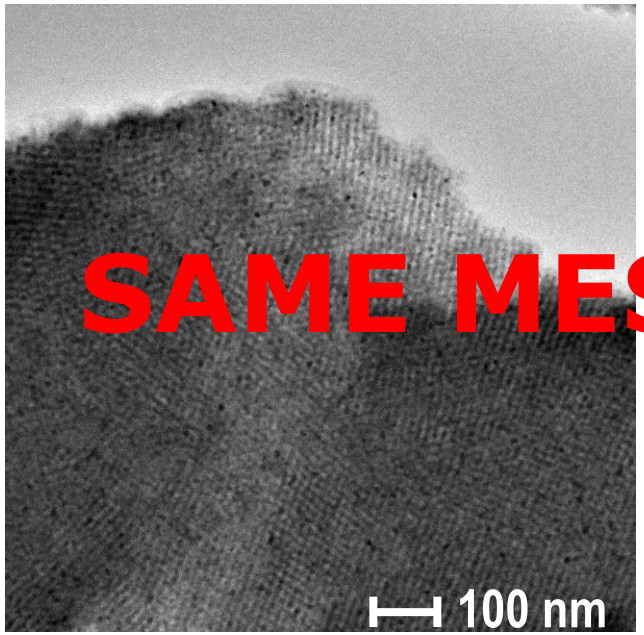
Risk to fill the pores



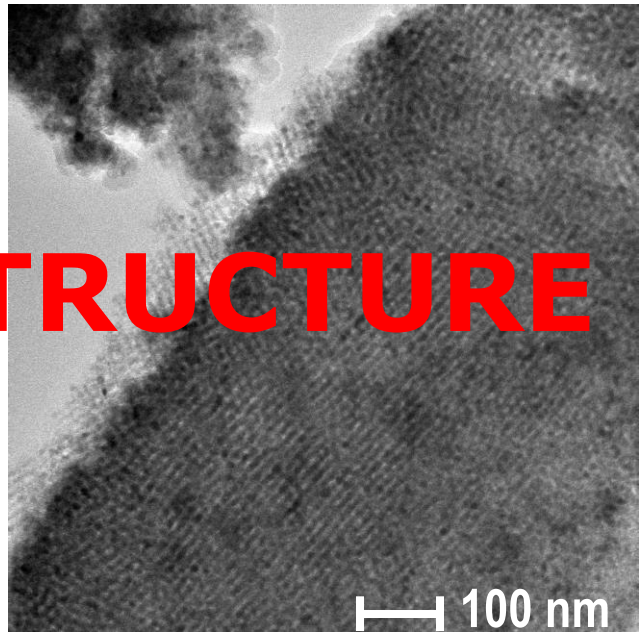
TEM
Gridlike bilayer films

No surfactant elimination between the layers

Surfactant elimination between the layers

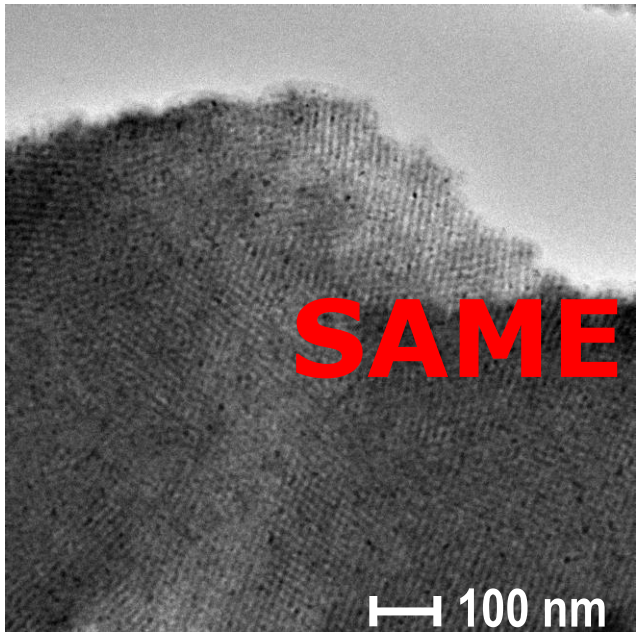


SAME MESOSTRUCTURE



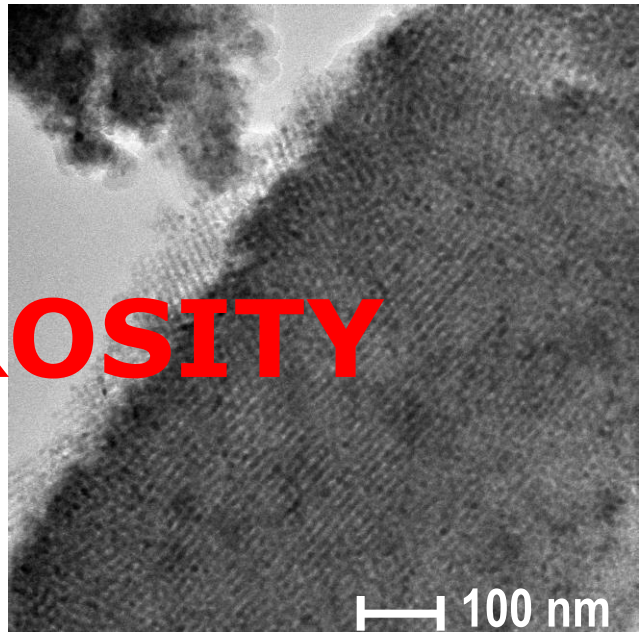
Porosity
Gridlike bilayer films

No surfactant elimination between the layers



39%

Surfactant elimination between the layers



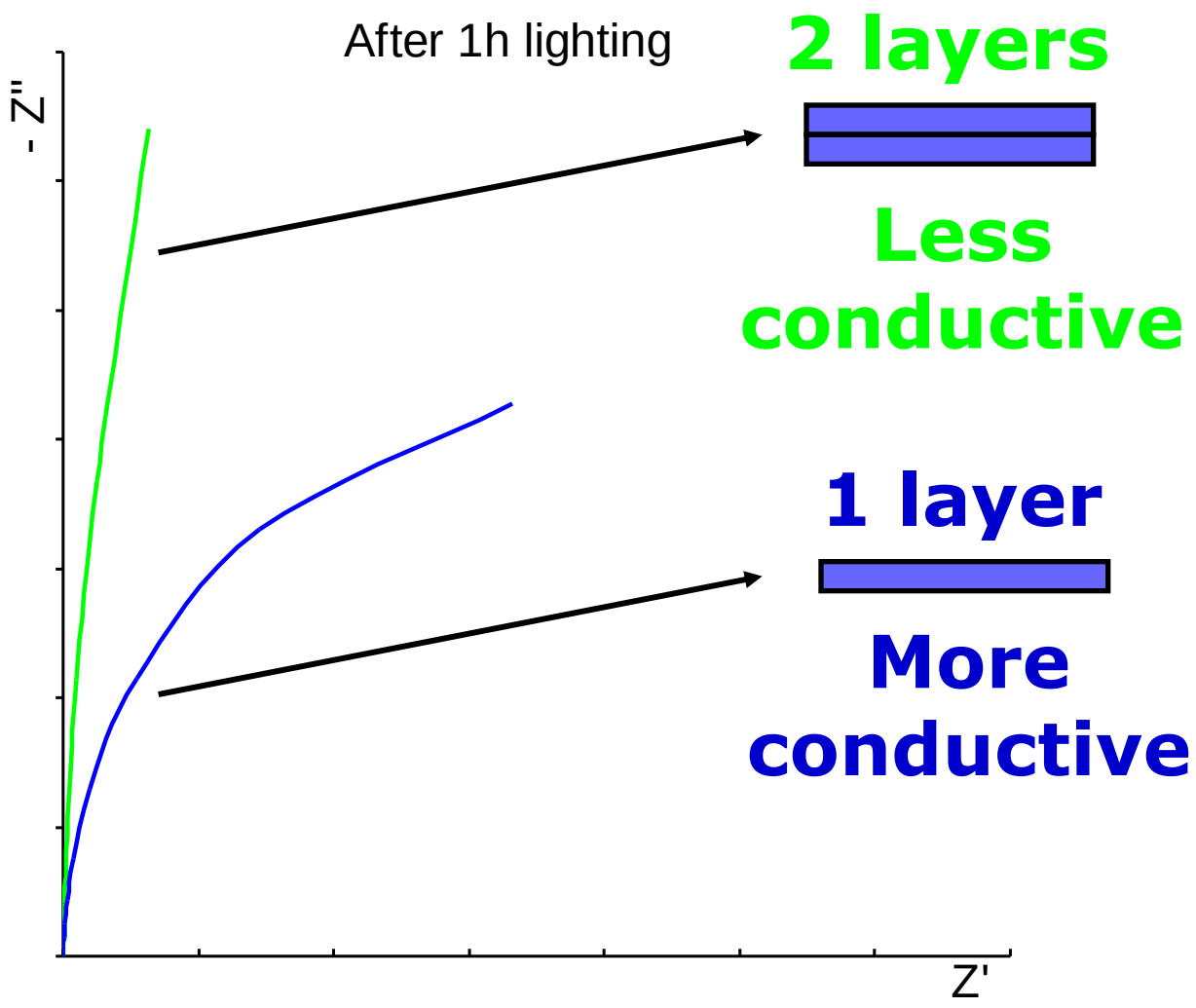
39%

SAME POROSITY

Mechanical profilometry

Increase of the film thickness

EIS
Bilayer films



Summary and perspectives

Summary

- 2 kinds of mesostructures according to the RH conditions
  - Wormlike structure more porous but less conductive

Summary

- Increase of the film thickness
  - With and without surfactant elimination between the layers
  - Monolayer and bilayer films with the same mesostructure and the same porosity but bilayer film less conductive

Perspectives

- Comparison of the photovoltaic performance of a film of TiO_2 nanoparticules and a controlled mesoporous thin film with analogous thickness
- Comparison of the photovoltaic performance of a wormlike film and a gridlike one

Thank you for your attention

Acknowledgments

- Prof R. Cloots and Dr C. Henrist, University of Liege, Belgium
- X. Mathieu and Dr A. Decroly, Faculty of Engineering, Mons, Belgium
- Prof C. Sanchez and his team, University Pierre et Marie Curie, Paris, France
- Arcelor-Mittal Research Center