Microstructured Conducting Polymers On-Chip

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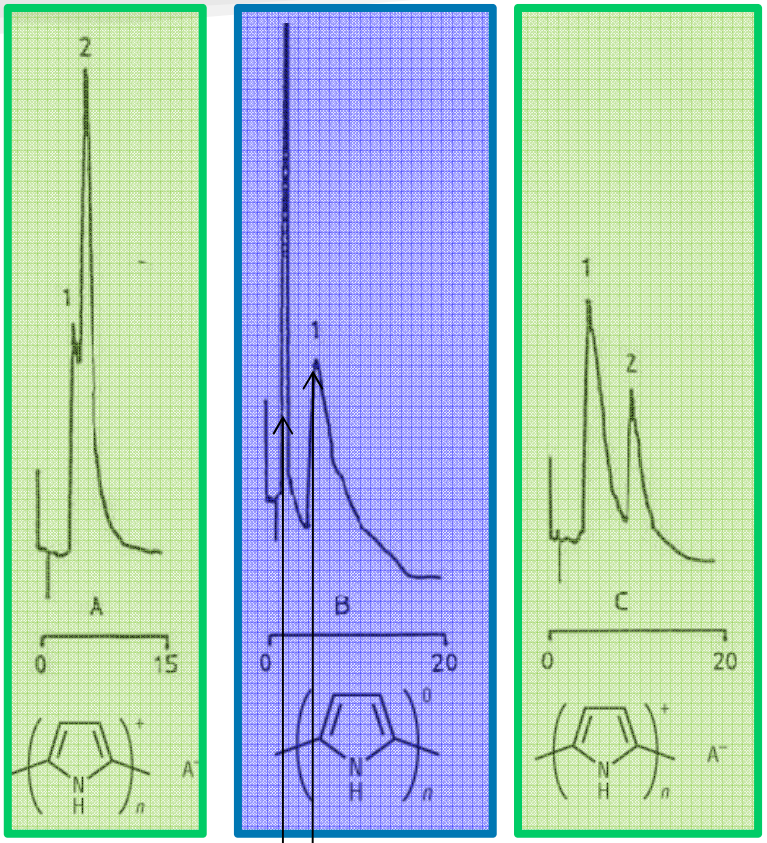
Outline

- Conducting polymers in chromatography
- Fabrication of conducting polymer monoliths on-chip
- μChip electrochemical cell design
- Electrochemistry on-chip
- Applications

Electroactive polymers as coatings on separation phases: Early work



- Particulate packing: Ppy-coated silica particles
- Chemical switching of Ppy states

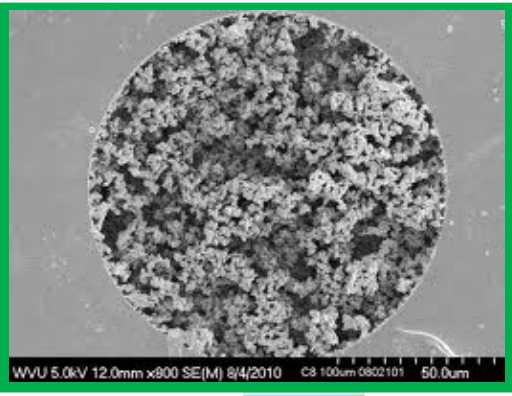
Chriswanto & Wallace, J. Liq. Chrom. & Rel Technol., 19:2457 (1996)

15 YEARS ON……
TIME TO REVISIT!

From particulates to monoliths in chromatography

Passive, inert structures comprised of rigid polymer rods

UV or thermally curable monomers, e.g., methacrylates, styrenes etc.



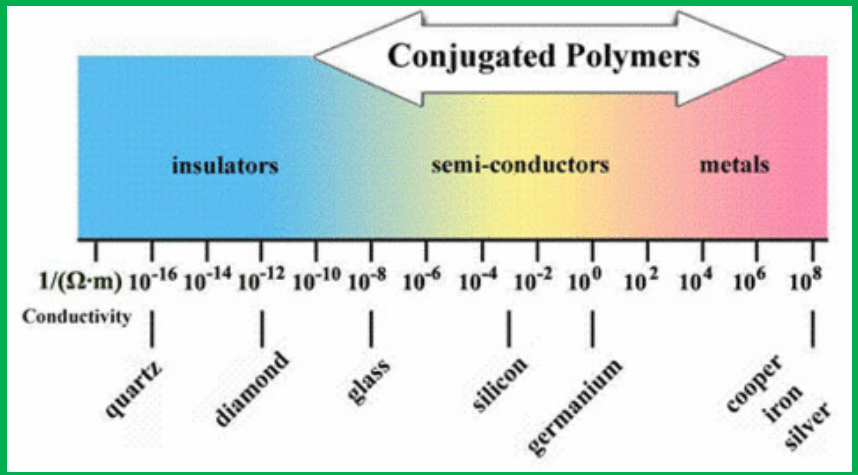
Do functional materials offer a viable alternative???

Conducting polymers as monoliths could provide:

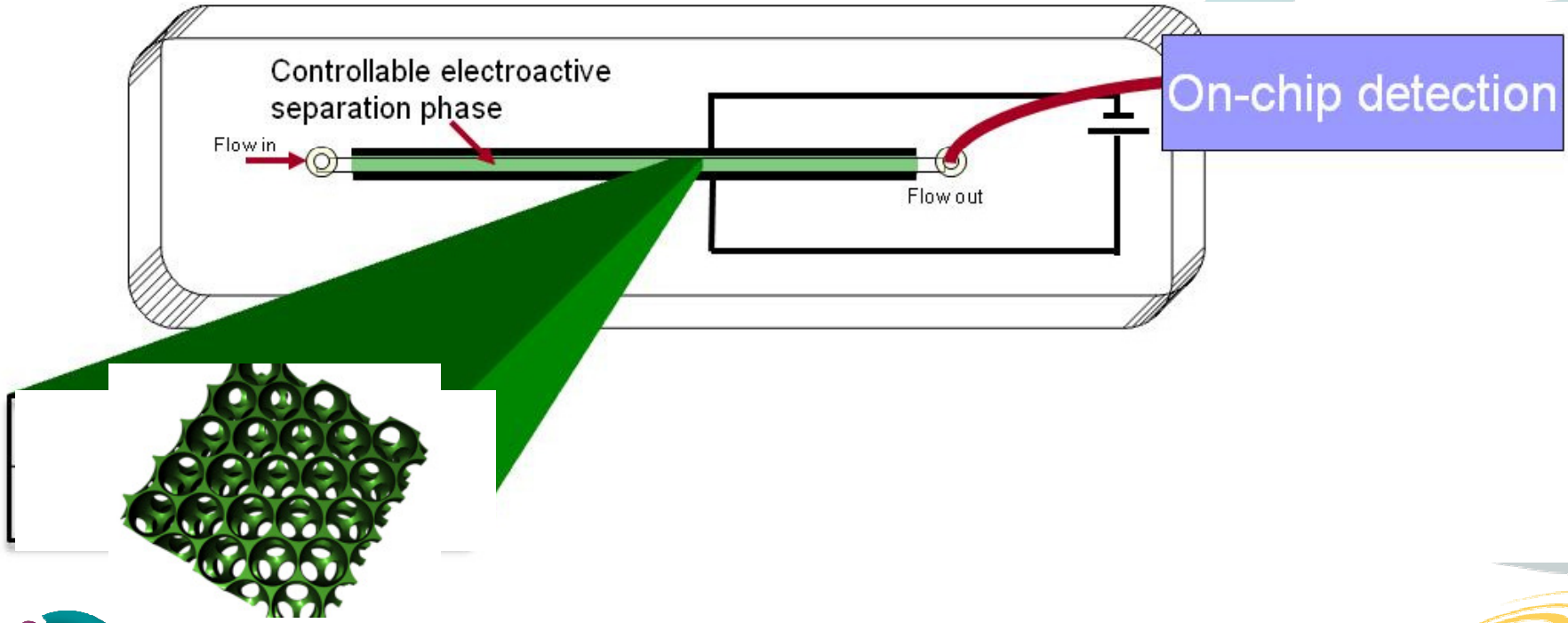
A new fabrication method

Conducting stationary phases

Dynamic separations (active)



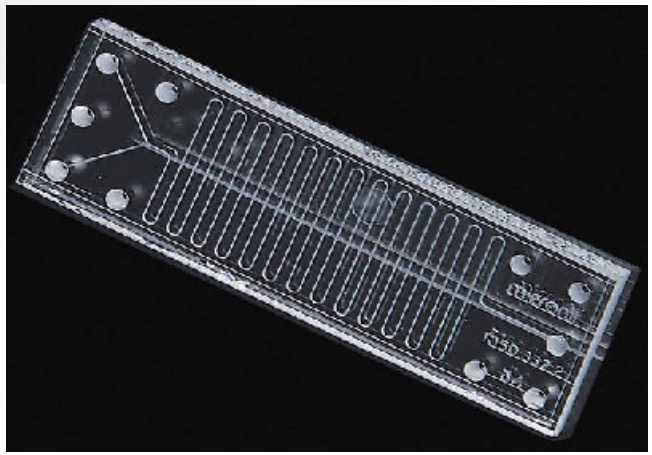
Electroactive Monolith µChip (EMµ)

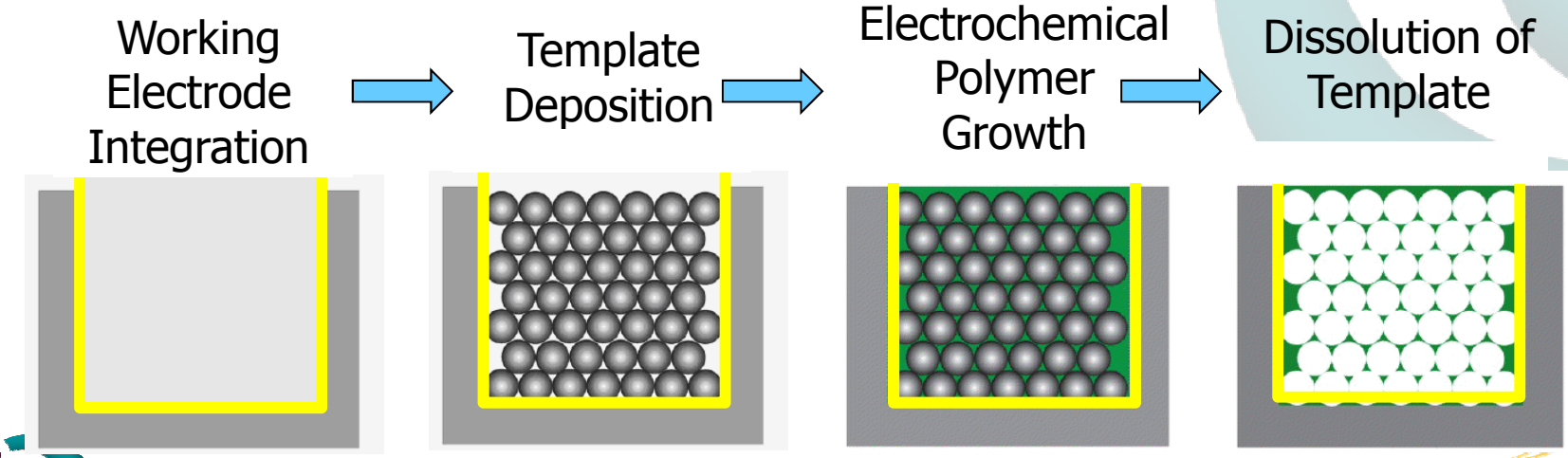


EMμ credentials

- Electrochemical growth of **uniformly templated** monolithic stationary phases
- Precise control over stationary phase fabrication enabling high reproducibility
- Micro-structuring of the monolithic stationary phase enabling:
  - Further decrease of the A-term in Van Deemter
  - Large flow through pores
  - Small skeleton size
- Precise electrochemical tuning of stationary phase before & during separation to affect:
  - Retention factors
  - Hydrophobicity/hydrophilicity
  - Pore size
  - Ionic capacity

Conducting polymer monoliths – fabrication on-chip





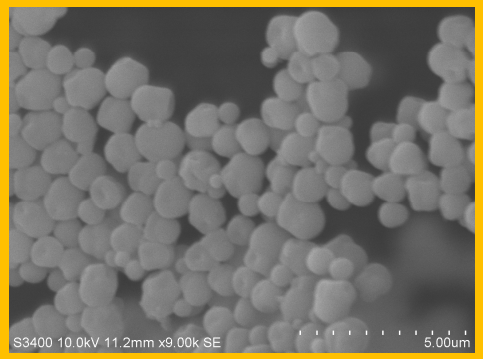
Channel Width: 110 micron

Dissolvable PS template

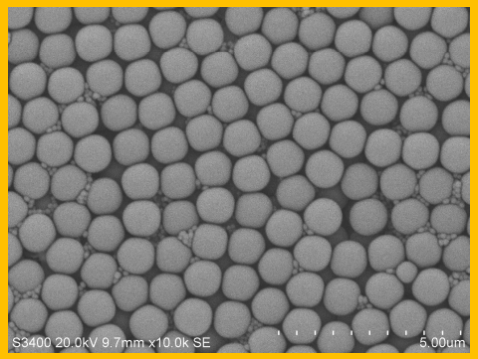
PS bead synthesis

Two Critical Factors:

Appropriate cross-linker concentration to give uniformity and permit dissolution

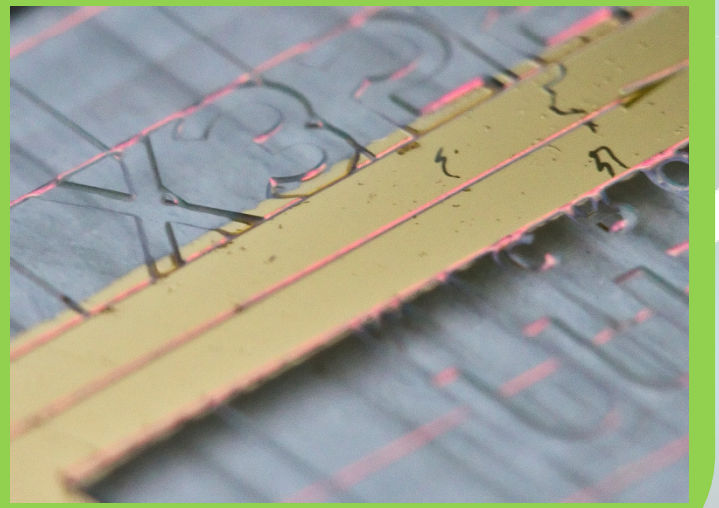


vs.

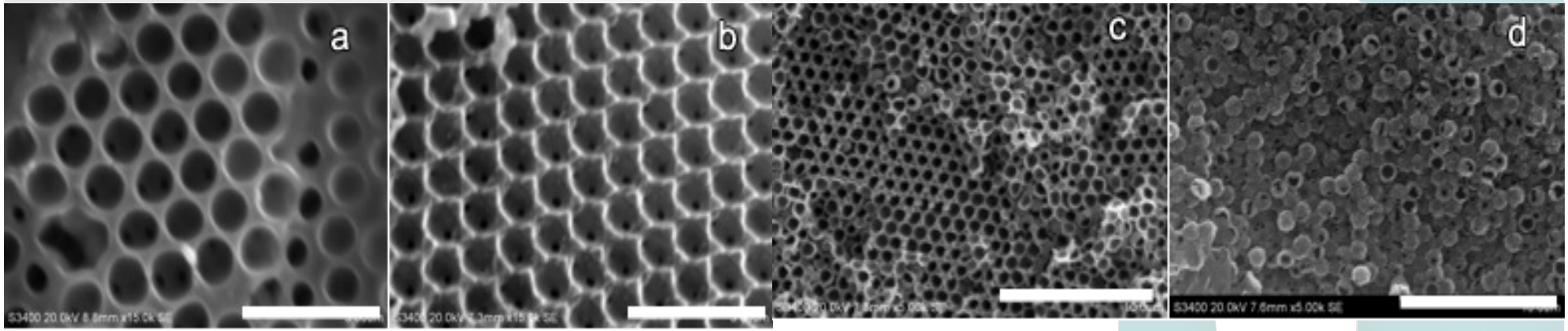


Surfactant content of dispersions

PS crystal in μfluidic channel



Surfactant levels in PS dispersions – resulting PANI structures

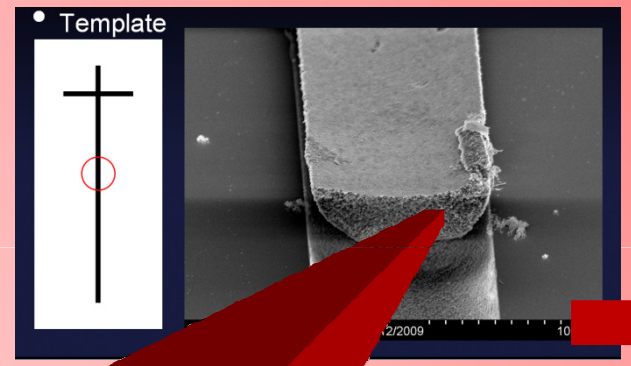


Deionised Water | 0.01 % w/v SDS | 0.1 % w/v SDS | 1 % w/v SDS

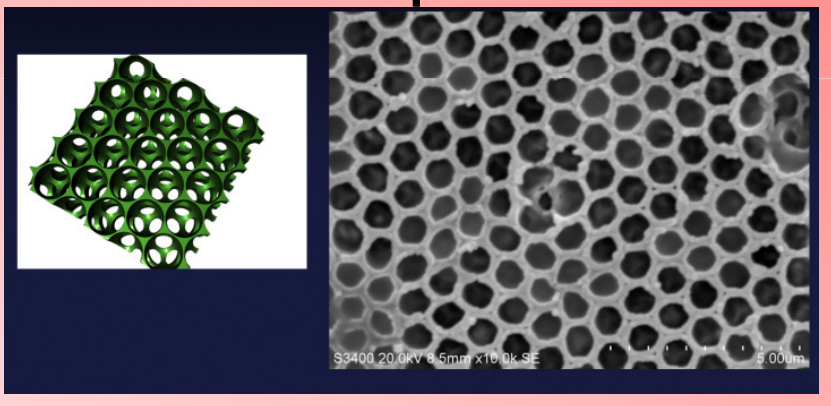
Increasing %w/v surfactant in dispersions - Order in resulting structures changes

On-chip conducting polymer monolith

PS Template

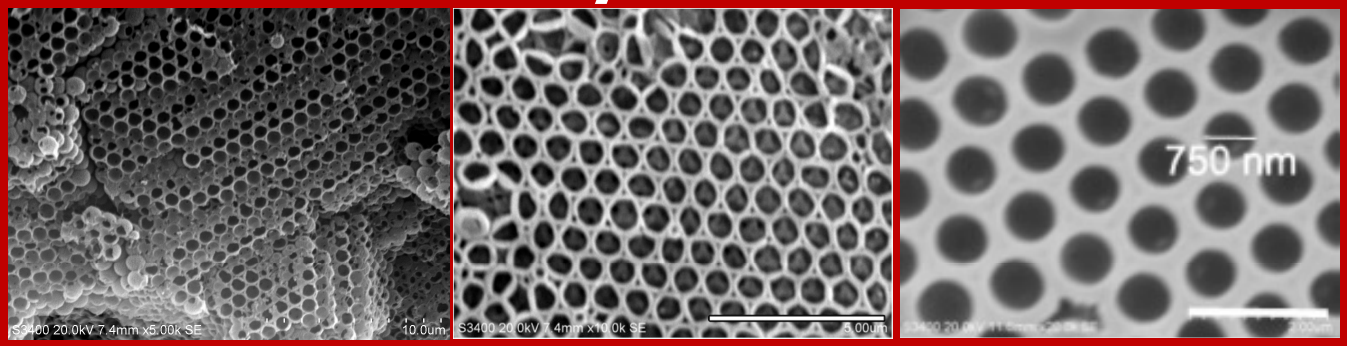


Polyaniline Inverse Opal

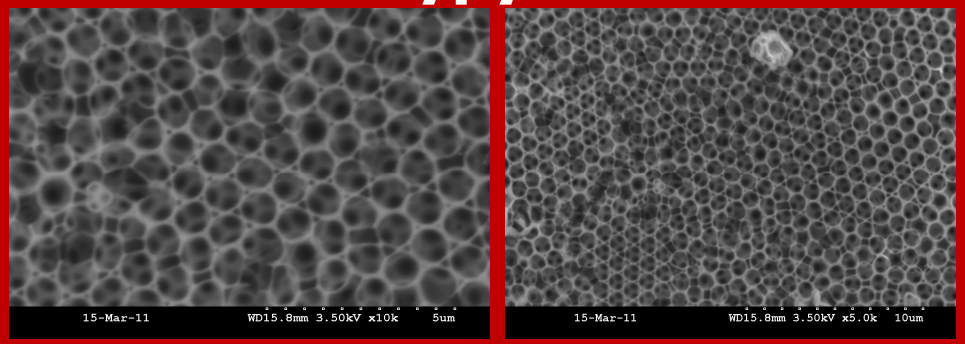


Micro-structured conducting polymers on-chip - unimodal

Polyaniline



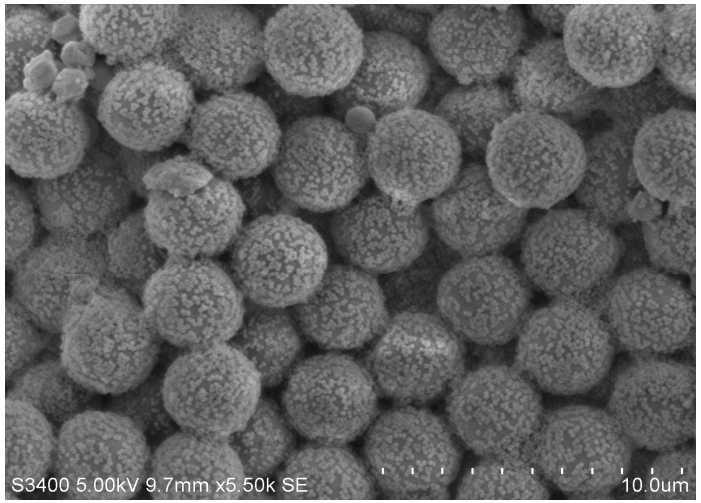
Polypyrrole



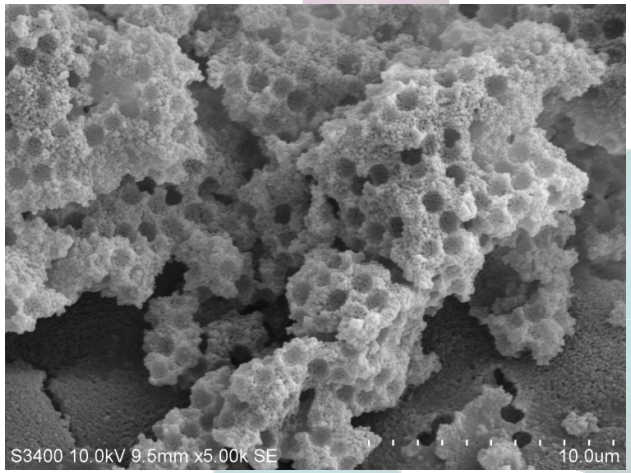
Order in 3-D
A new way for improving chip-to-chip reproducibility of monolithic stationary phases

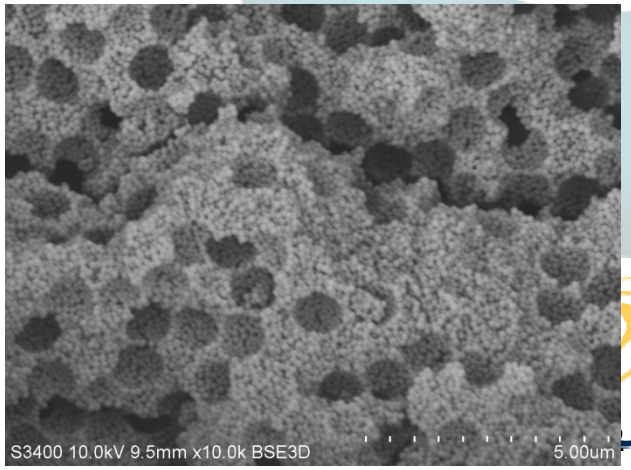
Bimodal Structures

PS template comprising 3 micron & 300 nm beads



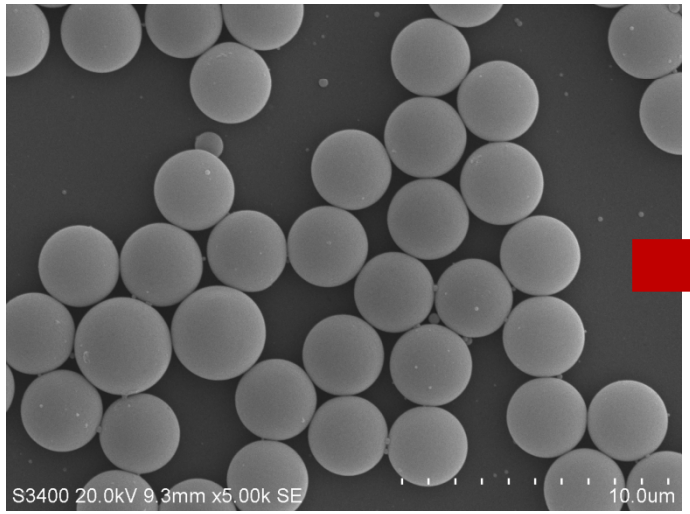
Bimodal Ppy Monolith



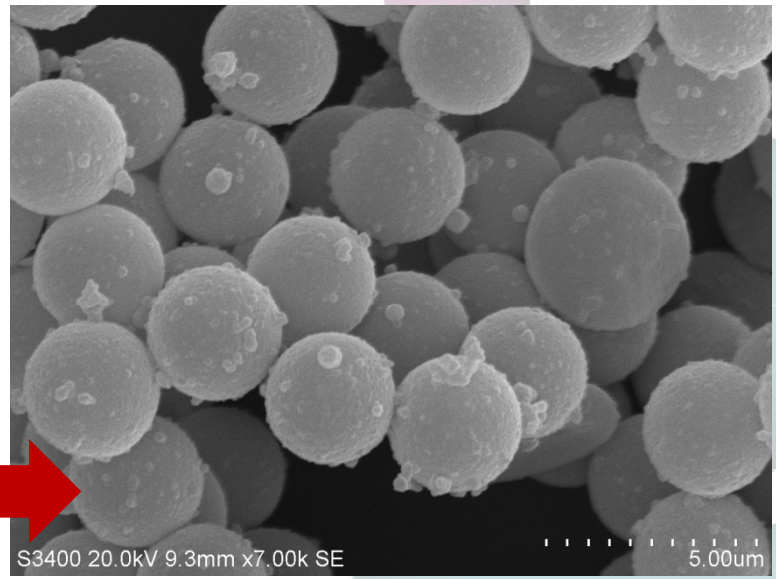


Composite structures for chip packings

PS template (3 μm beads)



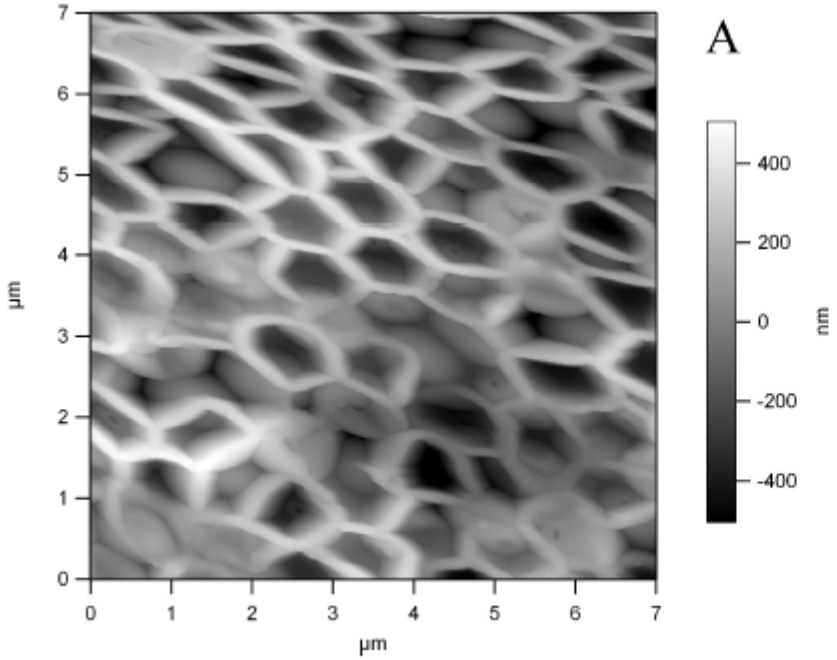
Ppy coated PS beads



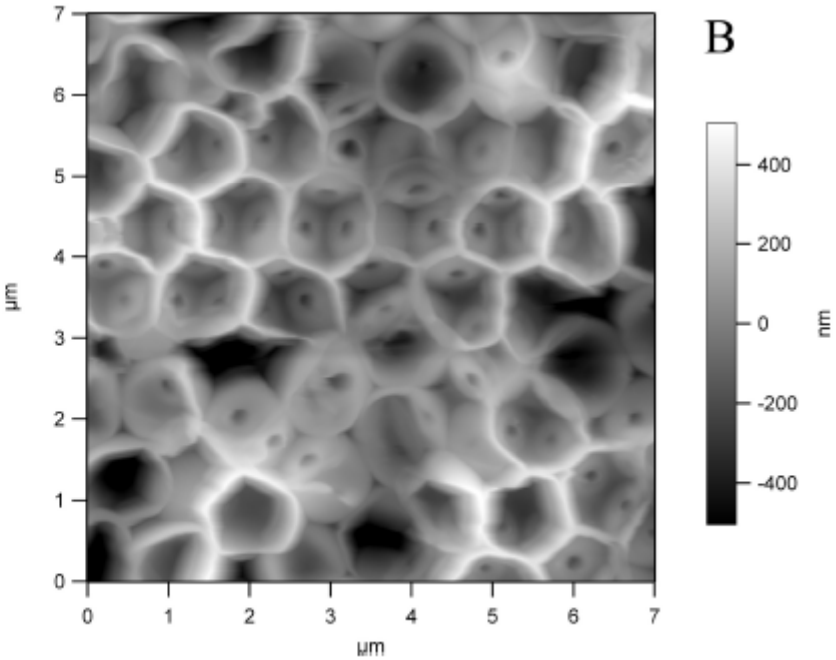
Dry and wetted states of inverse opals

Electrochemically grown micro-structured Ppy doped with DBS

Dry State

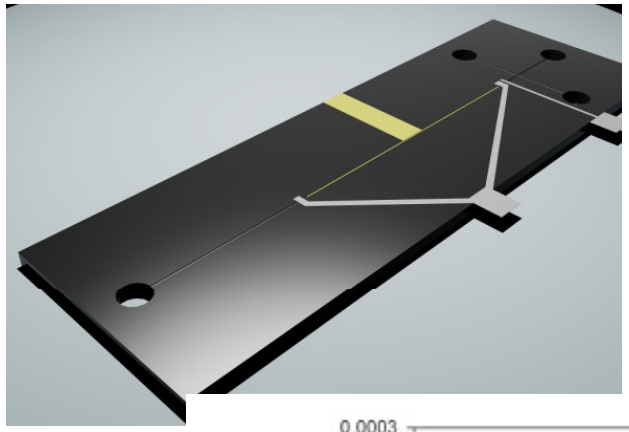


In Electrolyte

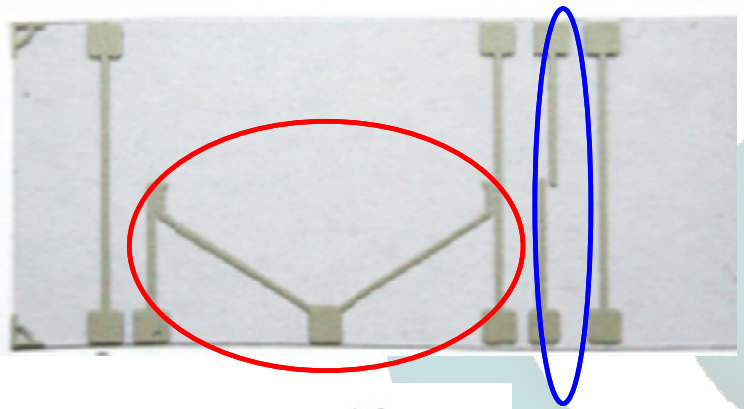


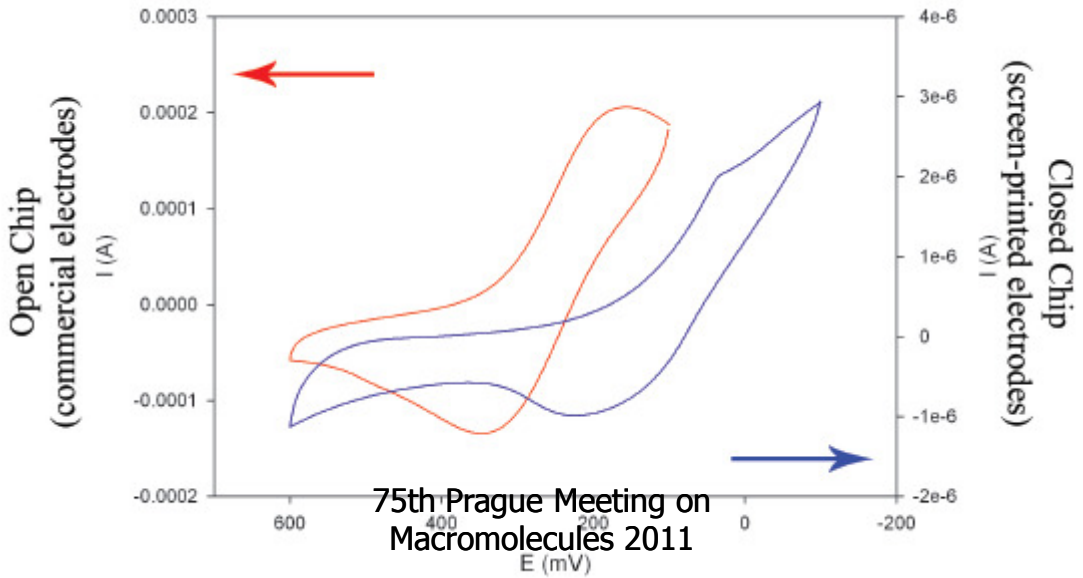
On-chip electrochemical cell

Glass Base Chip

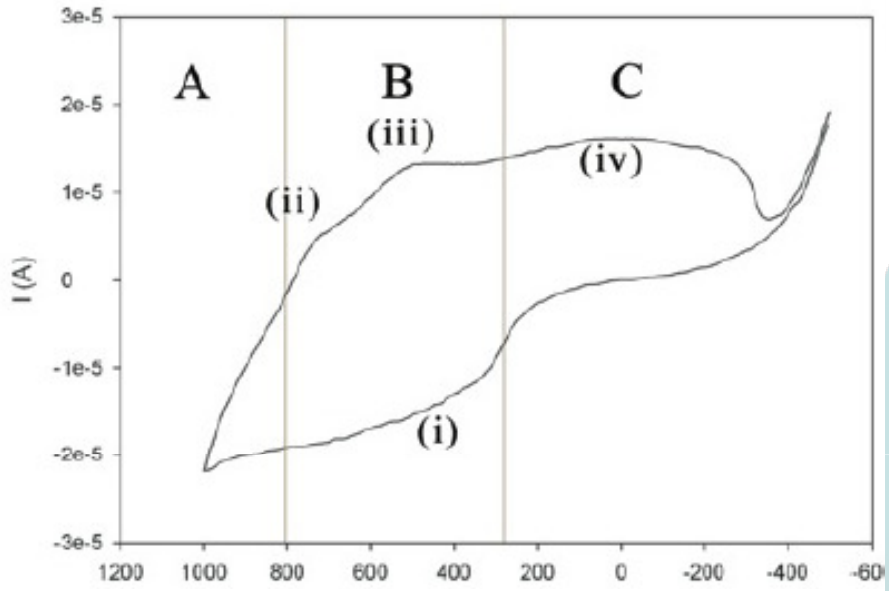


PET lid with silver paste screen-printed cell electrodes



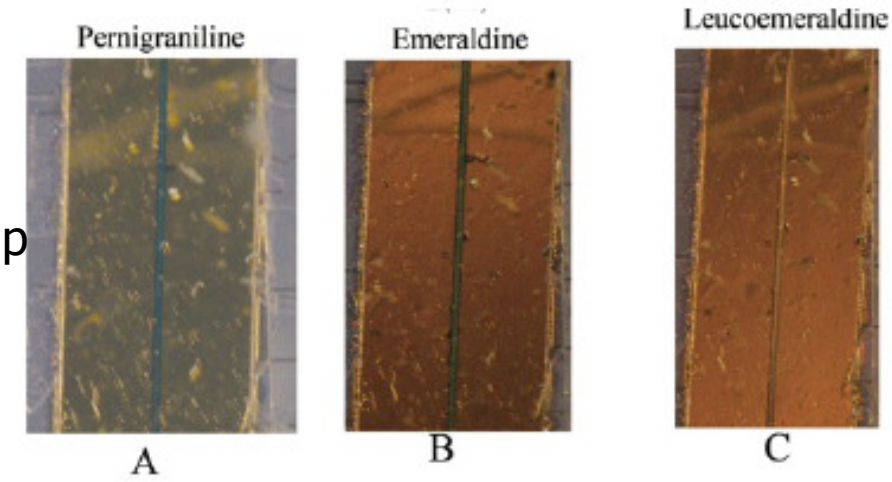


PANI electrochemistry on-chip

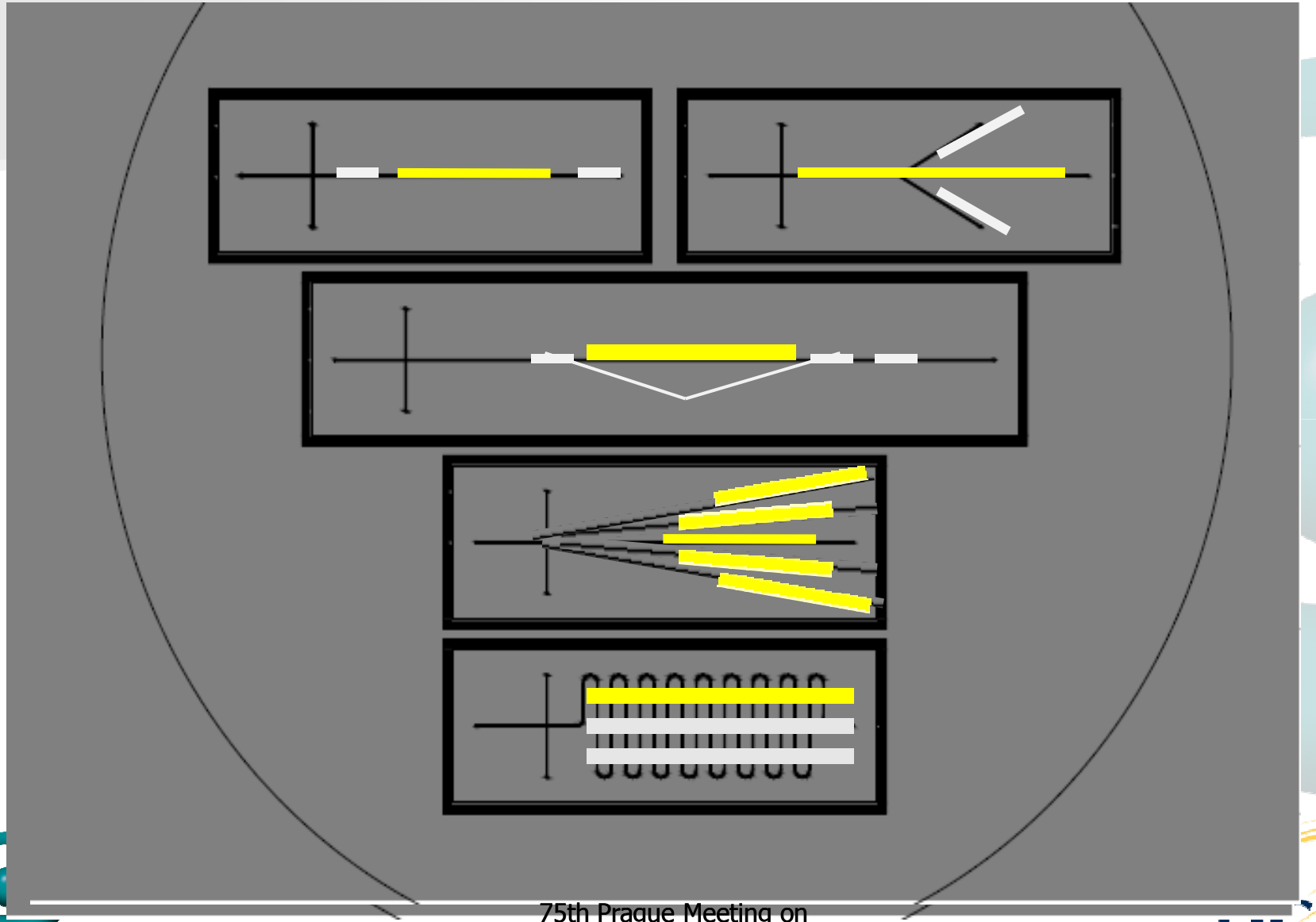


50 mV s^{-1}
1 M HCl

Corresponding
colour change on-chip



Improving chip design

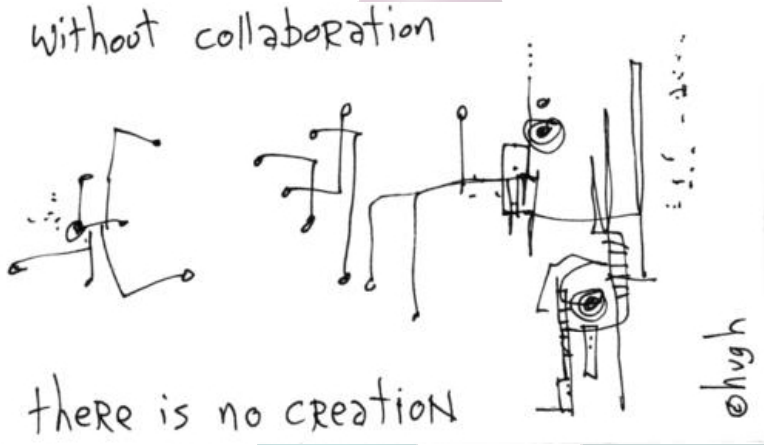


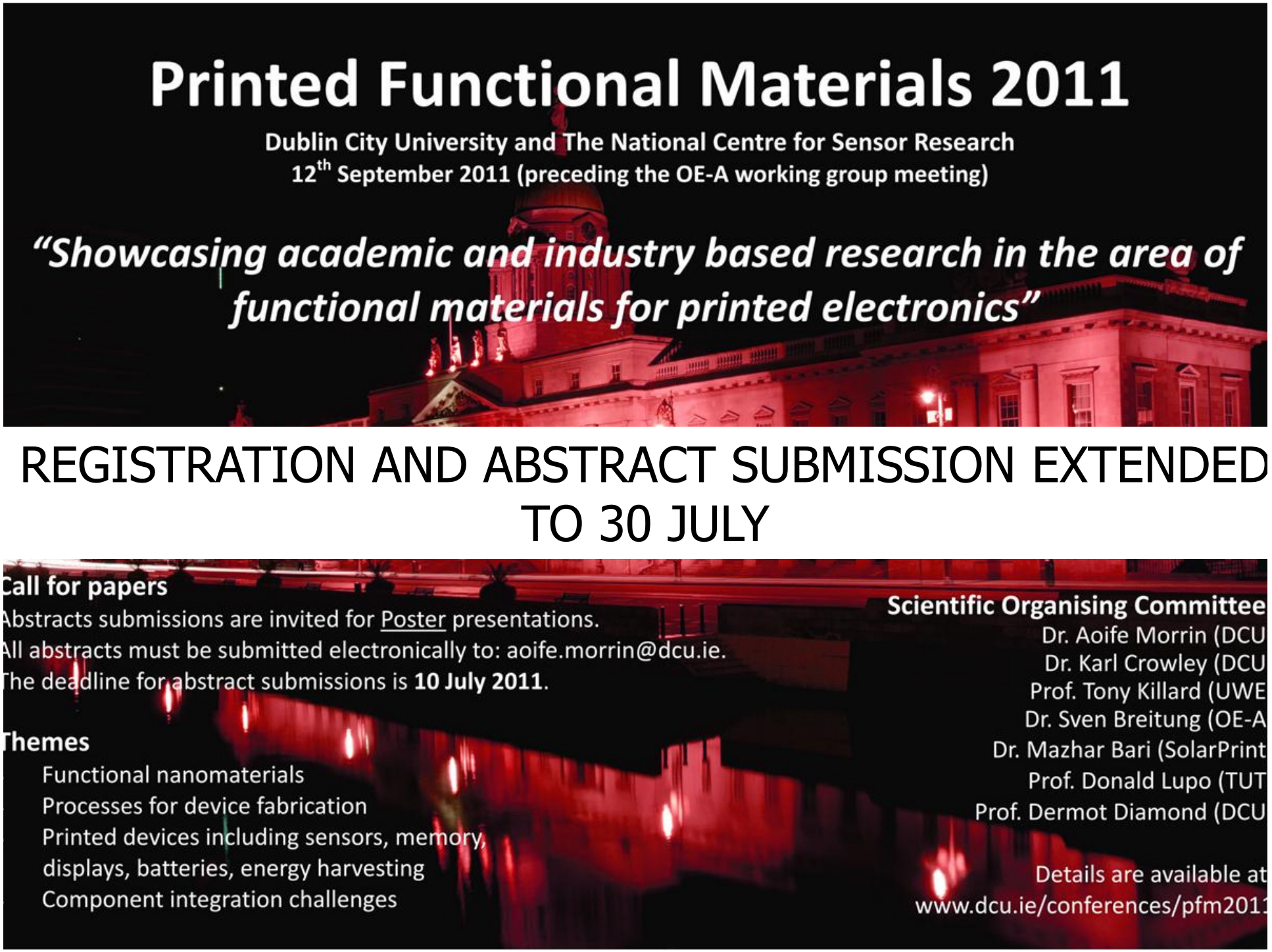
Target applications

- HPLC
  - Highly reproducible micro-structured polymer monolithic stationary phase for nanoLC, HPLC chip, and electrochromatography
  - EMLC: Precise tuning of stationary phase properties before & during separations (by application of a voltage)
- Lab-on-a-chip applications
  - Point of care diagnostics e.g., (multi-analyte) electrochemical sensing on-chip
  - Fluidic control

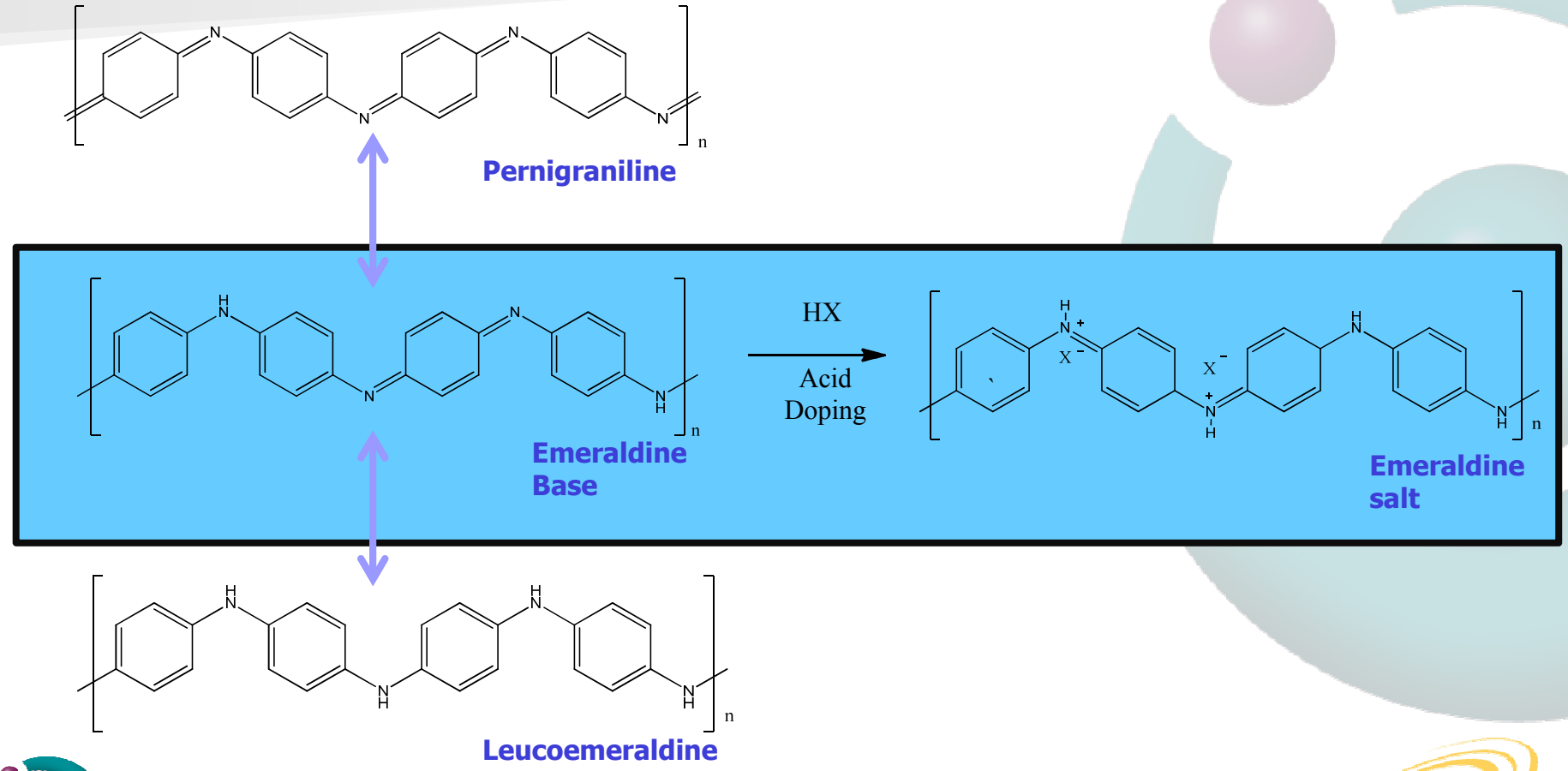
Thanks!

- The organisers and audience at Prague Meeting on Macromolecules 2011
- Dr. Blánaid White
- Prof. Malcolm Smyth
- Prof. Gordon Wallace
- Prof. Tony Killard
- Dr. Damian Connolly
- Dr. Jeremy Galineau
- Brian Gorey
- Dr. Courtney Collins
- Orla Gaffney
- Dr. Fuqiang Nie
- Science Foundation Ireland & Enterprise Ireland

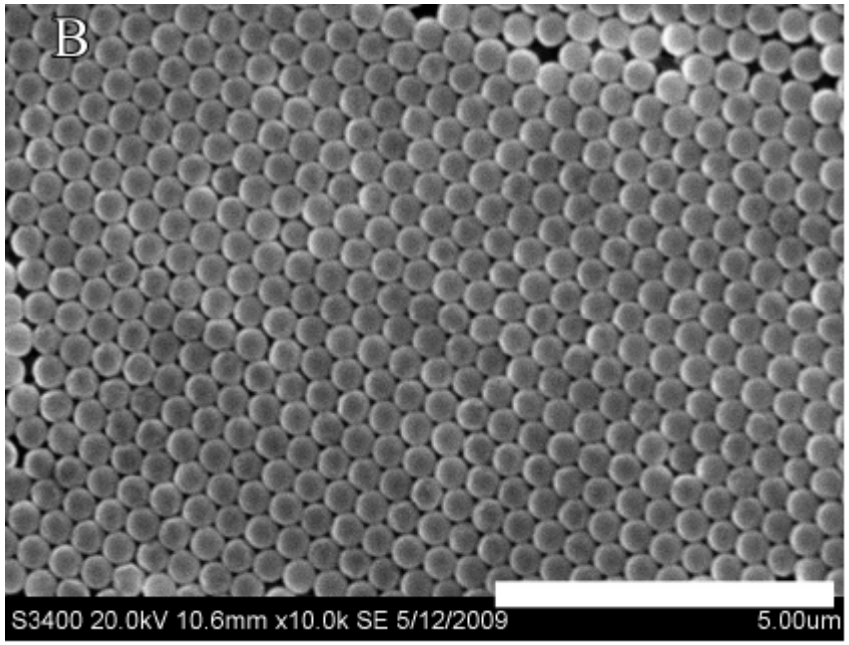



Printed Functional Materials 2011
Dublin City University and The National Centre for Sensor Research
12th September 2011 (preceding the OE-A working group meeting)
"Showcasing academic and industry based research in the area of functional materials for printed electronics"
REGISTRATION AND ABSTRACT SUBMISSION EXTENDED TO 30 JULY
Call for papers
Abstracts submissions are invited for Poster presentations.
All abstracts must be submitted electronically to: aoife.morrin@dcu.ie.
The deadline for abstract submissions is 10 July 2011.
Themes
Functional nanomaterials
Processes for device fabrication
Printed devices including sensors, memory, displays, batteries, energy harvesting
Component integration challenges
Scientific Organising Committee
Dr. Aoife Morrin (DCU
Dr. Karl Crowley (DCU
Prof. Tony Killard (UWE
Dr. Sven Breitung (OE-A
Dr. Mazhar Bari (SolarPrint
Prof. Donald Lupo (TUT
Prof. Dermot Diamond (DCU
Details are available at
www.dcu.ie/conferences/pfm201

Electroactive Polymers



Surfactant Levels in PS Dispersions



Packing conducting polymers on-chip?

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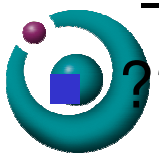
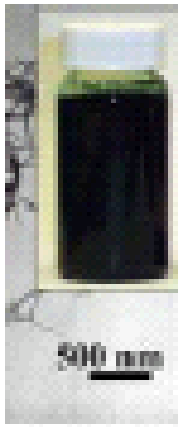
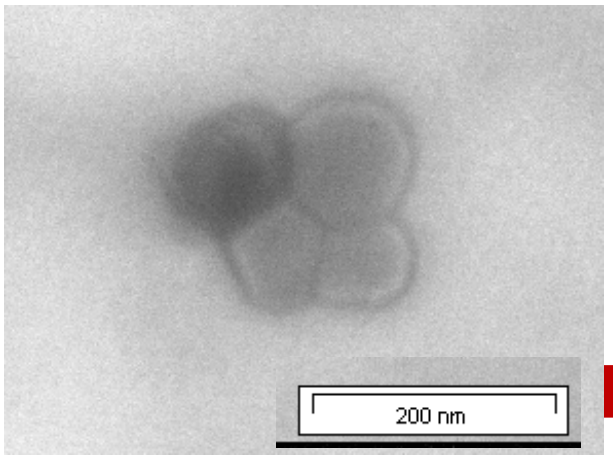
  - EMLC: Precise tuning of stationary phase properties before & during separations (by application of a voltage)
- Lab-on-a-chip applications
  - Point of care diagnostics e.g., (multi-analyte) electrochemical sensing on-chip
  - Fluidic control
- ????



Packing conducting polymer nanoparticles on chip

PANI nanoparticles:
80 nm





Pack directly on-chip by capillary fill?