Simulation of Photonic Crystals Particle Filling By Electrospray Ionization

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COMSOL, 2010, Paris
Outline

1. Introduction
   - Moving particles with electrospray
   - Filling of particles using electrospray

2. Main Simulations
   - 3D structure
   - Silicon with one back contact under the photonic crystal
   - Silicon with contacts in each hole of the photonic crystal
   - Alumina with a big back contact under the membrane

3. Experimental results

4. Conclusions

5. Acknowledgments
The main objective of this simulation is to check the possibility of filling photonic crystals by the means of electrospray. With simple simulations we were able to get an approximated reference about the feasibility of this technique.
Filling of photonic crystals

- Filling with electroplating technique

![Diagram of photonic crystals filling](image)

*D. Hernández et al. "3D metallo-dielectric structures combining electrochemical and electroplating techniques"*
Filling of photonic crystals

- Niquel in Si SEM images

D. Hernández et al. "3D metallo-dielectric structures combining electrochemical and electroplating techniques"
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Moving particles with electrospray

http://rsl.eng.usf.edu/Pages/ResearchElectrospray.html
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Filling of particles using electrospray

- Nanoparticles patterned in a square
- Polystyrene nanoparticles patterned in a line

Dezhi Wu et al. Pattern Deposition of Electrosprayed Polymer Nanoparticles

CRne Picture of a sample electrosprayed in our lab.
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Arnau Coll
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3D structure

Sizes

- Height $12 \times 10^{-5} m$
- Wide $3,8 \times 10^{-5} m$
- Length $3,8 \times 10^{-5} m$
- Holes:
  - Square $2 \times 10^{-12} m^2$
  - Height $1 \times 10^{-4} m$
3D structure
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Ring effect

- Particles with ring
- Particles without ring
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Silicon with one back contact under the photonic crystal

- Cross section at few nanometers from the top
- Line crossing the holes at the same height
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Alumina with a big back contact under the membrane

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Particle tracking

- Particle tracking with silicon
- Particle tracking with alumina

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Experimental Results

- Vertical cross section of alumina
- Polystyrene nanoparticle inside alumina pore

*CRne* Picture of a sample electrosprayed in our lab.
Experimental Results

- Polystyrene nanoparticle inside alumina pore
- Polystyrene nanoparticles inside alumina pores

CRne Picture of a sample electrospayed in our lab.

CRne Picture of a sample electrospayed in our lab.
EDS Results

- Polystyrene nanoparticle inside alumina pore
- Spectrum of materials

*CRne* Picture of a sample electrospayed in our lab.
Conclusion and future improvements

- Simulation is a good tool for a first approximation
- Simulation improvements
  - Including masks
  - Checking the initial conditions of the particles: charge, speed, etc.
- Physical improvements:
  - Obtain some silicon photonic crystals samples
  - Check the distribution of sizes in the nanoparticles dissolution
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Technicians from the CRNE
Thank for your attention!!, UPC-MNT team