My current research status

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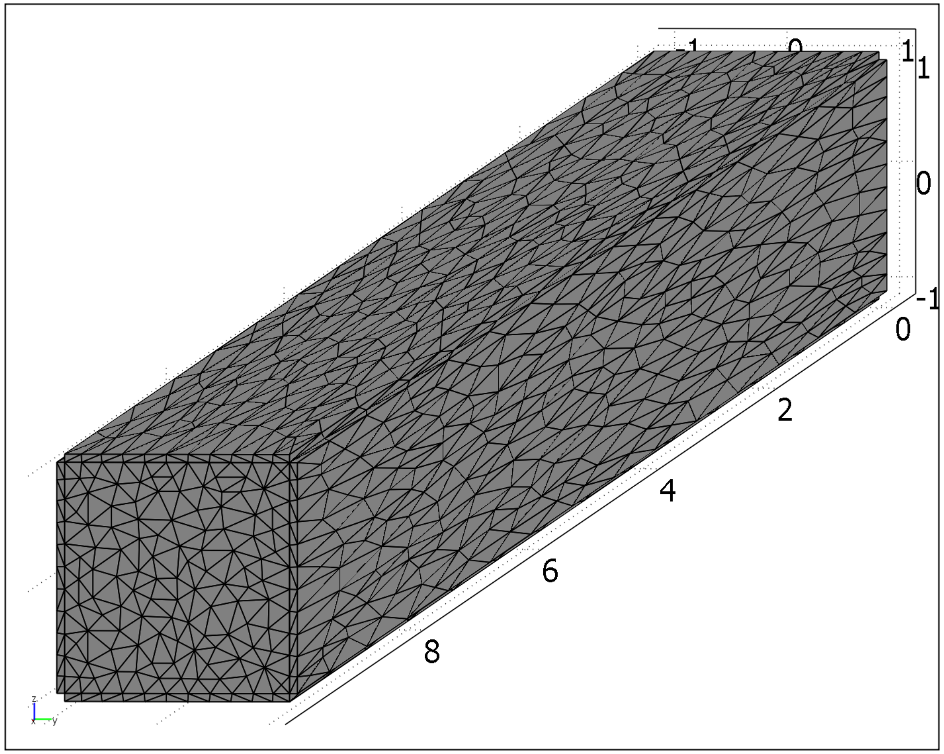
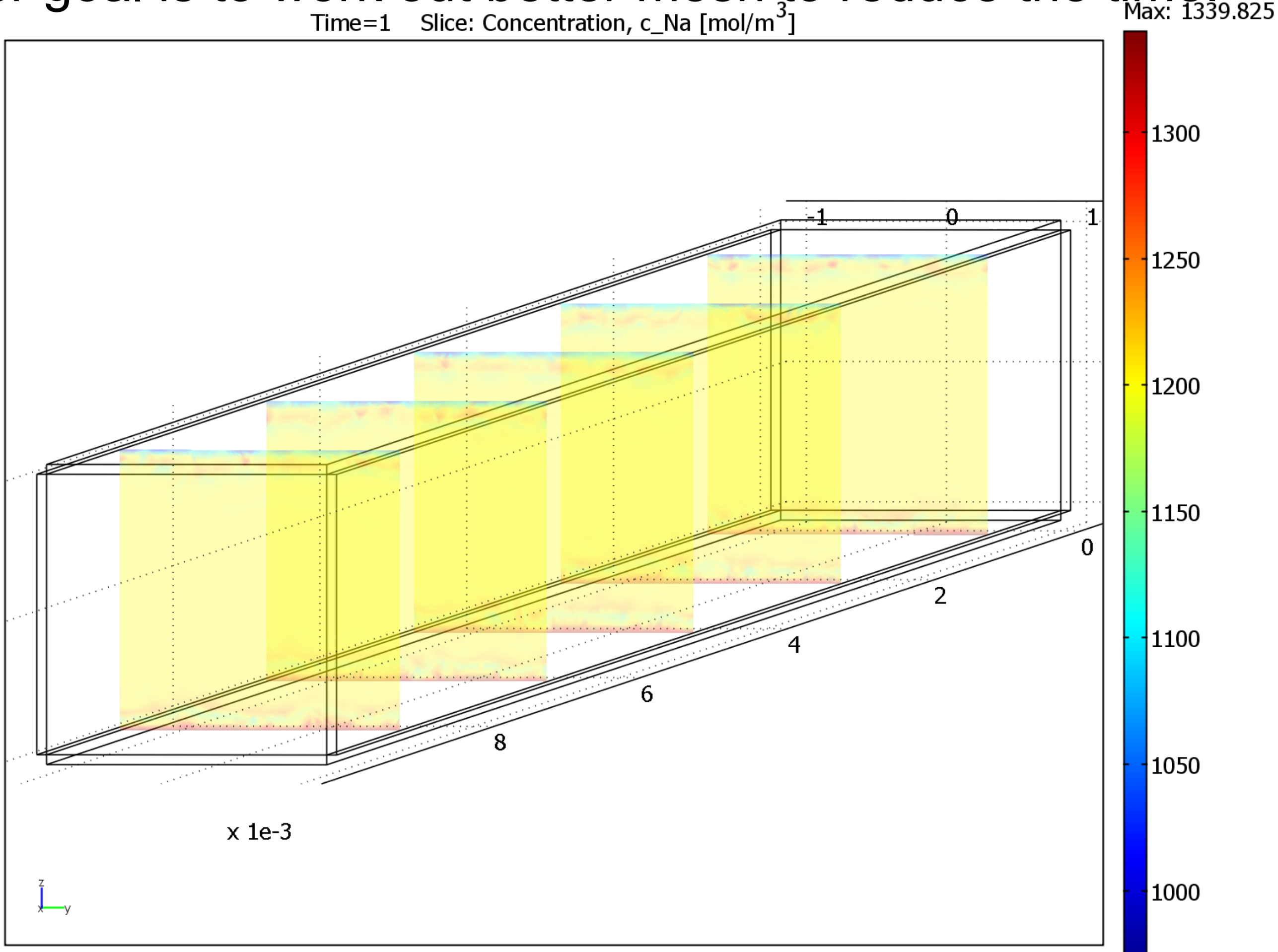
New stuff

- I have started to create a 3D model for an IPMC strip.
  - Turned out that due to the really thin Platinum layers on the surface of the Nafion, creating mesh and solving it is quite a challence
    a. We are talking about tens of thousands of degrees of freedom here...



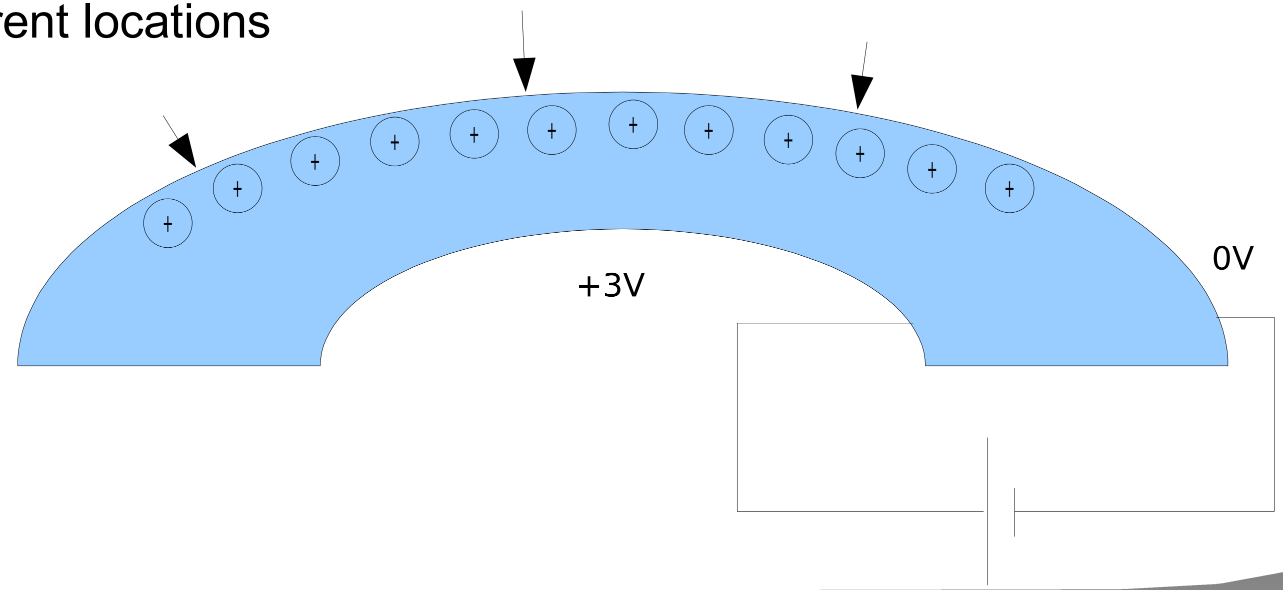
New stuff

- However, I have managed to simulate charge trasport in 3D.
- As any time dependent problem takes at least 20 minutes to solve, further goal is to work out better mesh to reduce the time.



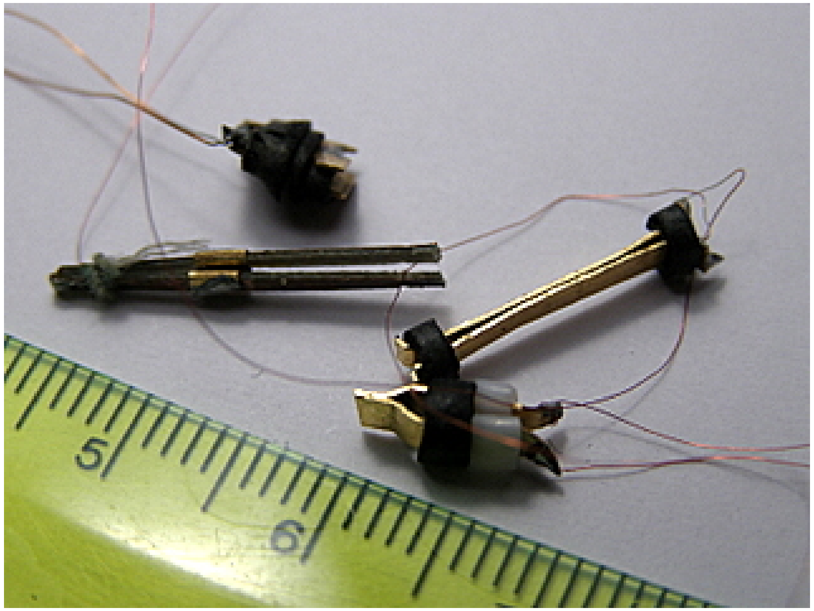
Ideas about measurements

- For future papers, I should compare simulations to experimental data more extensively
- I have taken some time to think/discuss about surface voltage distribution measurment
  - A researcher in the lab in Estonia have been working on this subject for about 2 years now
  - He has a kind of nice machine for bending a muscle and measure the surface resistance automatically (measurment takes like 6 hours or so...)
  - Anyway, a lot could also be done by measuring voltage on the surface on different locations



Ideas about measurements

- Challenges are making really thin contacts and clamps and wiring
- Also a good voltage measuring and recording tool is needed



More new things – nonconstant Young Modulus

- As Nemat Nasser has shown, stiffness of a polymer depends heavily on solvent uptake
- The idea is to make Young modulus dependent on solvent uptake. It would mean that the modulus is not uniform inside the Nafion
- Following Nasser's theory, the stiffness could be calculated as follows:

$$K = p_c \cdot \frac{1+w}{w_0 I_n - (w_0/w)^{4/3}}$$

- where w is swelling ratio, p is cluster pressure, I is related to porosity.
- Problem with analytical approach is that there are really many variables. It could be even way too many for creating reasonable equation system.
- So basically for numeric approach the interpolation of experimental results could even work better.

nonconstant Young modulus

- Another thing I'm working on related to this topic, is relating charge density to swelling
- Current model does not consider any solvent back diffusion – only diffusion of the charged particles is modeled.
- As swelling depends also on solvent concentration, the extra diffusion should be calculated.
- Nasser has proposed the following equation:

$$\frac{\dot{w}(x,t)}{1+w(x,t)} = D_{BL} t_c(x,t)$$

- t in the equation equals pressure in the boundary layers, caused by swelling and electrostatic forces.

Other things/ideas

- I have read many papers – lately papers written by N. Nasser – these are really informative...
  - These have also been inspiration for ideas of modeling swelling inside the Nafion polymer and possible overall stiffness change – that's something for the future.
- As I'm taking Fluid Mechanics course (R. A. Guyer, Dept. of Physics), I have some thoughts about appling the knowledge in my model – e.g. adding drag force to the model later...
- SPIE conference paper is submitted
- Priorities in close future:
  - Experimental data comparison to simualtion results
  - Extending the simulation a bit