5. Operation of OECTs
5.3 Advanced OECT models

- **A thermodynamic field-theory – now fully self-consistent**
  - Adding now external electric field using the same way as before

$$F[\Psi,\phi] = \int dV\, f_0(\Psi) + \frac{\kappa}{2}(\nabla\Psi)^2 + \rho(\Psi)\phi + \frac{\epsilon}{2}(\nabla\phi)^2 \rightarrow$$

$$\mathcal{L}[\Psi,\phi] = F[\Psi,\phi] + \lambda\left(N - \int dV\, \Psi(x)\right)$$

  - Lagrange Multiplier is the chemical potential and Poisson Equation

$$\mu_0 = \frac{\partial f_0}{\partial\Psi} - \kappa\nabla^2\Psi + \frac{\partial\rho}{\partial\Psi}\,\phi$$

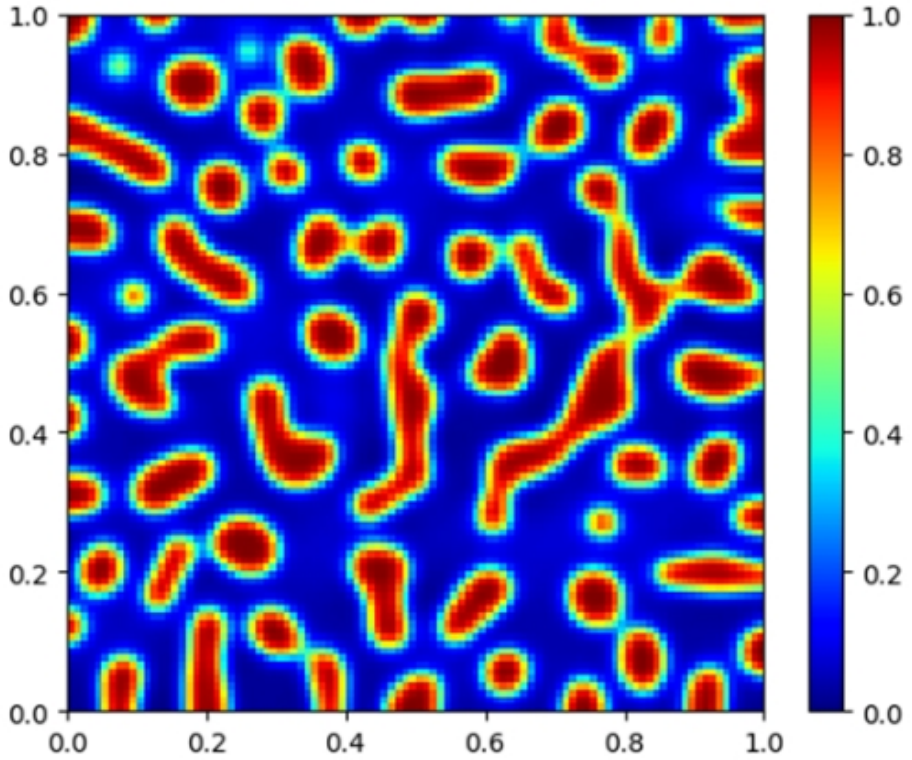
$$0 = \rho(\Psi) - \frac{\epsilon}{2}\nabla^2\phi$$

  - Now we have a fully self-consistent solution and could start with transport!

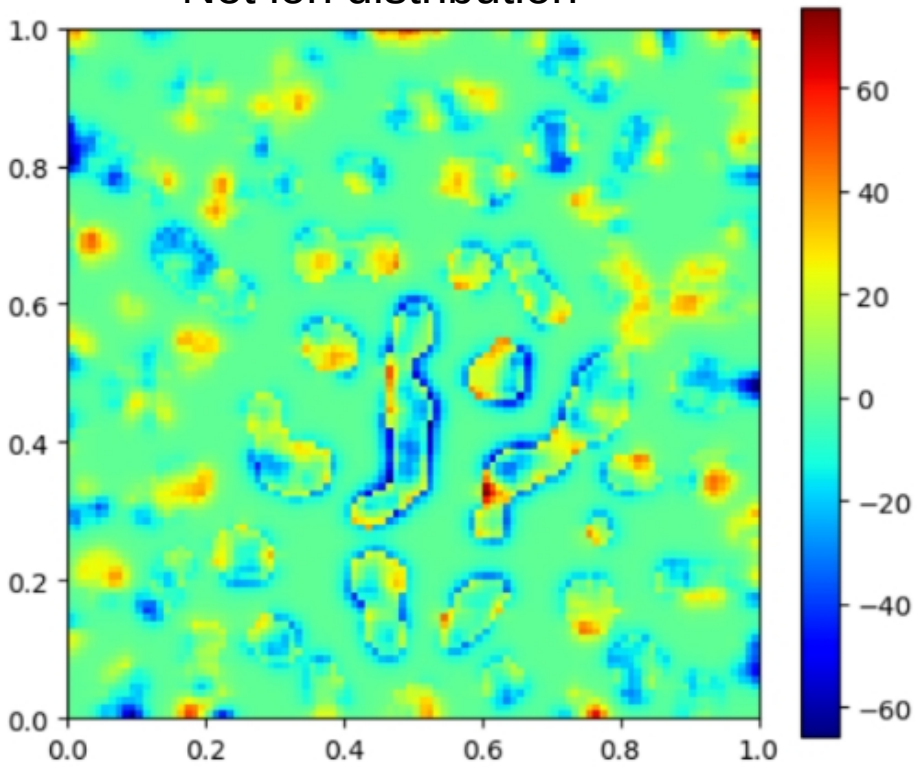
5. Operation of OECTs
5.3 Advanced OECT models

- **A thermodynamic field-theory – now fully self-consistent**
  - Including now ion-movement into model (added to the Free energy)

Distribution of charged and uncharged PEDOT



Net ion distribution



5. Operation of OECTs
5.3 Advanced OECT models

- **What still needs to be done**
  - A lot….
    - Confirm existing of phase on micro-scale
    - Energy and length scale need to be experimentally validated
    - Determine size of units in model
    - Understand origin of bistability on molecular scale
    - Simplify model so it can be applied for devices

From Thermodynamic to Information Processing

- **From Gibbs Free Energy to AI**
  - Hopfield networks = associative memory → Specific excitation of a ensemble of neurons (0/1) results in a specific energy landscape (information about excitation pattern is stored)
  - Hopfield networks are based on the Ising Model = Identical to our thermodynamic theory