Design Optimization of An Electrochemistry System

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Introduction: Optimization of a typical electrochemical system with insulating shields is considered in this work, which objective is to smooth the current density distribution along electrode surface. The mesh control was discussed to allow movement of design variable, i.e., position and width of the insulating shields.

Computational method:
The electrochemical cell used in this work is shown in Fig.1.

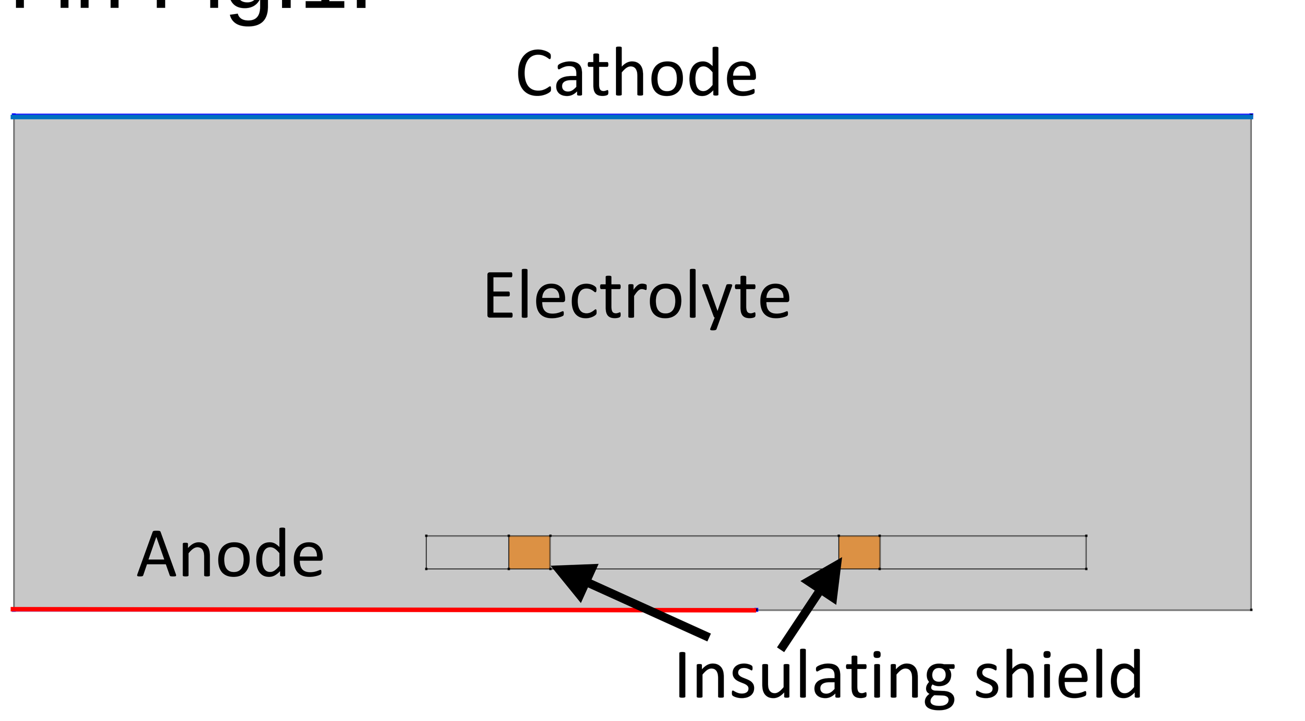

Figure 1. Setup of the electrochemical cell and initial position and shape of insulating shields

Potential model is considered here to calculate the current density i in the electrolyte:

$$i = -\left(F^2 \sum_i (z_i)^2 m_i c_i\right) \nabla\varphi_l = -K_e \cdot \nabla\varphi_l$$

Where z_i is the charge number of the ith species, m_i is the mobility of the ith species, c_i is the concentration of the ith species, φ_l is the electric potential and K_e is the electrical conductivity.
The optimization objective is to find suitable position and width for the insulating shields to get a smoother current distribution along anode surface.

$$Minimize: \int_0^L (i_{loc} - i_{ave})^2 dx$$

Here, i_{loc} is the local current density, i_{ave} is the average current density along anode. Coordinate search algorithm was adopt to find the optimal solution.

Results: Moving mesh method is used to realize the movement and change in width of the insulating shields. The shape and position of shields after optimization are shown in red.

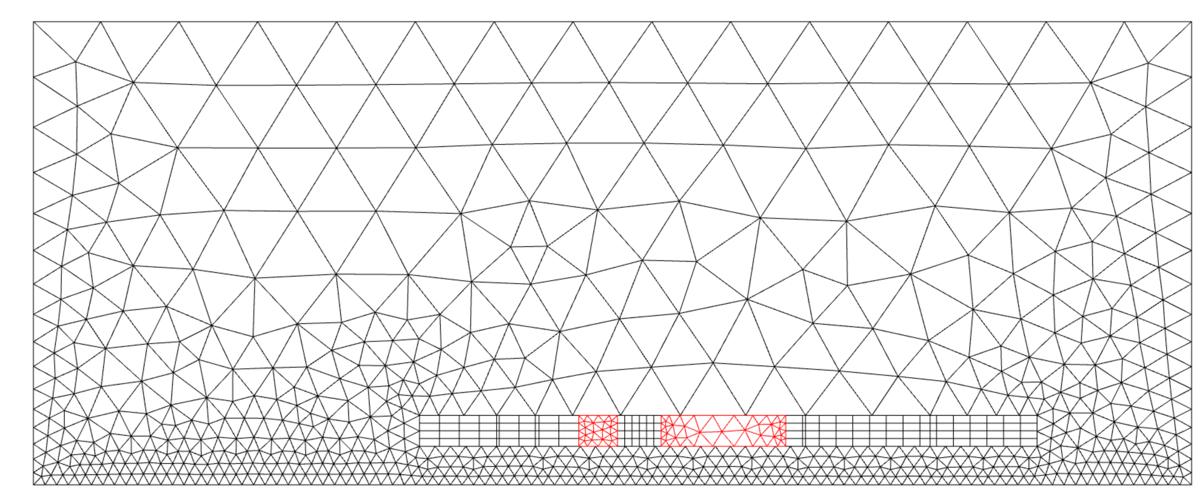

Figure 2. Moving mesh for the shield

Fig.3 shows the current distribution at optimized positon of insulating shield. Fig.4 shows the current distribution along anode before and after optimization.

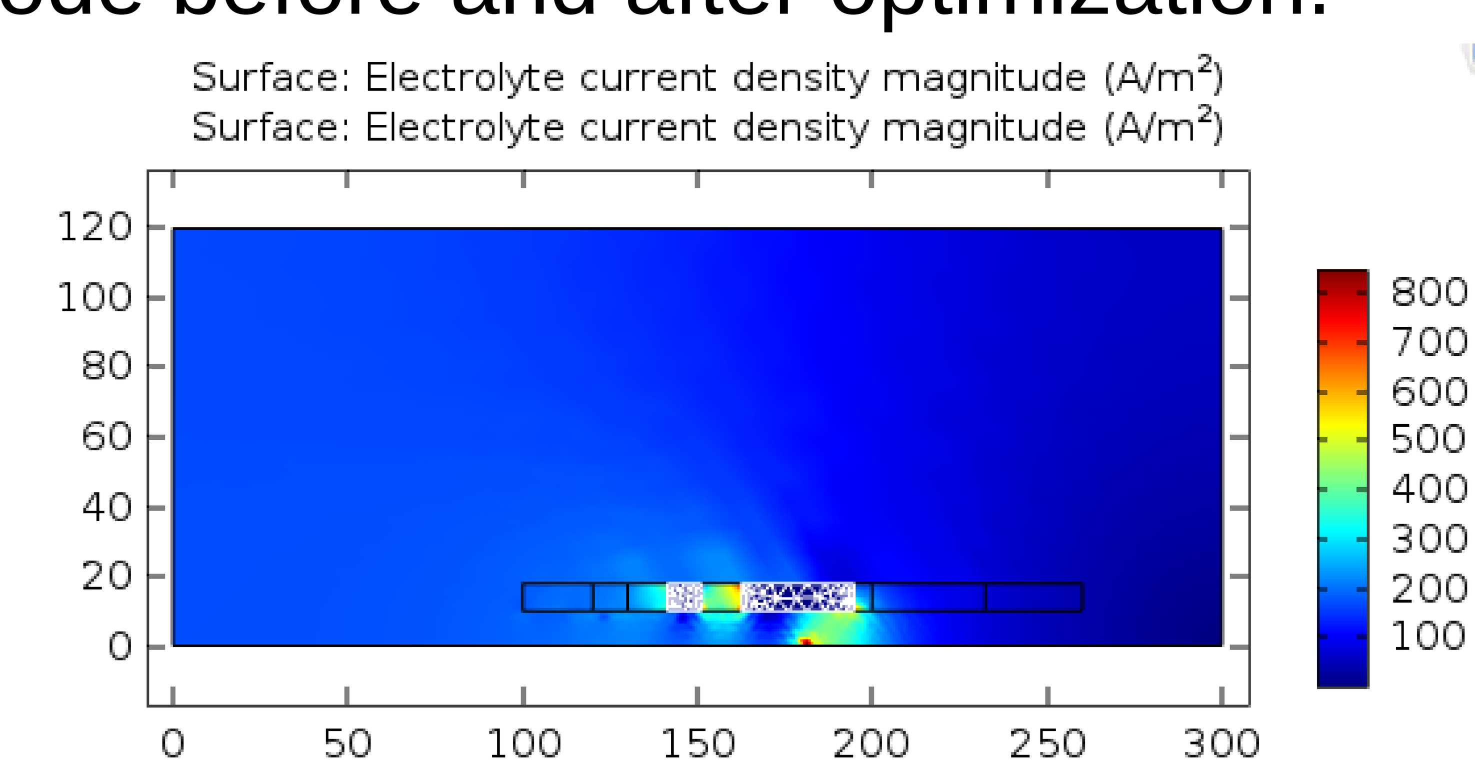

Figure 3. Current distribution after optimizion

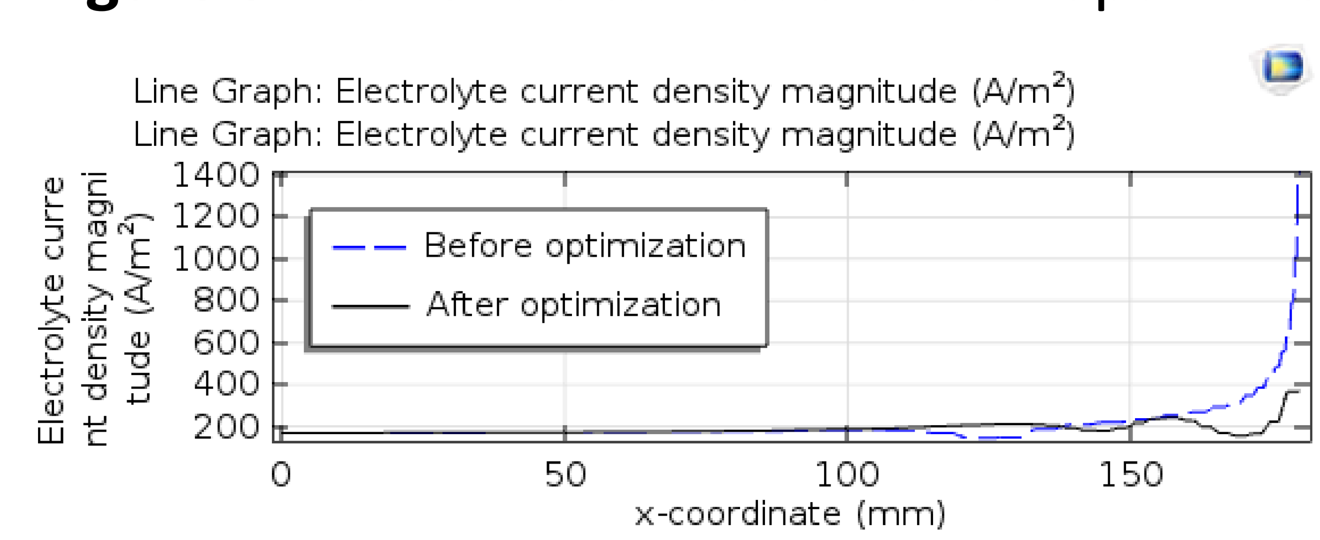

Figure 4. Current distribution along cathode before and after optimization

Conclusions: Optimization of electrochemistry system is considered. It is found that combining optimization algorithm with FEM procedure is effective to find desirable parameters for electrochemical system.

References:

1. M. Purcar. et al., Optimization of the current density distribution in electrochemical cells based on the level set method and genetic algorithm, The European Physical Journal Applied Physics, Vol.56(1), P11302(2011)

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