Non-Linear Stability Analysis of Cells Having Different Types of Cathode Surface Geometry

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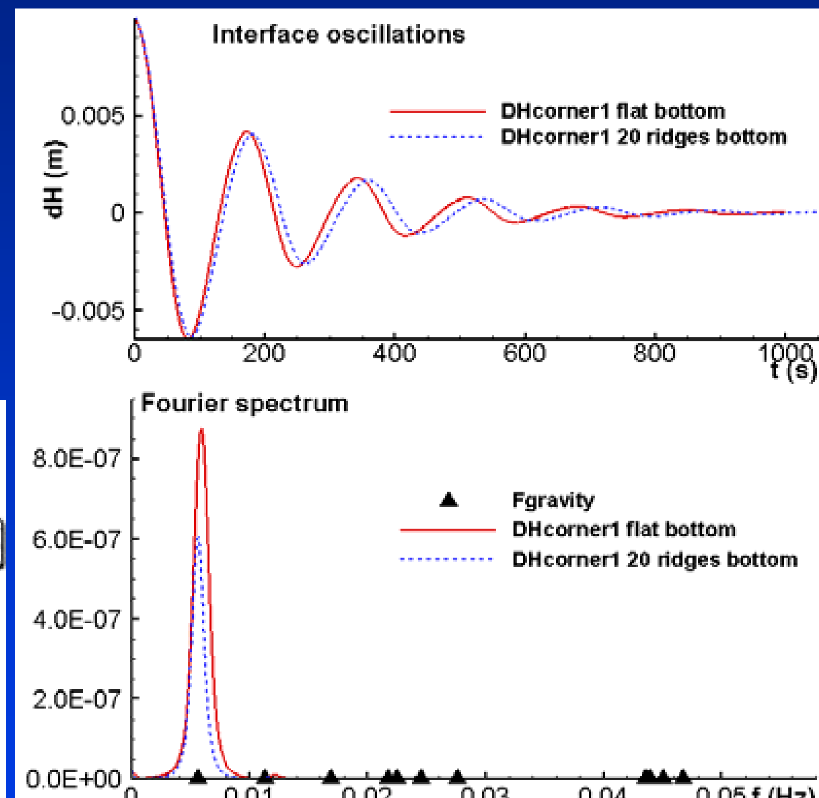
Plan of the Presentation

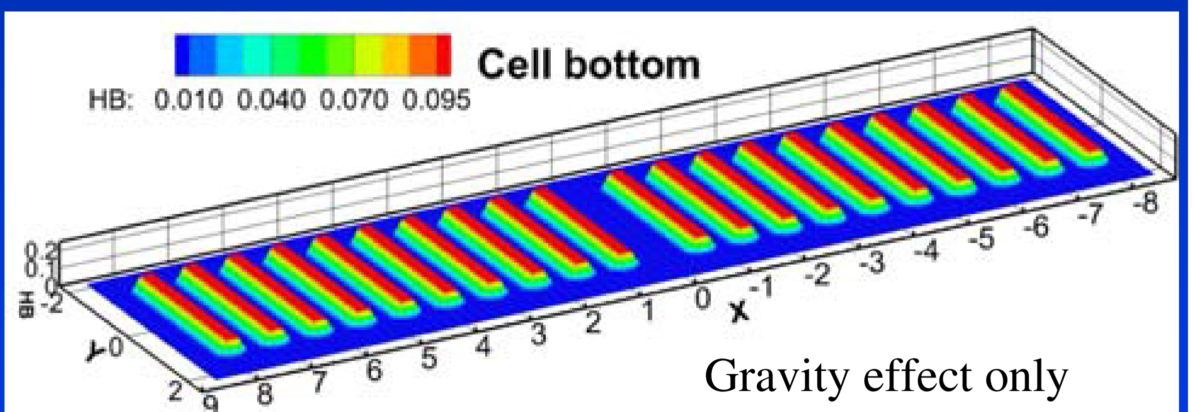
- Introduction
  - The irregular cathode surface technology has some effect on the drag of the cathode surface on the metal flow
  - The irregular cathode surface technology has significant impact on the metal pad horizontal current
  - The irregular cathode surface technology may or may not have a significant impact on the global steady-state metal flow pattern and bath-metal interface deformation
- Cell stability study on a standard flat cathode surface cell
  - 500 kA cell with regular flat cathode surface base case
  - Base case minus 5 mm ACD
  - Base case minus 5 cm metal pad level
  - Base case plus 15 cm ledge toe thickness
  - Improved magnetic field case
- Cell stability study on a cathode with lateral ridges
- Cell stability study on a cathode with longitudinal ridges
- Conclusions

Introduction

The irregular cathode surface technology has some effect on the drag of the cathode surface on the metal flow

The effect of bottom friction enhancing elements is evaluated using the depth sensitive turbulent velocity model. The sloshing gravity wave without MHD interaction is confirmed to be damped moderately in the presence of the bottom ridge elements.





Ref: V. Bojarevics, "MHD of Aluminium Cells with the Effect of Channels and Cathode Perturbation Elements," TMS Light Metals 2013, 609-614.

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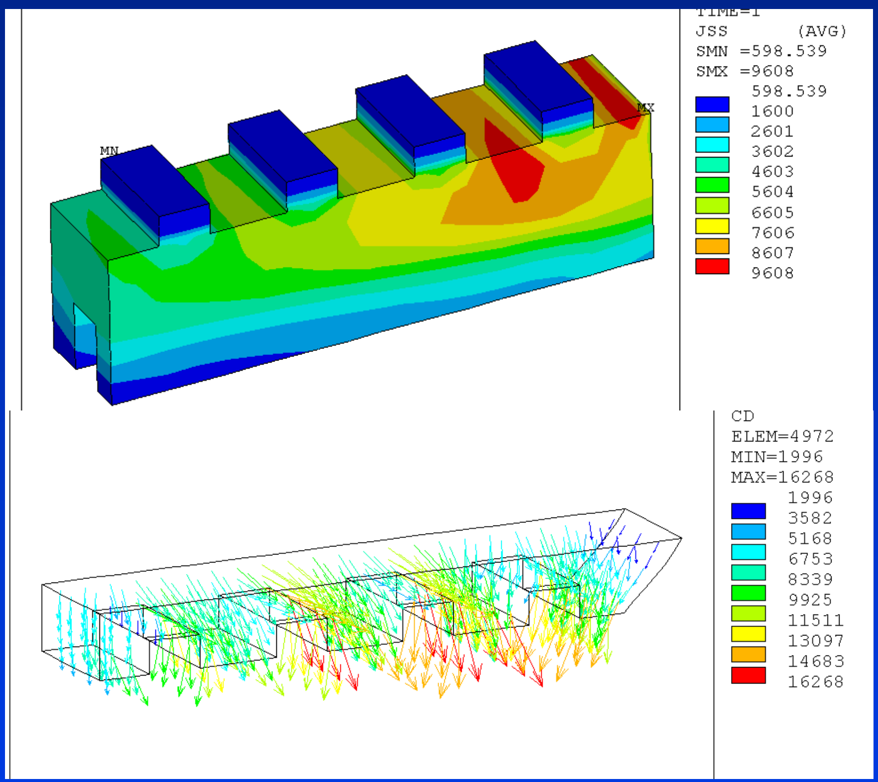
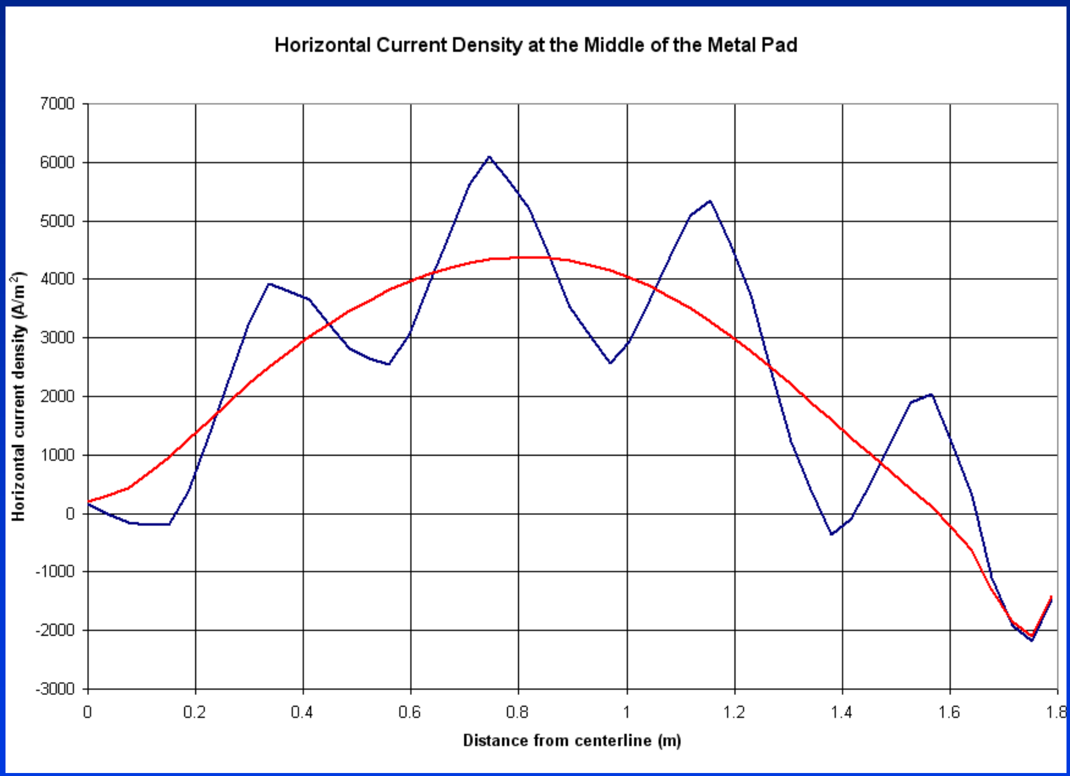
Introduction

The irregular cathode surface technology has significant impact on the metal pad horizontal current





Ref: M. Dupuis and al, "Influence of the Cathode Surface Geometry on the Metal Pad Current Density and MHD Cell Stability," TMS Light Metals 2014, 479-484.

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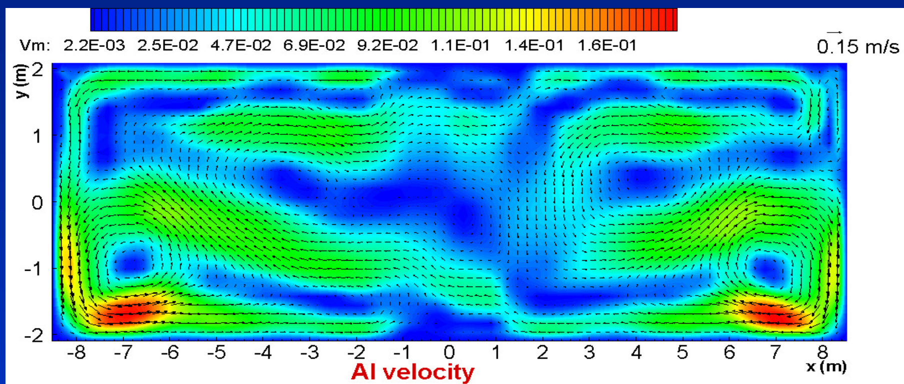
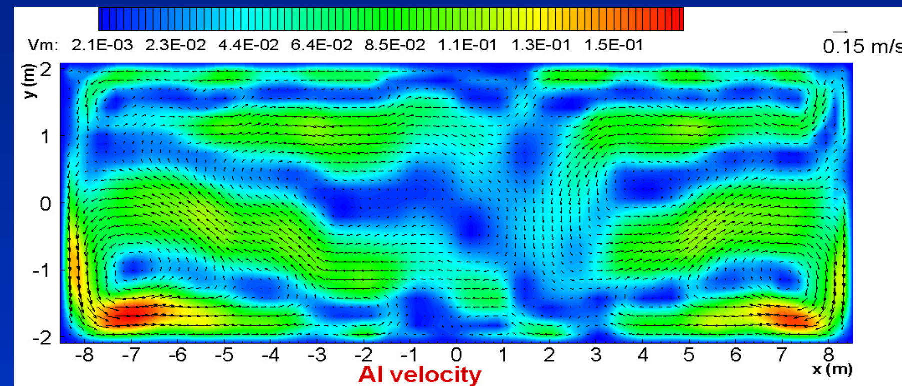
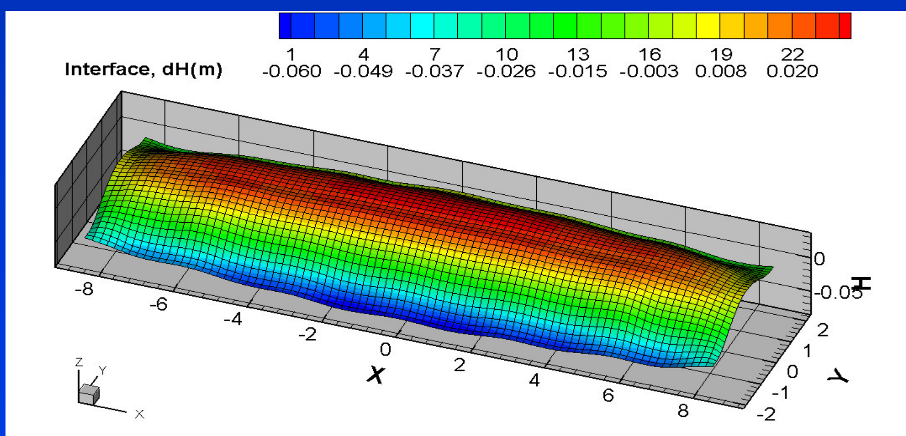
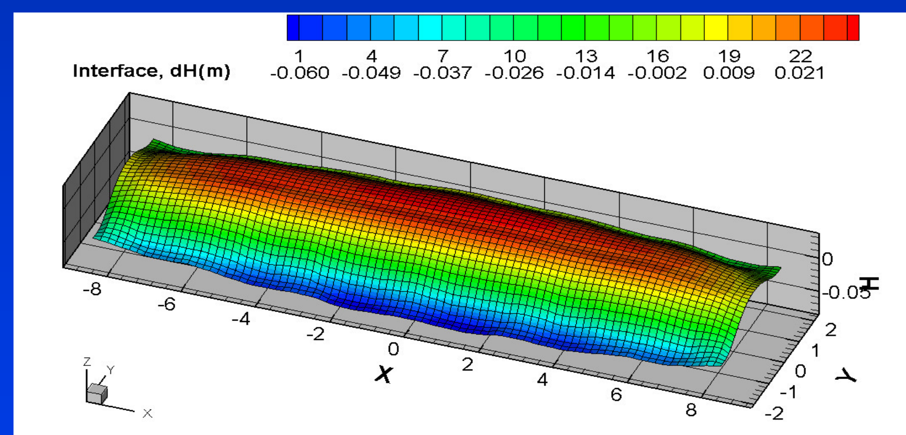
Introduction

The irregular cathode surface technology may or may not have a significant impact on the global steady-state metal flow pattern and bath-metal interface deformation





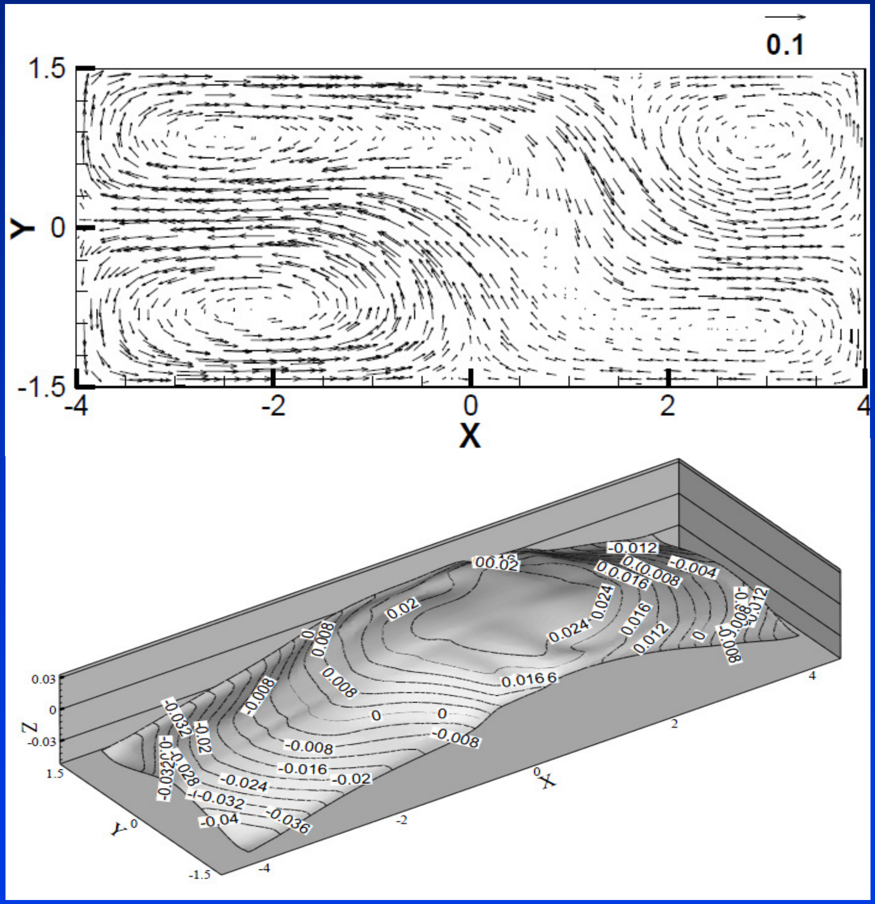


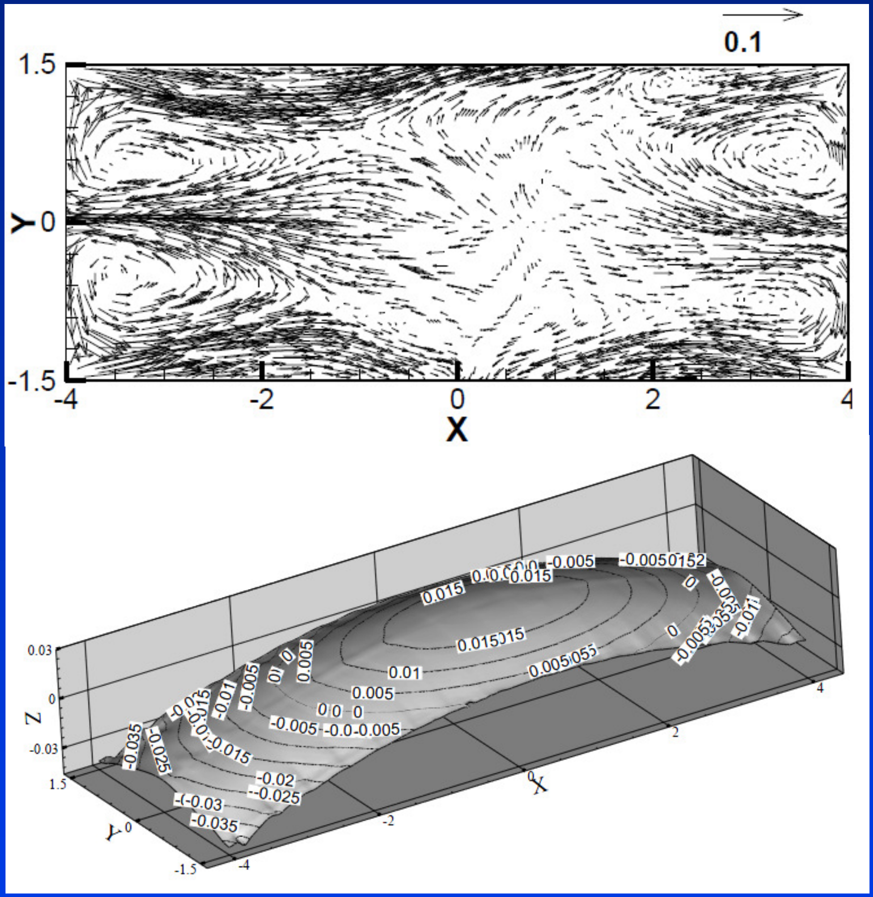


Ref: M. Dupuis and al, "Newest MHD-Valdis Cell Stability Studies," International Aluminiun Journal, 2014, 90(1/2), 42-44.

Introduction

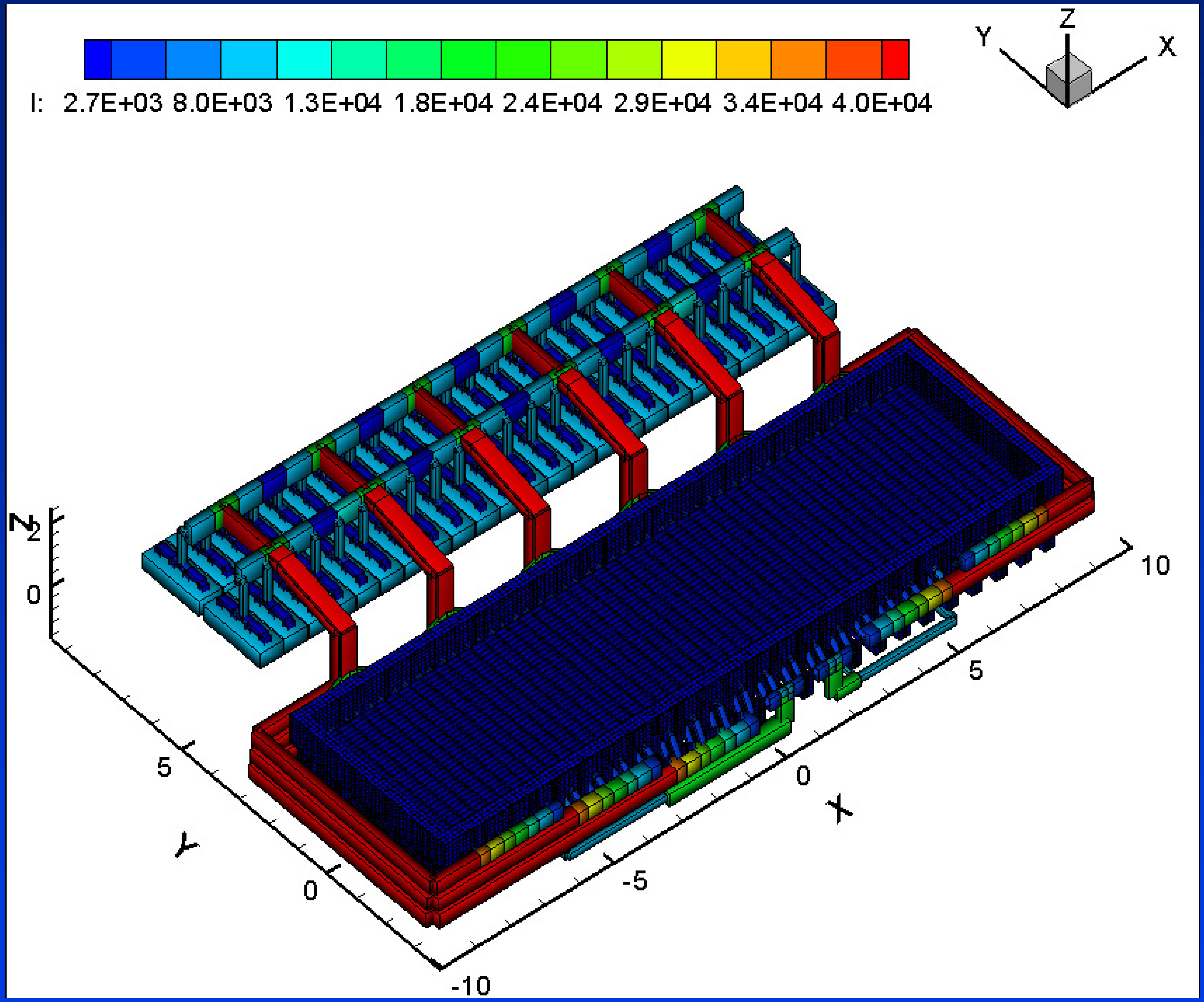
The irregular cathode surface technology may or may not have a significant impact on the global steady-state metal flow pattern and bath-metal interface deformation





Ref: Q. Wang and al, "Effect of Innovative Cathode on Bath/Metal Interface Fluctuation in Aluminum Electrolytic Cell," TMS Light Metals 2014, 491-494.

500 kA Cell with Regular Flat Cathode Surface Base Case



Geometry of the 500 kA base case model showing the current intensity solution in each conductor (in A)

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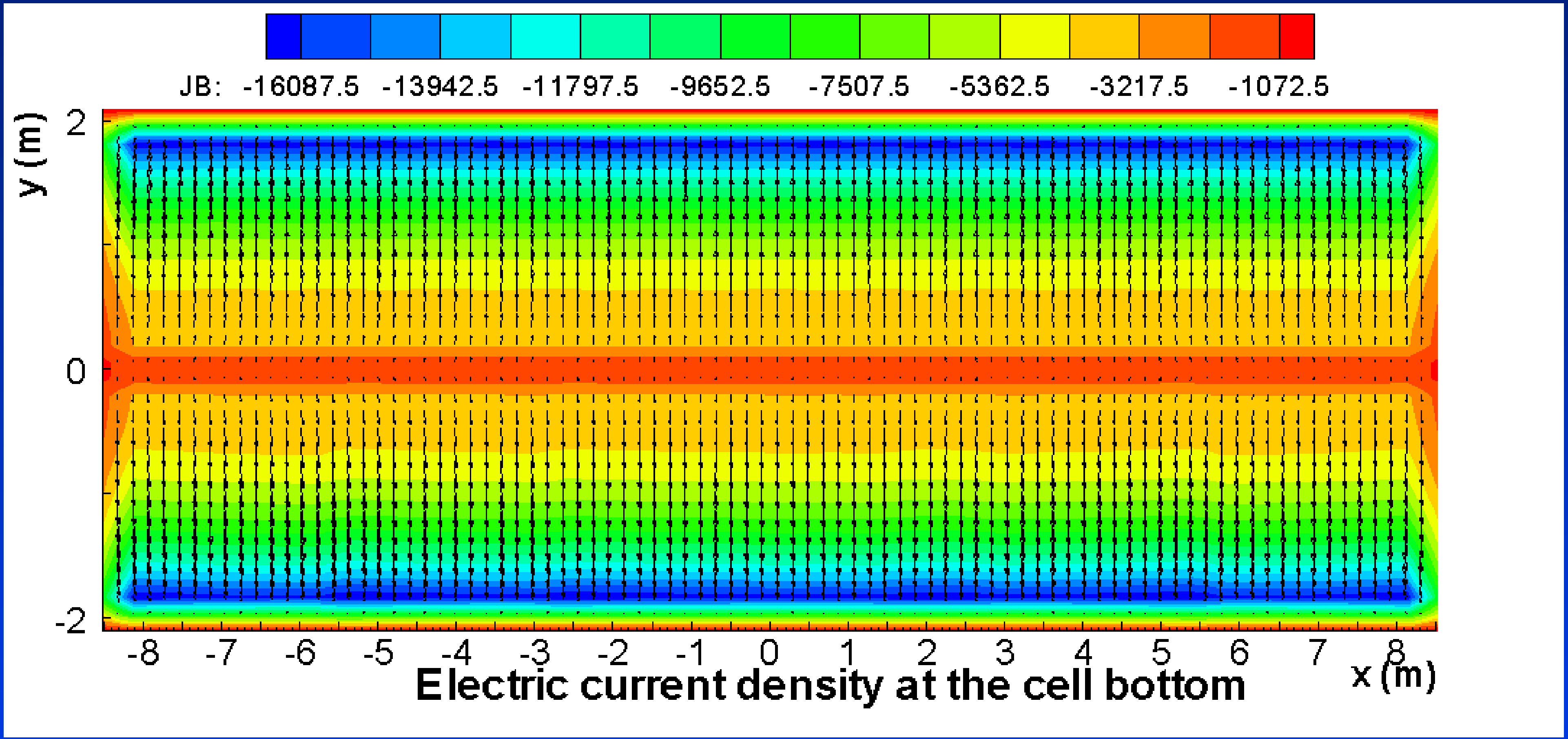
500 kA Cell with Regular Flat Cathode Surface Base Case



Current density solution on the top surface
of the cathode (in A/m^2)

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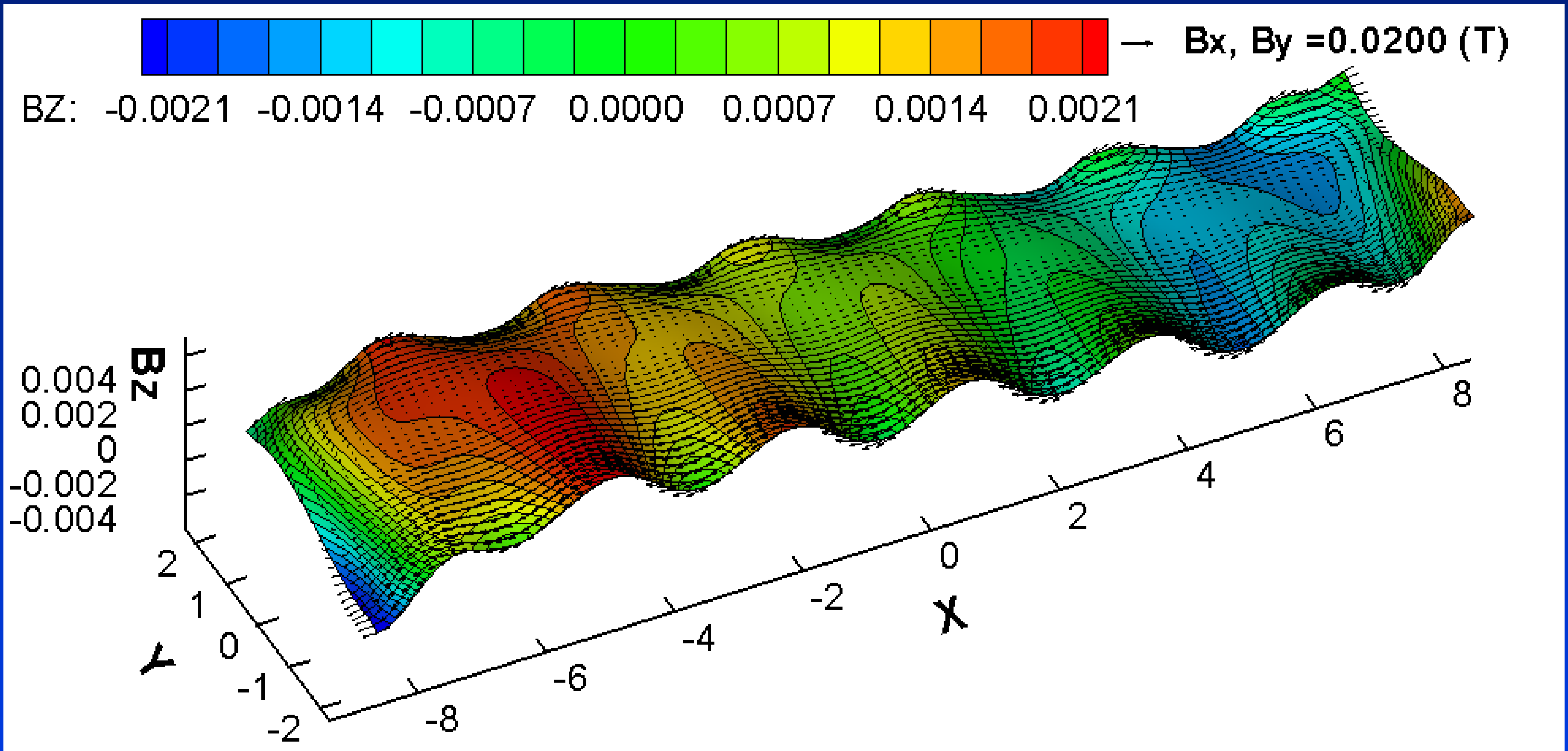
500 kA Cell with Regular Flat Cathode Surface Base Case



Vertical component of the magnetic field solution in the middle of the metal pad (in T)

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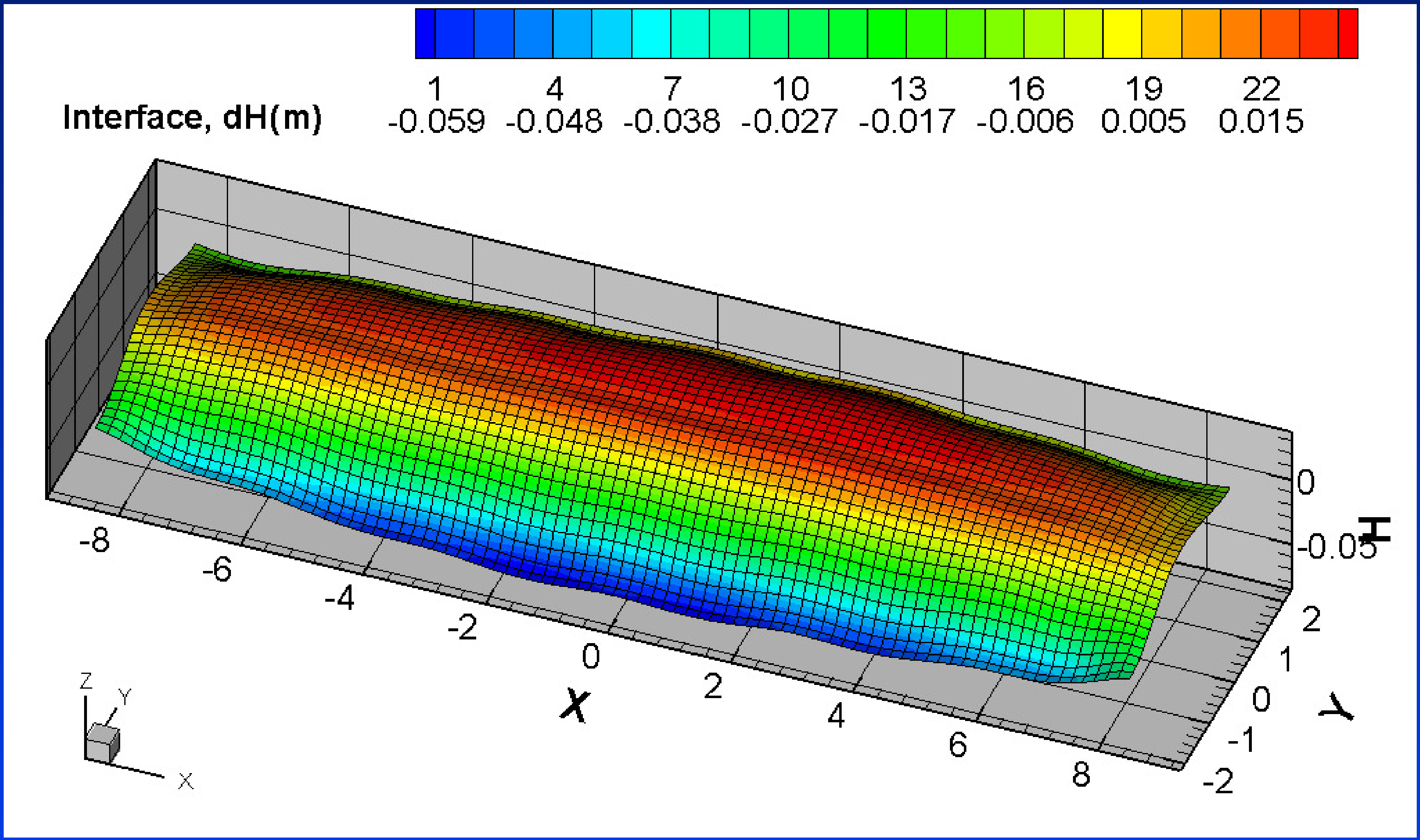
500 kA Cell with Regular Flat Cathode Surface Base Case



Steady-state bath-metal interface deformation (in cm)

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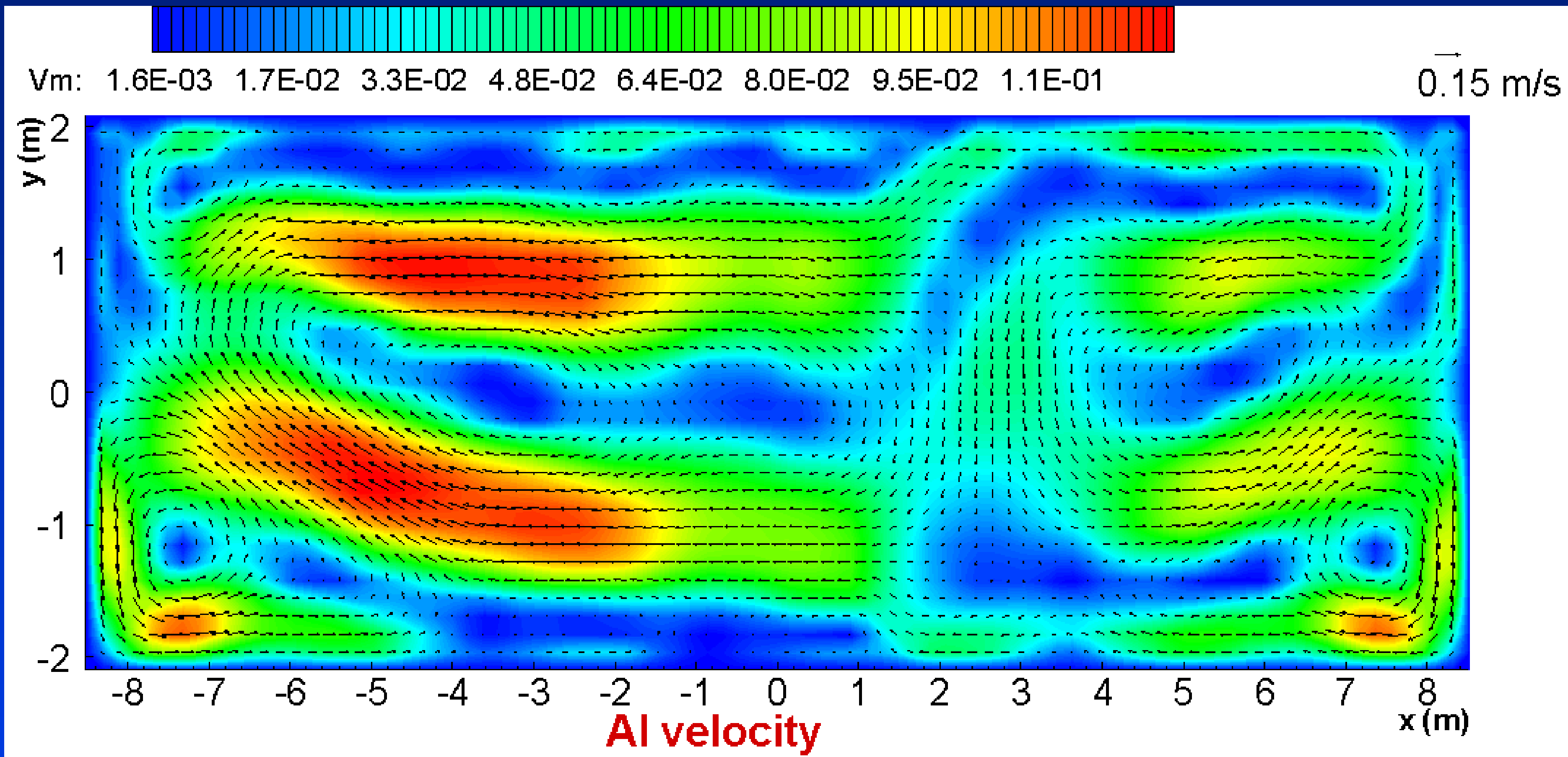
500 kA Cell with Regular Flat Cathode Surface Base Case



Steady-state flow pattern in metal pad (in m/s)

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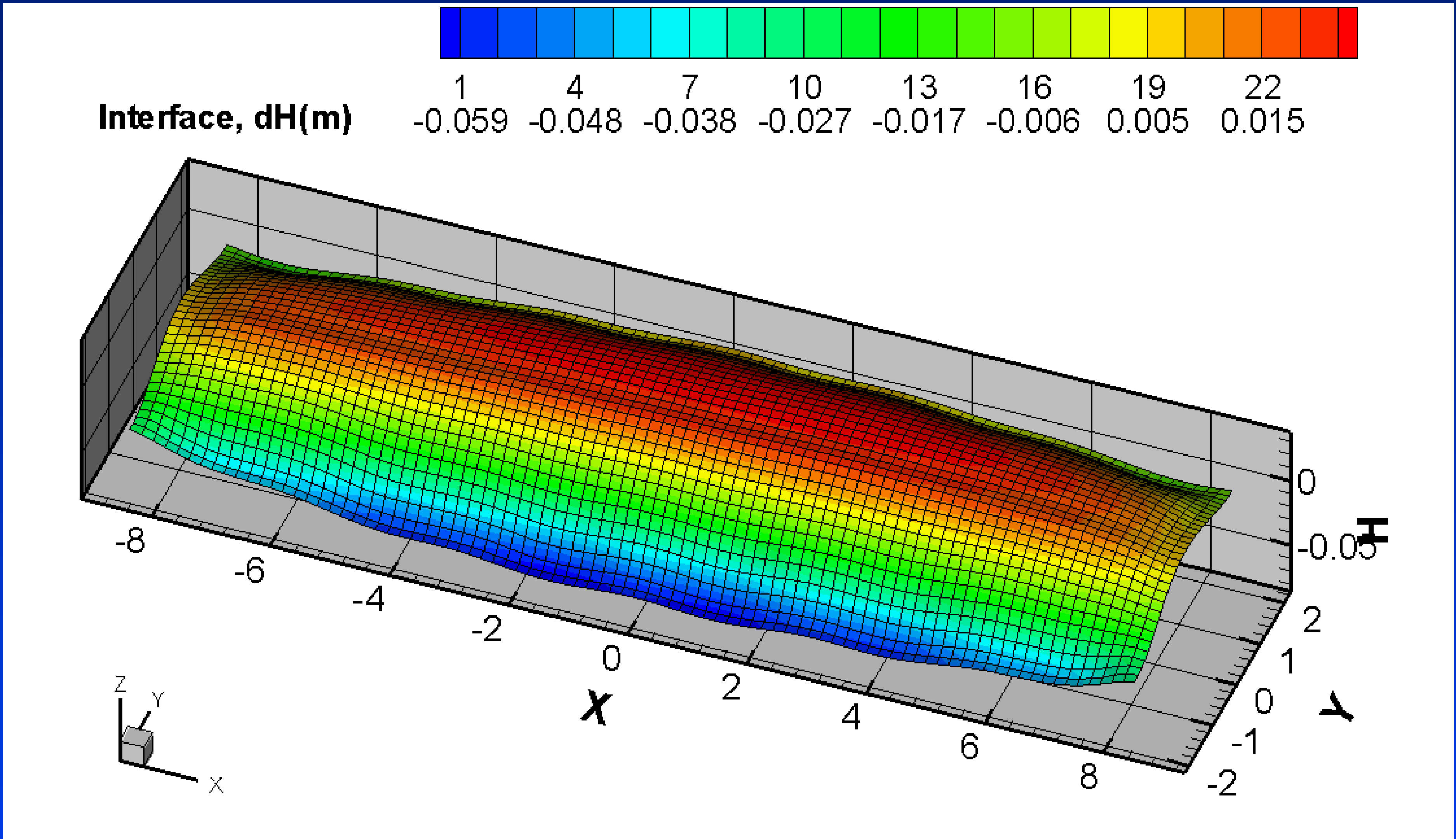
500 kA Cell with Regular Flat Cathode Surface Base Case



Evolution of the bath-metal interface during the cell stability analysis

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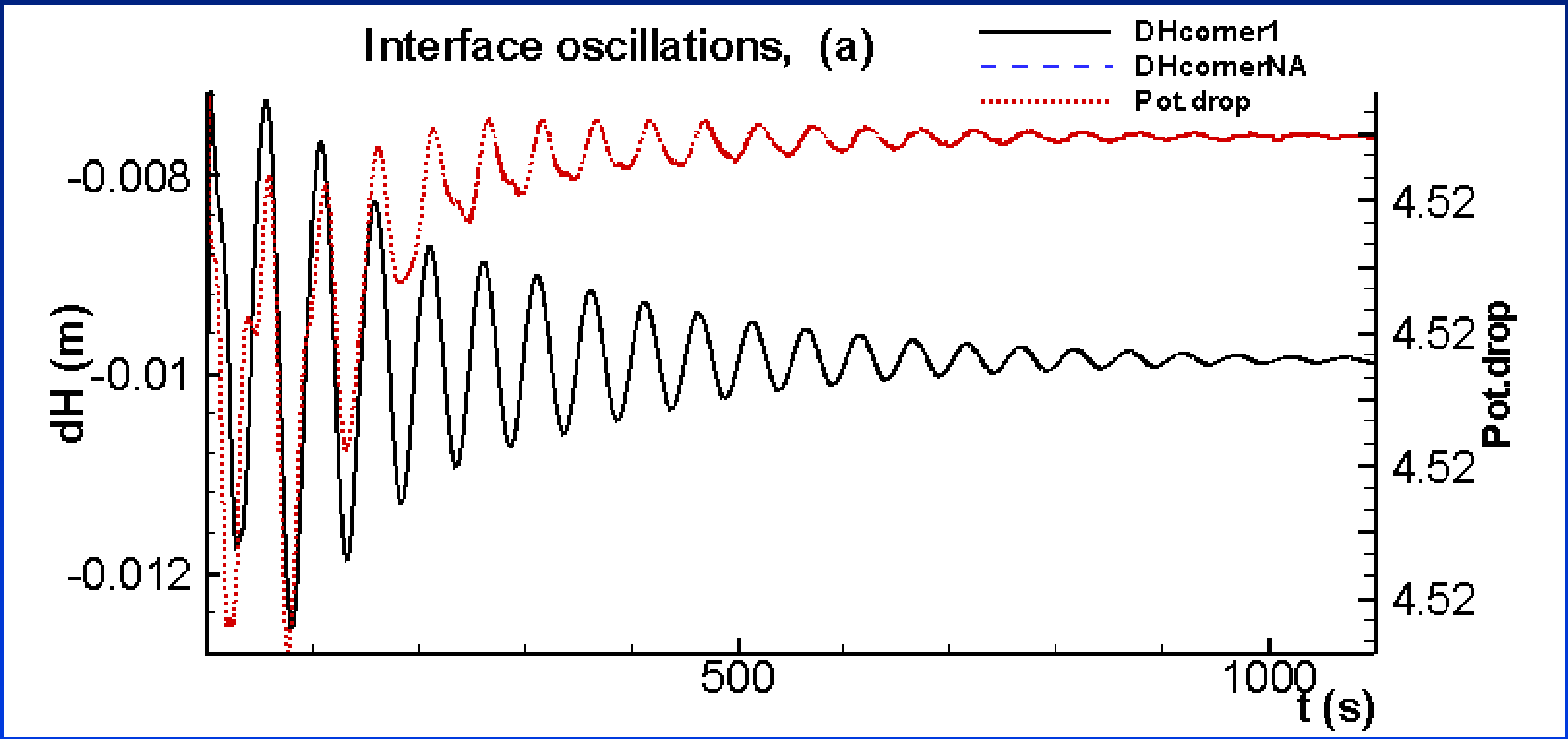
500 kA Cell with Regular Flat Cathode Surface Base Case



Evolution of one point on the interface position (in m)

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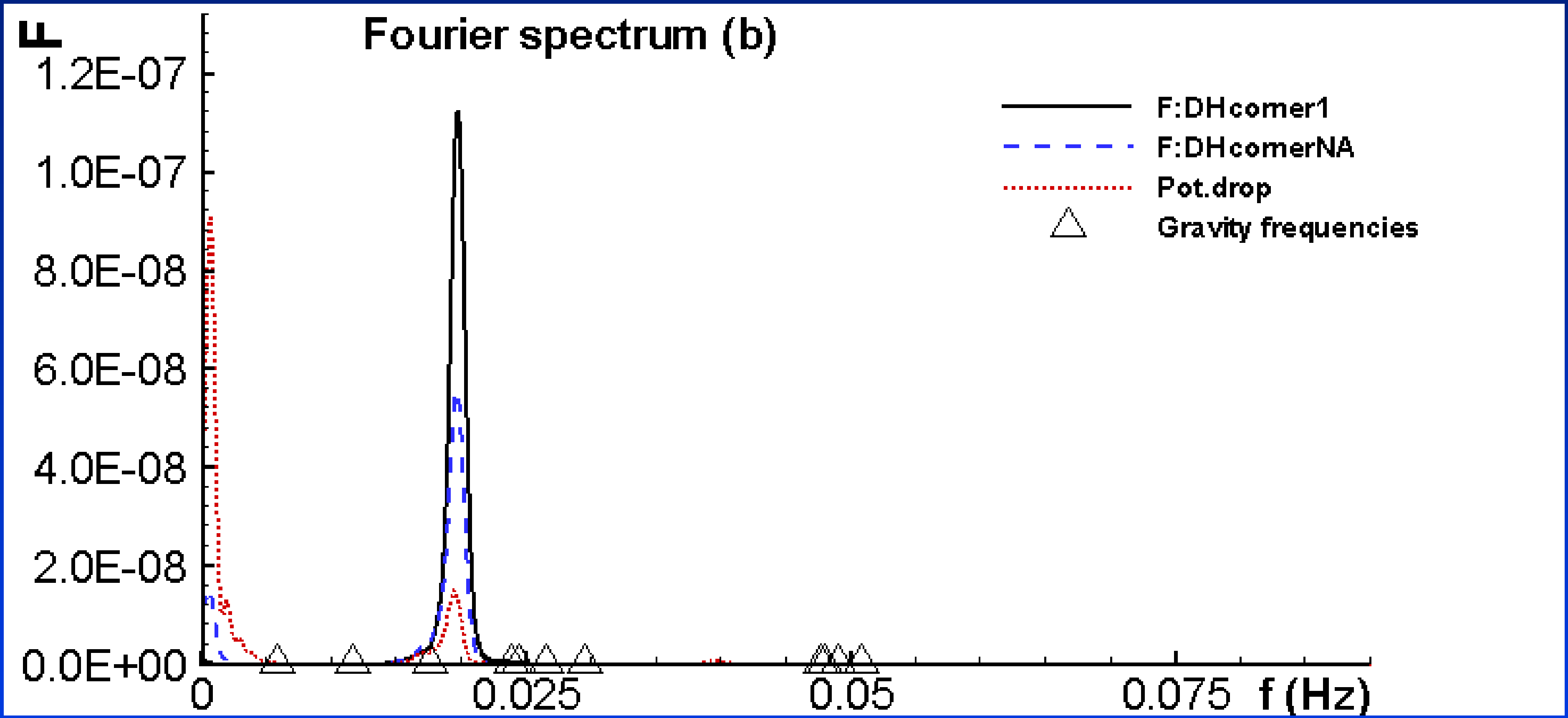
500 kA Cell with Regular Flat Cathode Surface Base Case



Results of the spectral analysis of the wave evolution

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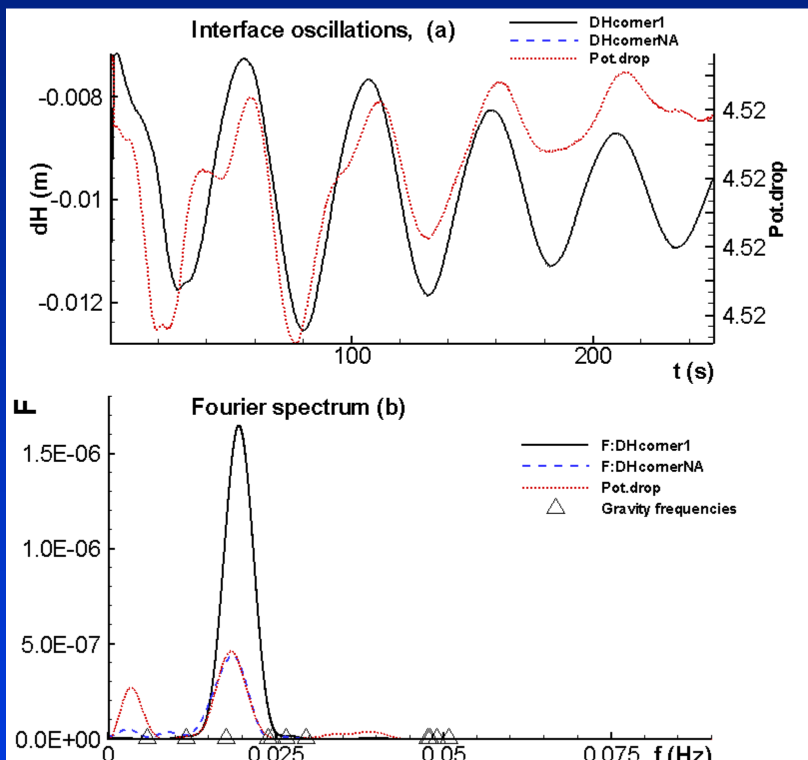
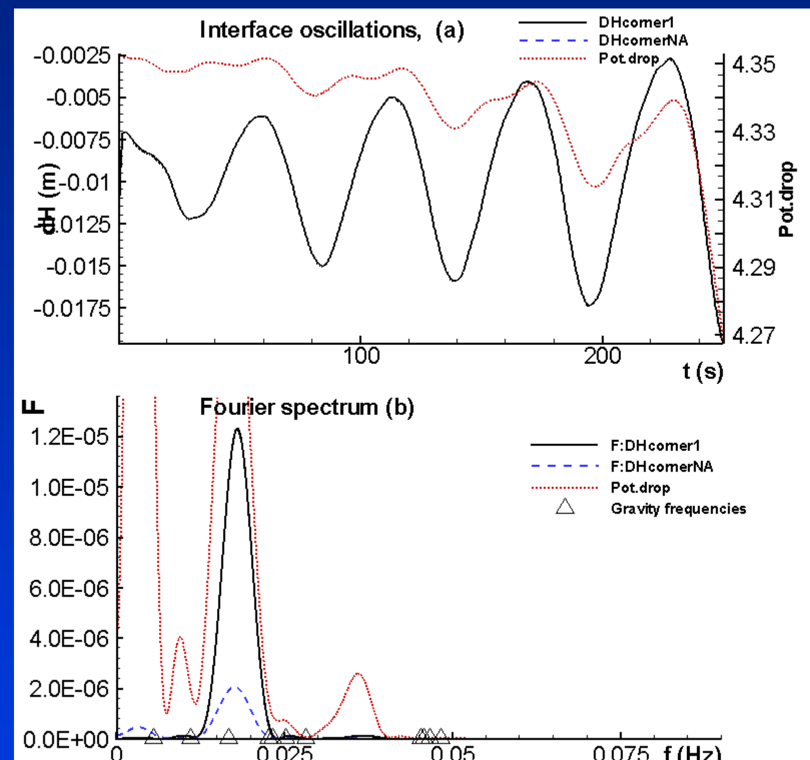
Base case minus 5 mm ACD





Comparison of the stability analysis with the base case on the left

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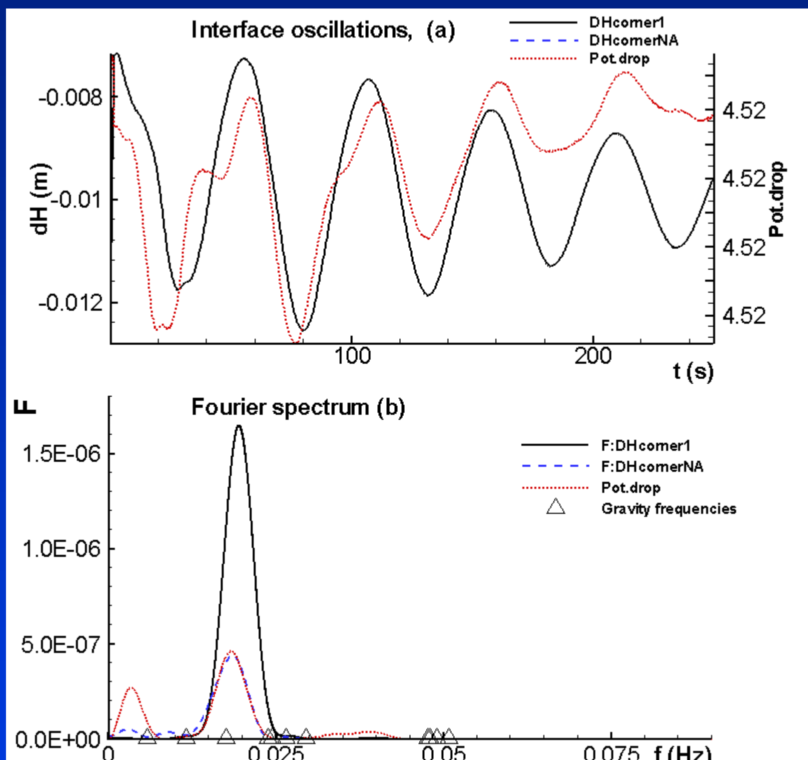
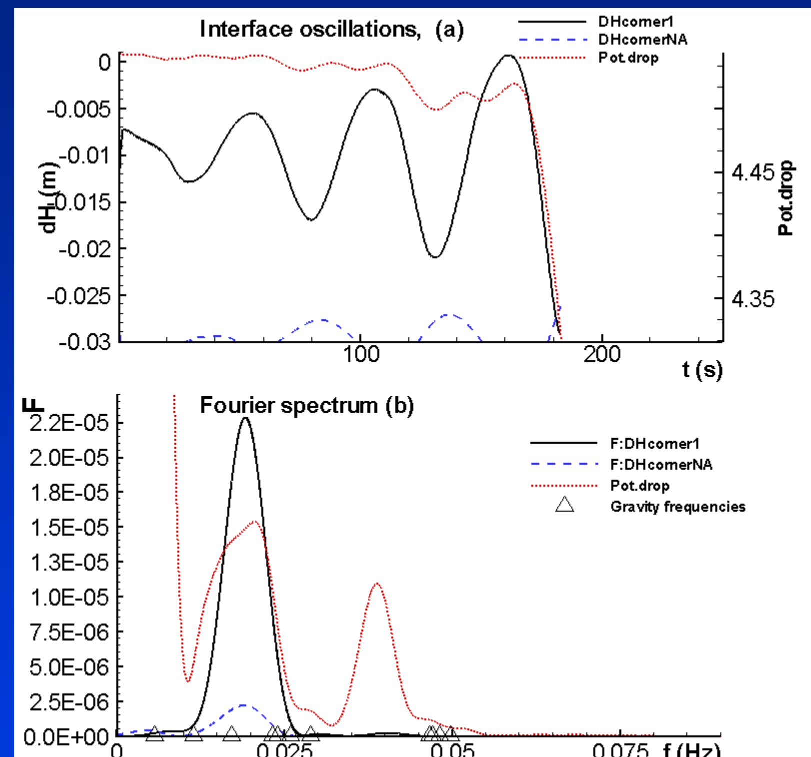
Base case minus 5 cm metal pad level





Comparison of the stability analysis with the base case on the left

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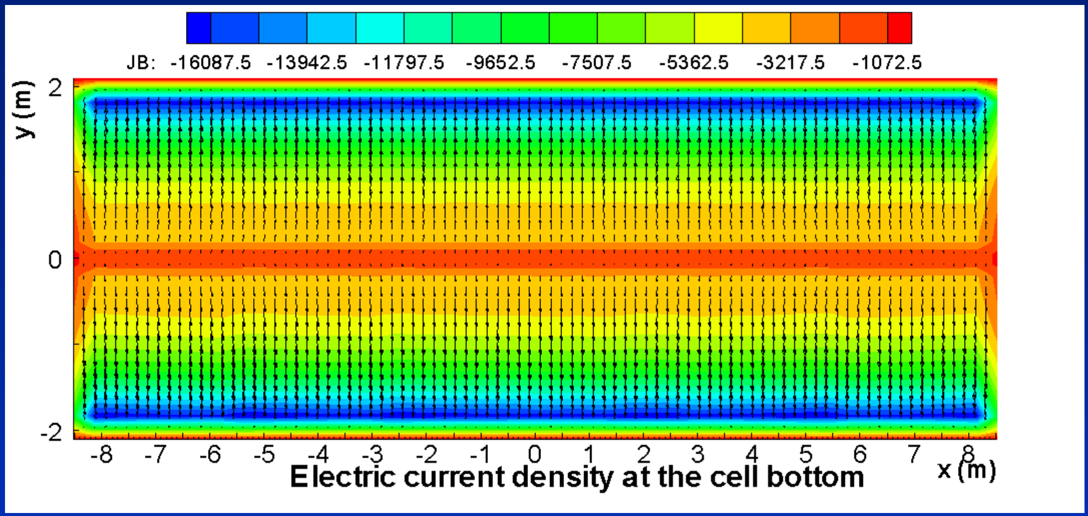
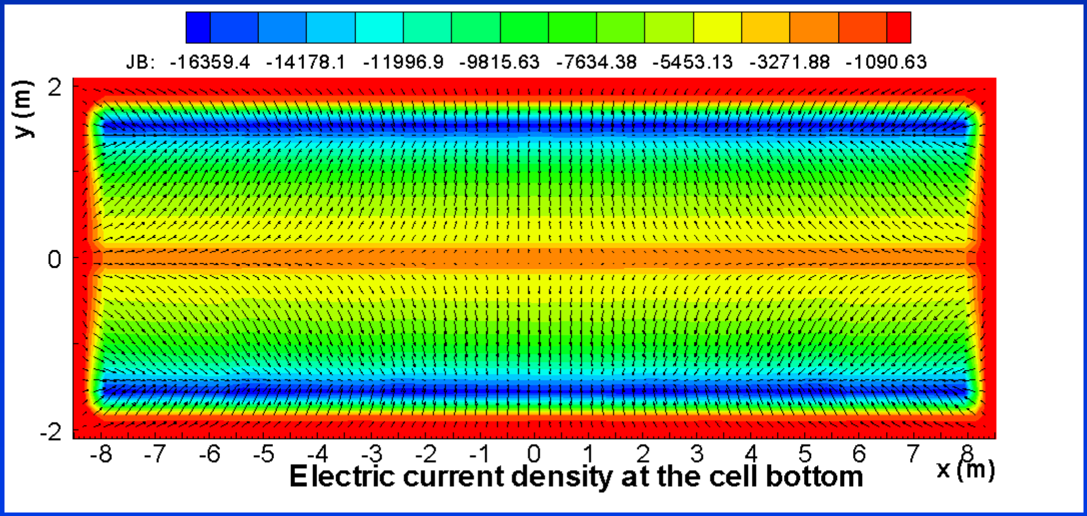
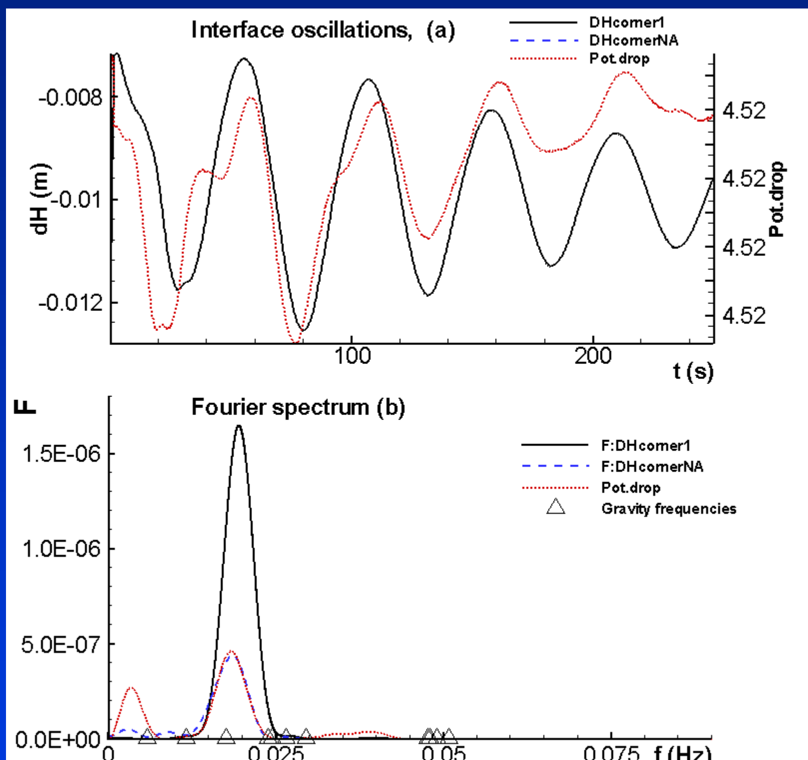
Base case plus 15 cm ledge toe thickness

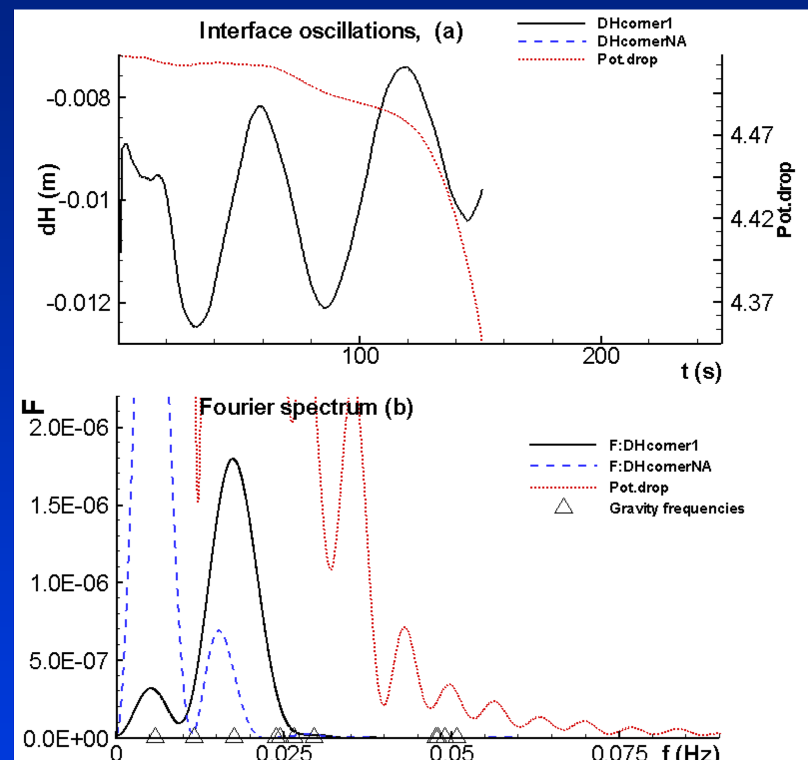




Comparison of the metal pad current density with the base case on the top

Base case plus 15 cm ledge toe thickness





Comparison of the stability analysis with the base case on the left

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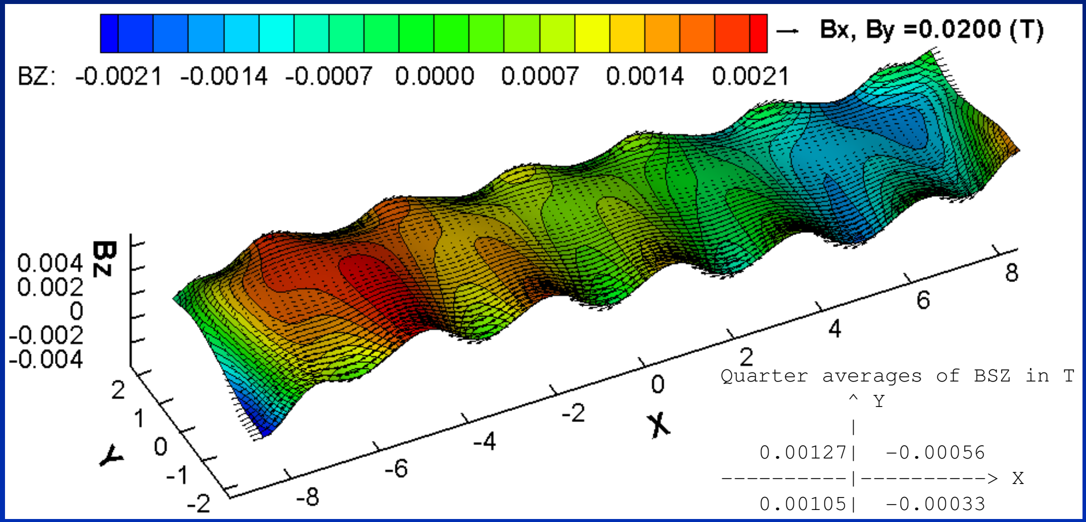
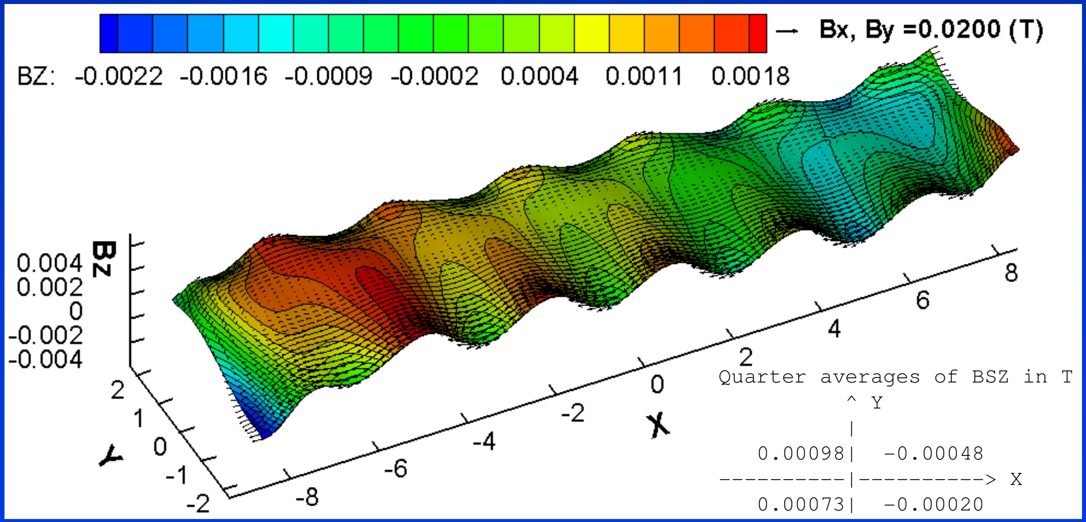
Improved magnetic field case





Comparison of the metal pad magnetic field with the base case on the top

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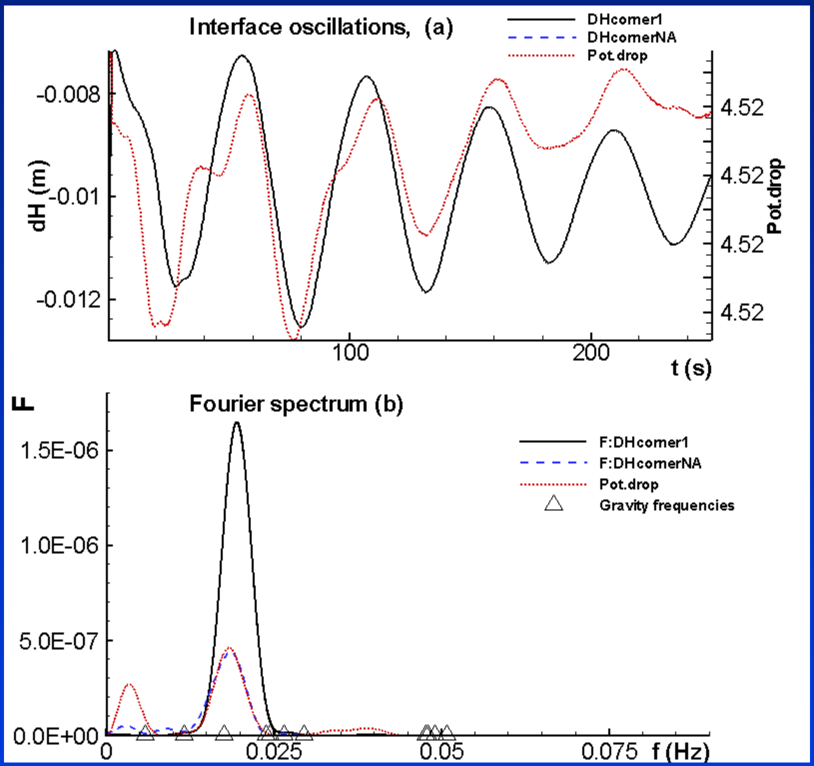
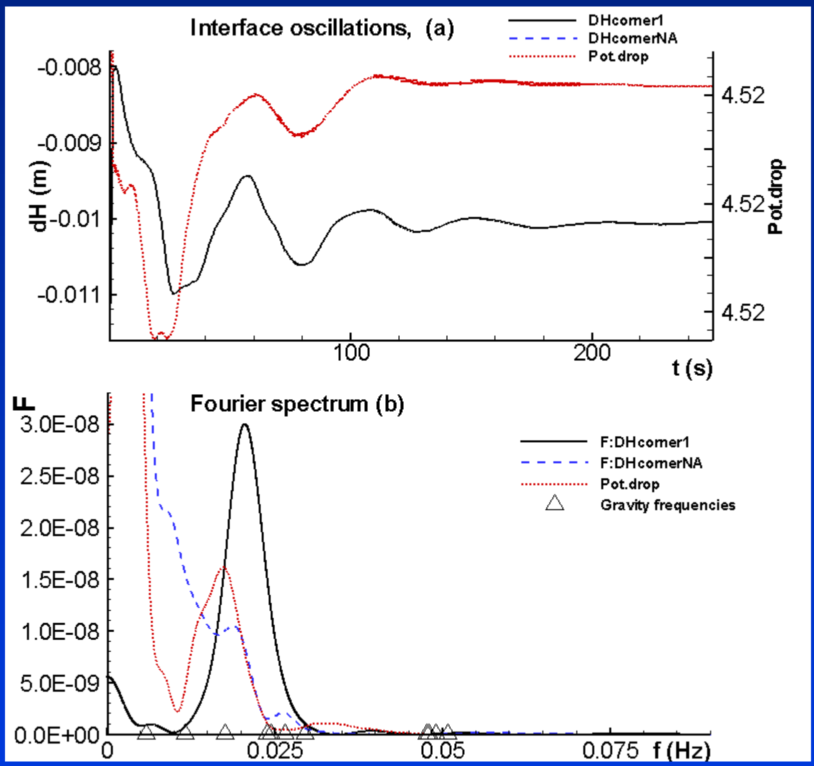
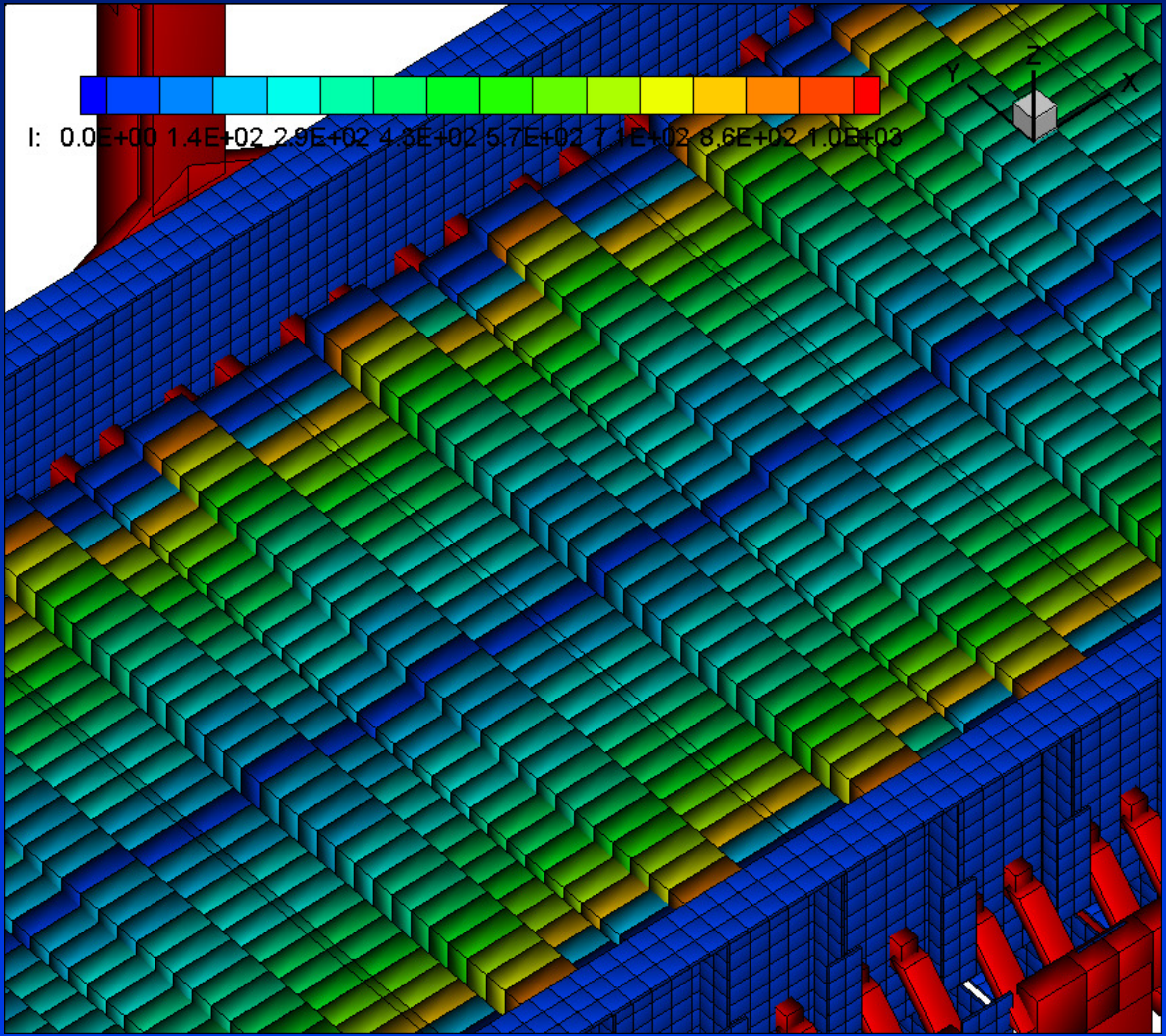
Improved magnetic field case





Comparison of the stability analysis with the base case on the left

Cell stability study on a cathode with lateral ridges



Geometry of the 500 kA base case model showing the current intensity solution in each conductor (in A)

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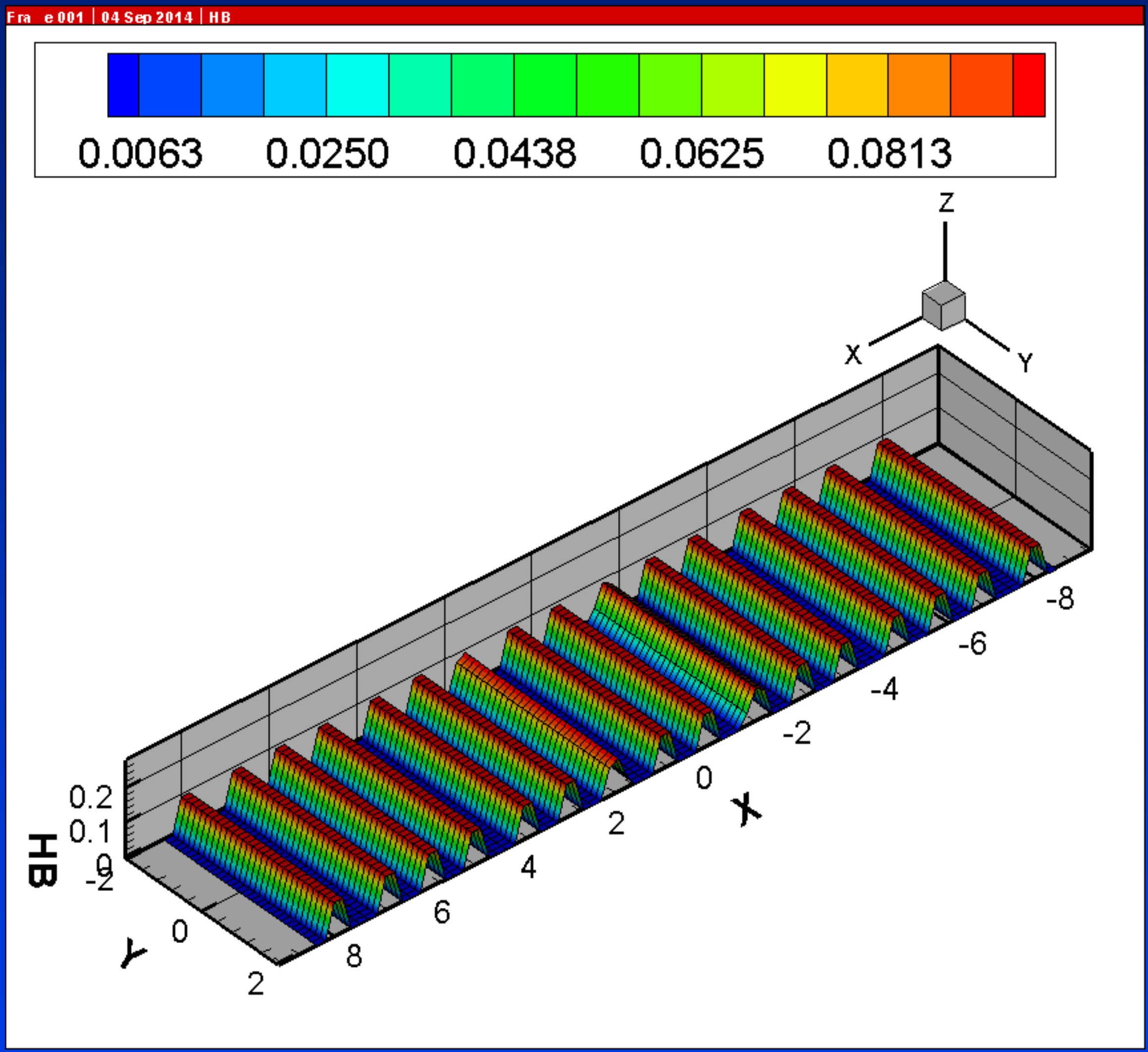

Spatial resolution of the 16 ridges geometry in the 80x30 CFD model mesh

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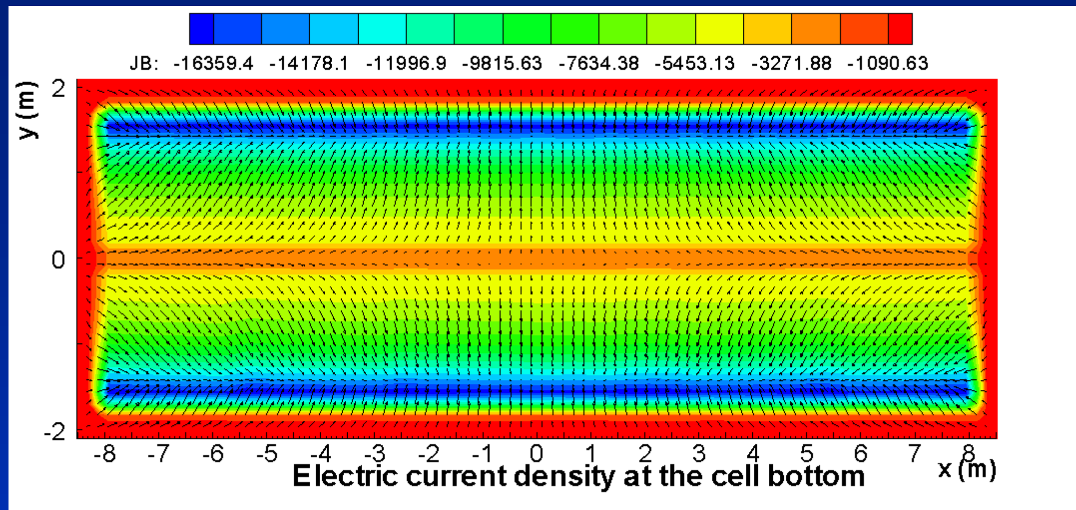
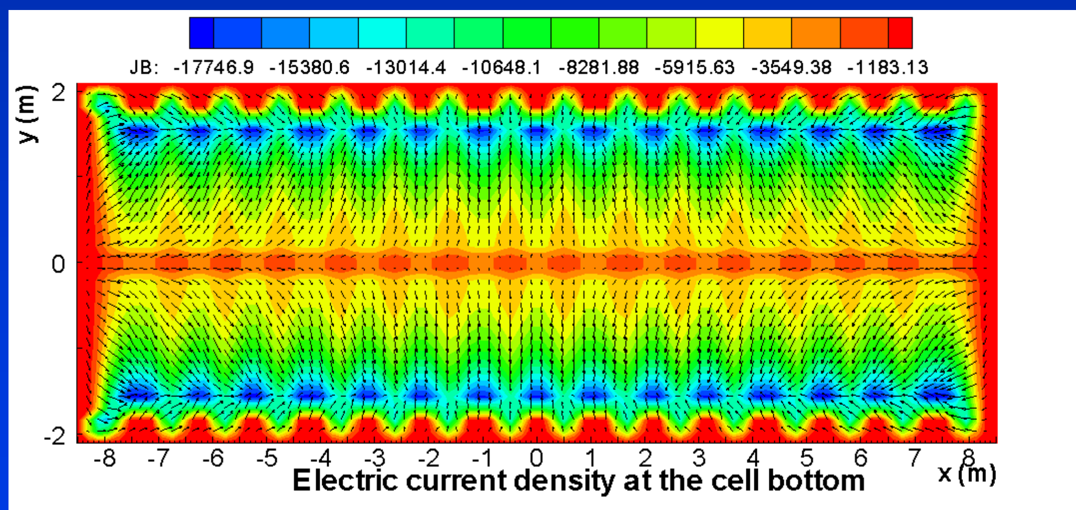
Cell stability study on a cathode with lateral ridges





Comparison of the metal pad current density with the reference case on the top

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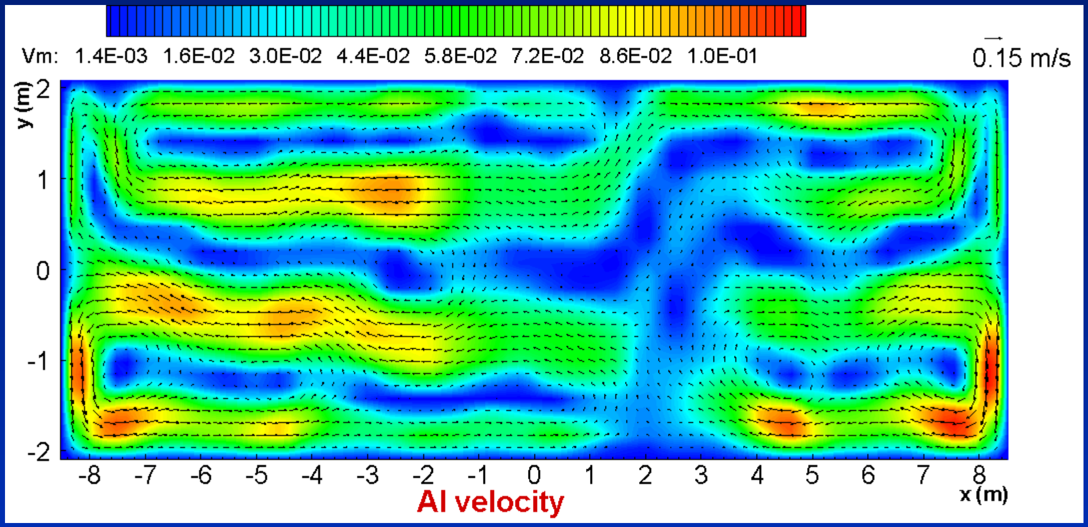
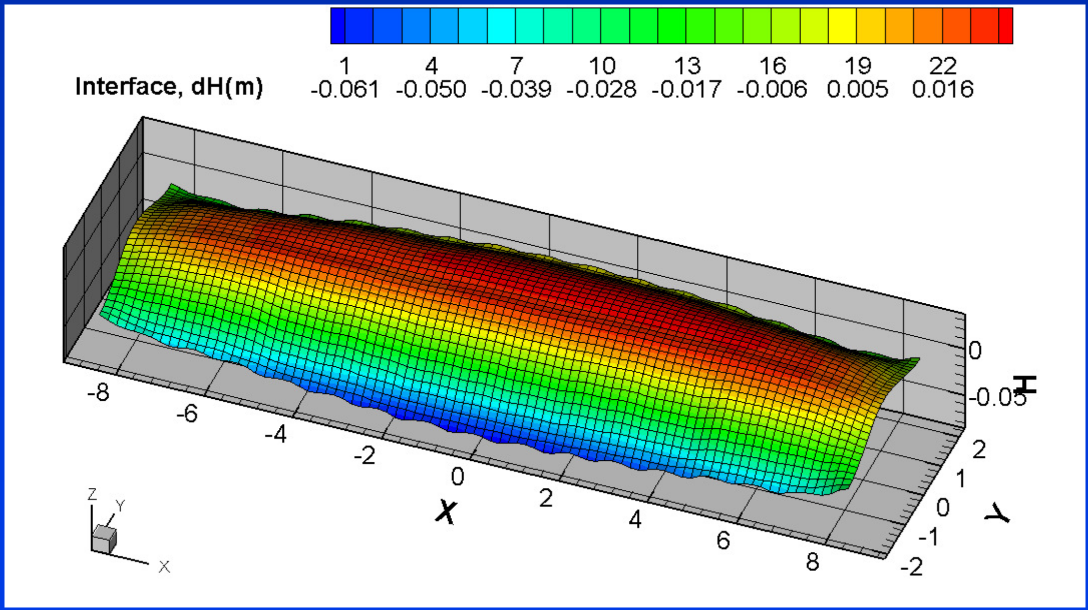
Cell stability study on a cathode with lateral ridges





Steady state solution

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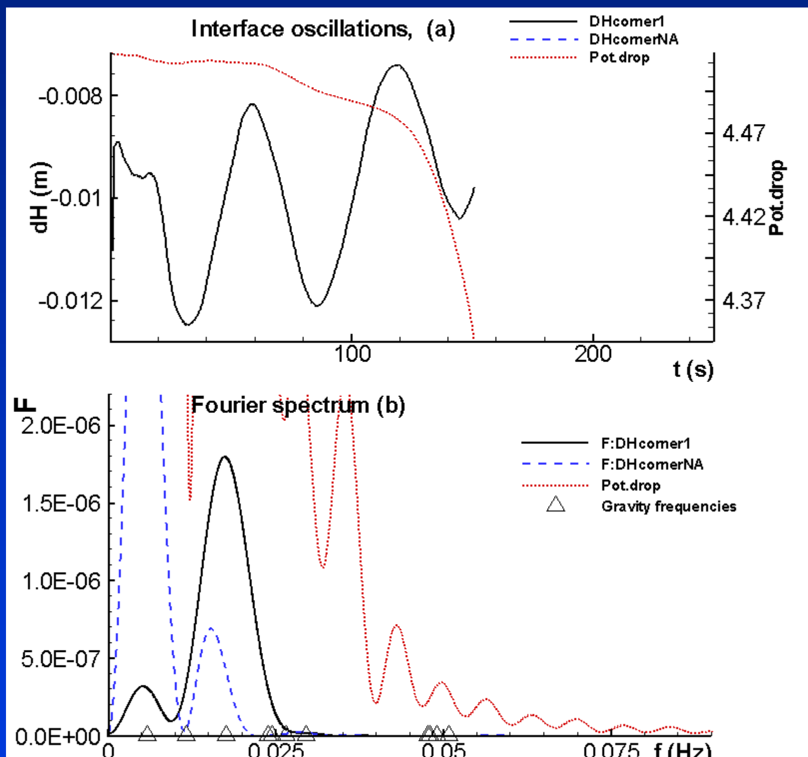
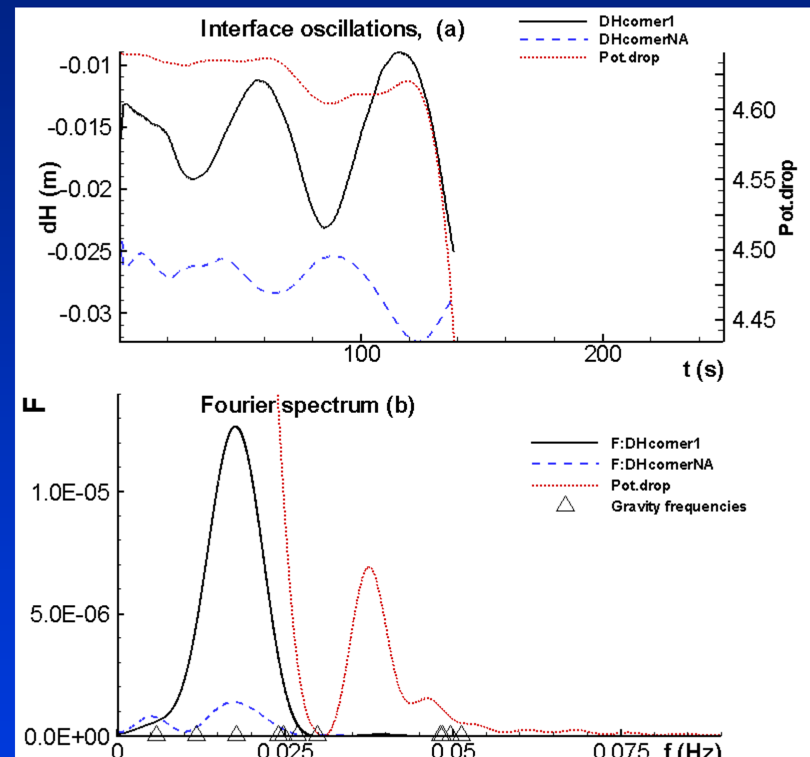
Cell stability study on a cathode with lateral ridges





Comparison of the stability analysis with the reference case on the left

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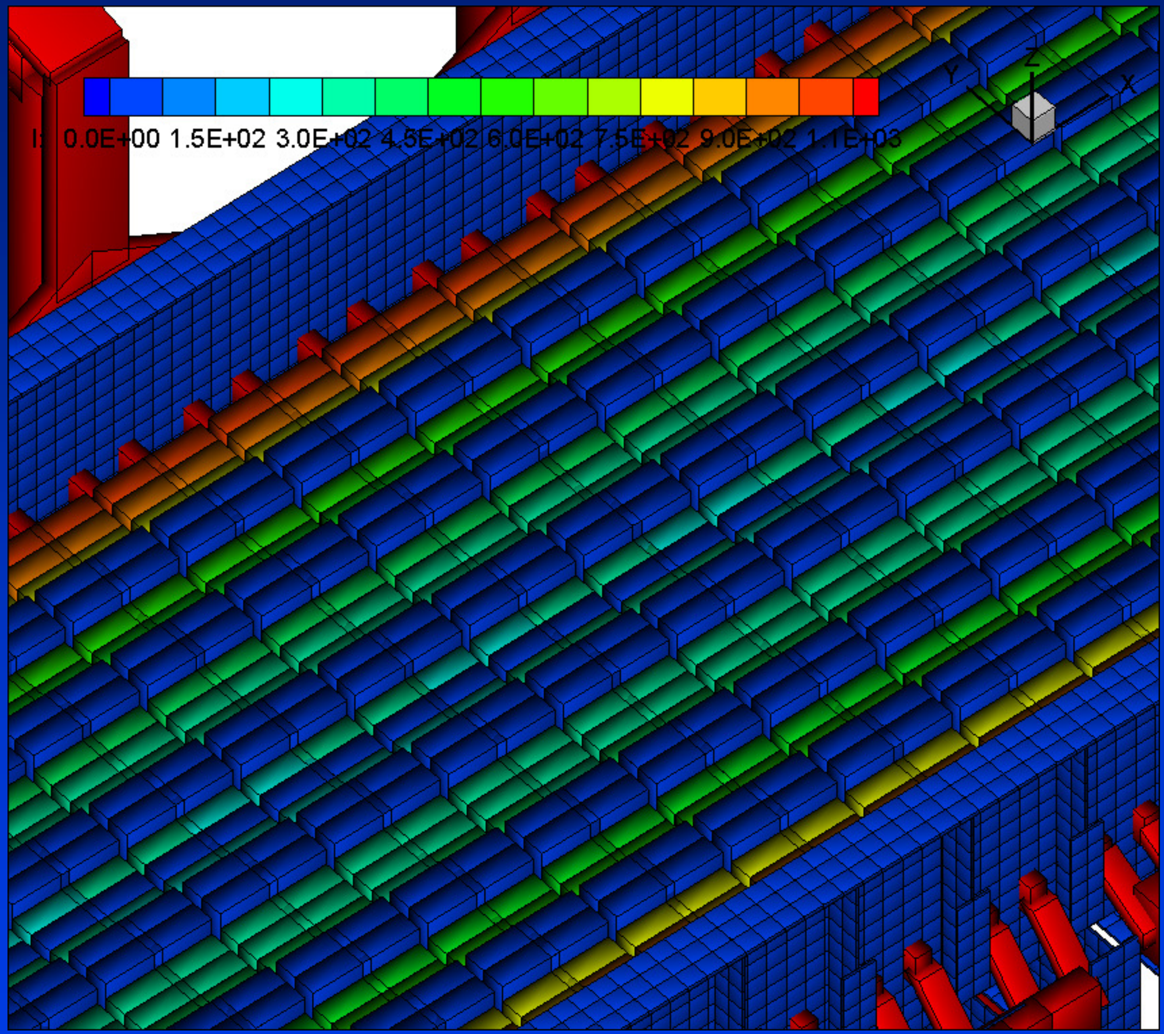
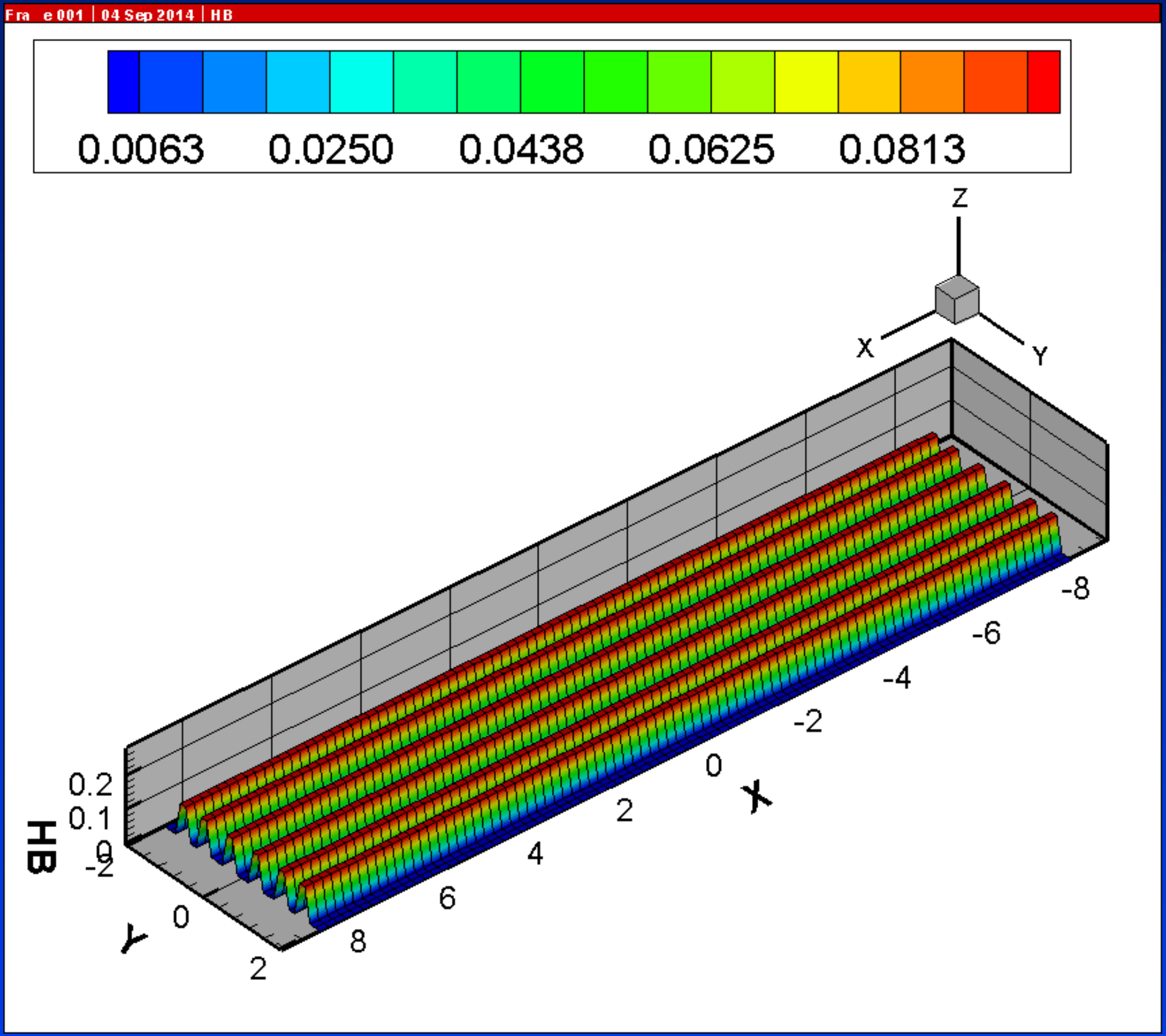
Cell stability study on a cathode with longitudinal ridges



Geometry of the 500 kA base case model showing the current intensity solution in each conductor (in A)

Cell stability study on a cathode with longitudinal ridges



Spatial resolution of the 6 ridges geometry in the 80x30 CFD model mesh

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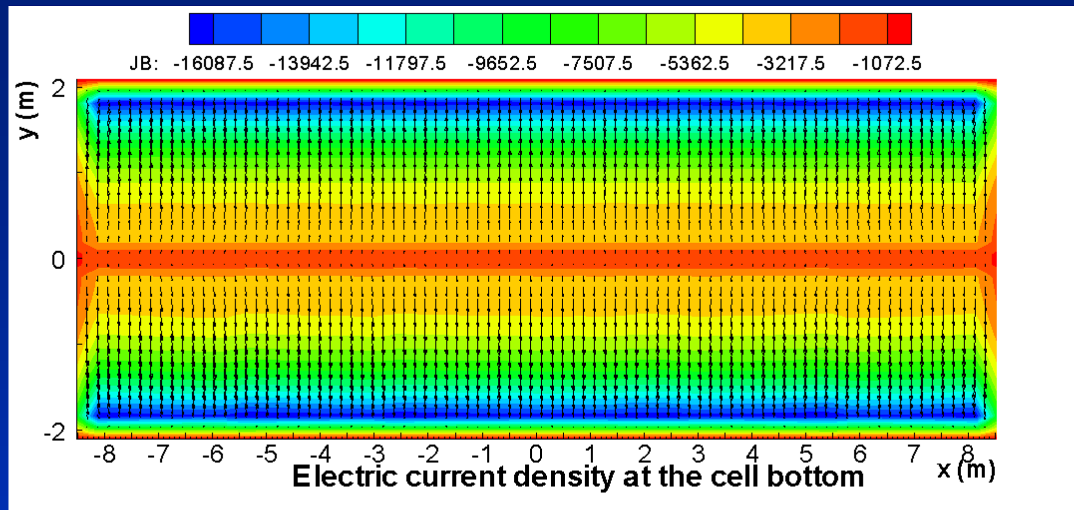
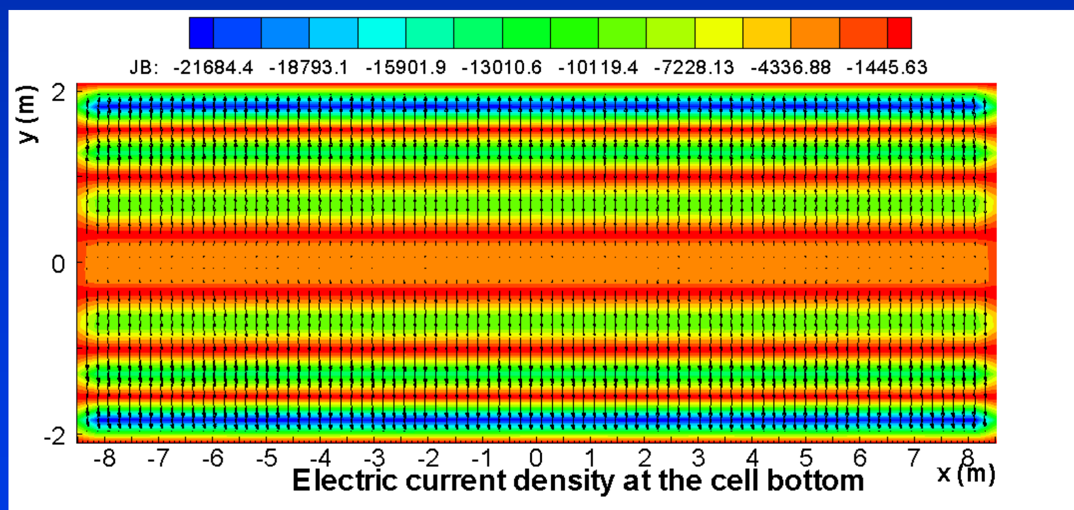
Cell stability study on a cathode with longitudinal ridges





Comparison of the metal pad current density with the base case on the top

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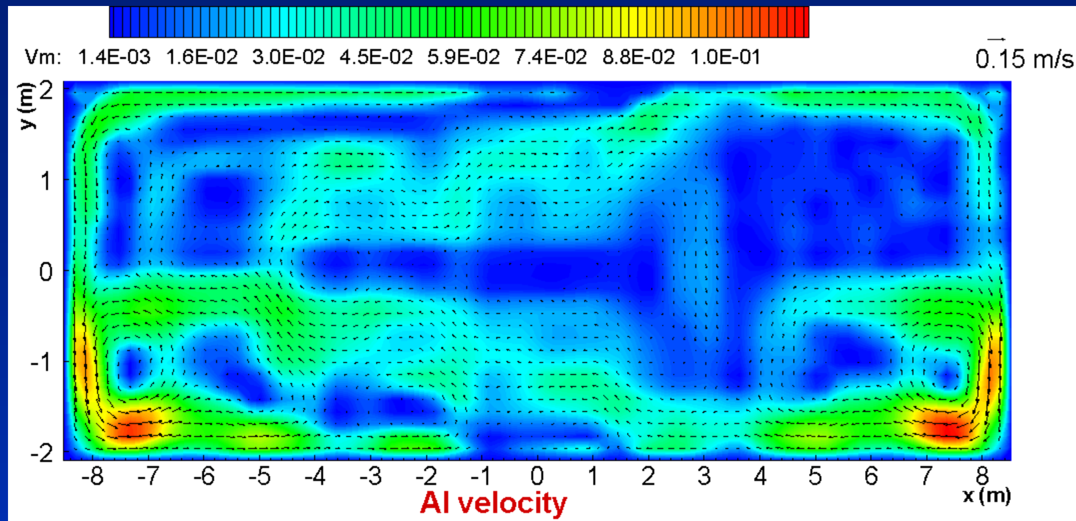
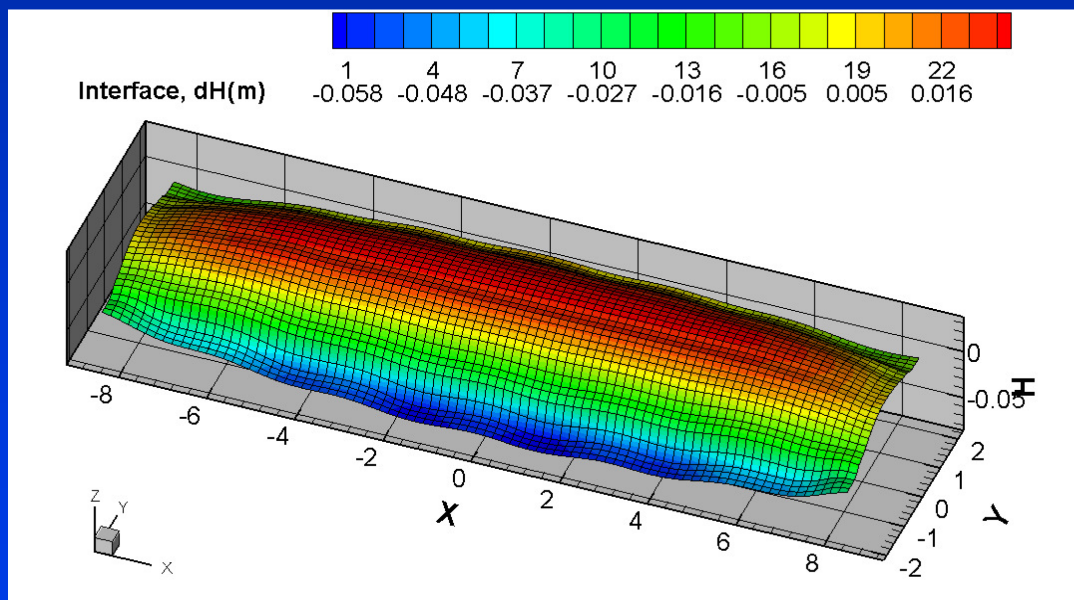
Cell stability study on a cathode with longitudinal ridges





Steady state solution

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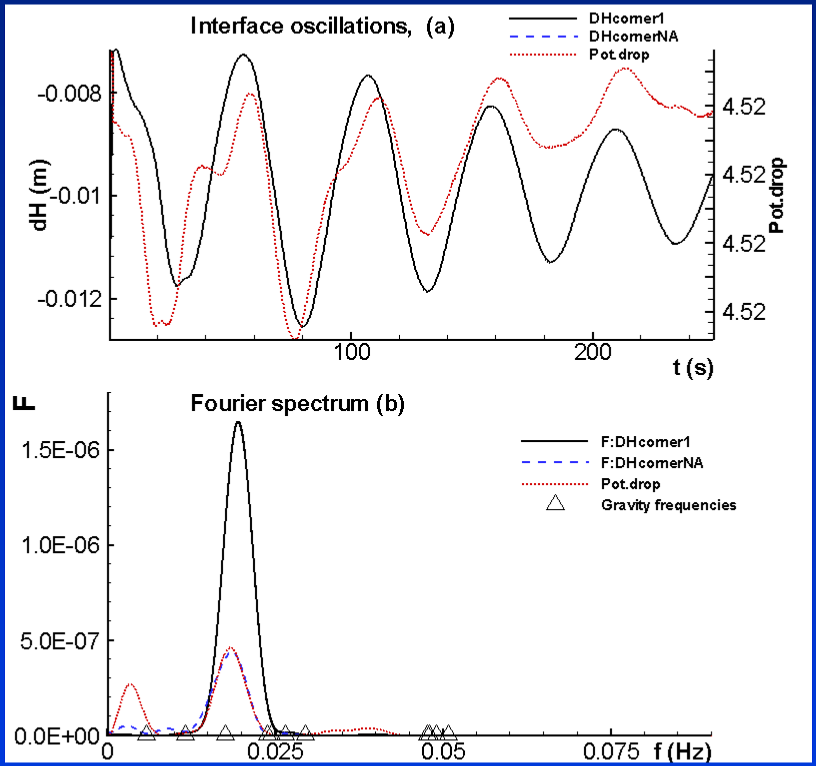
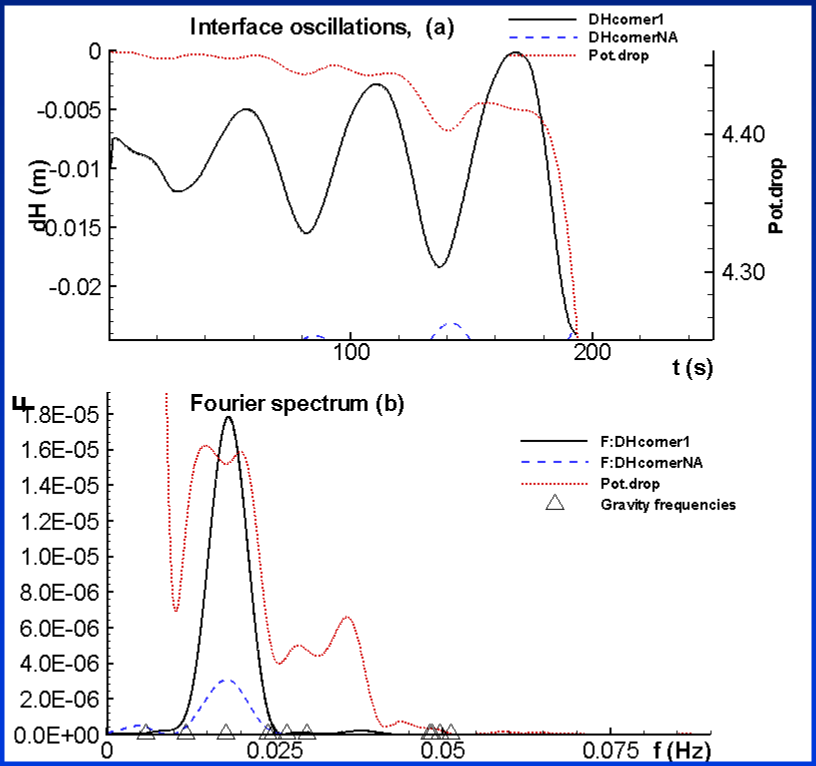
Cell stability study on a cathode with longitudinal ridges





Comparison of the stability analysis with the base case on the left

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Conclusions

- A thorough cell stability study has been carried out for a standard flat cathode surface cell. As expected, reducing the ACD, reducing the metal pad level and increasing the ledge toe thickness has a destabilizing effect on the cell. As expected as well, deducing the longitudinal gradient of the Bz has a stabilizing effect on the cell.
- As reported in previous study, the prediction of MHD-Valdis is that the presence of lateral ridges should not affect much the cell stability.
- When the impact of the longitudinal ridges on the metal pad current density previously reported is taken into consideration, the prediction of MHD-Valdis is that their presence has a destabilizing effect on the cell.

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