Single Discharge Simulations of Needle Pulses for Electrothermal Ablation

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Micro Electro Discharge Machining

- Electrothermal ablation with high surface quality is possible by applying needle pulses
- Model of a single discharge of micro scale electro discharge machining (EDM) was developed in accordance with Schulze et al [1] (**Fig. 1**)
- Implementation of experimental measured voltage and current curves (**Fig. 2**)
- Resulting power of the system (**Fig. 3**)

Model creation

- Axisymmetric pseudo-3D model (**Fig. 4**)
- Geometry size is 6 µm x 10 µm
- Triangular mesh is created and consists of 2947 elements (**Fig. 5**)
- Upper left corner is defined with an maximal mesh size of 0.0008 µm and a maximal element growing rate of 1.05
- Use of the heat transfer simulation module
- Time-dependent simulation of single discharge
- Simulation is focused on the heat input by the plasma channel
- Heat source is based on the Joule effect and is defined as boundary condition
- Current and voltage curve of a needle pulse generator are applied to calculate the heat source
- All boundaries except for the heat source are defined as thermal insulation
- Melting point of work piece material is 1573 K

Results

- A temperature of 3800 K is reached
- Visualization of crater by hiding temperature > 1573 K
- Total heat flux inside the work piece (**Fig. 6**)
- A discharge time of 87.5 ns was simulated
- Biggest crater was achieved at *t* = 65.625 ns
- Final crater has a depth of 0.72 µm and a width of 2.9 µm (**Fig. 7**)

Acknowledgements

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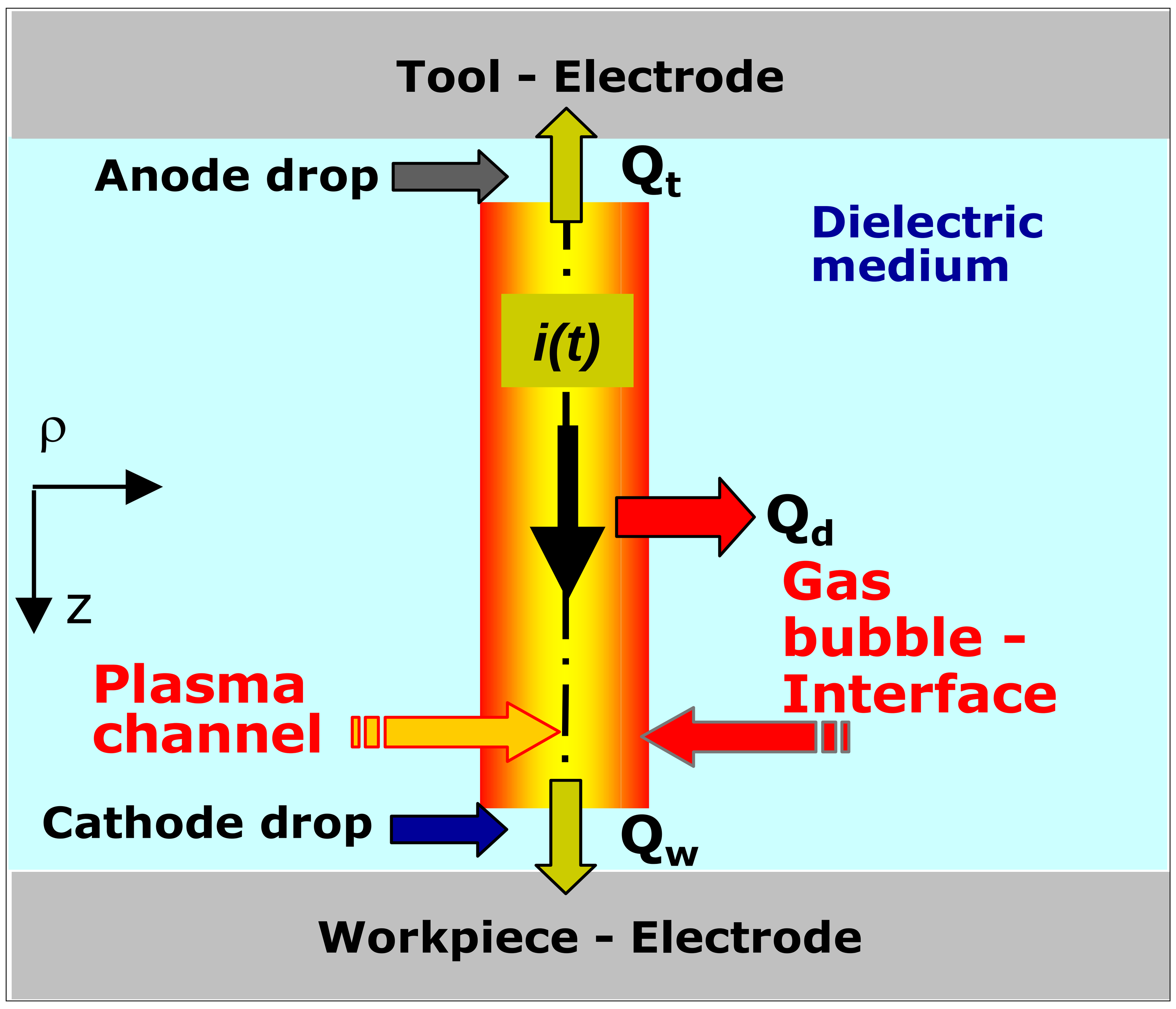

Figure 1. Schematic model of the plasma channel of a single discharge [1]

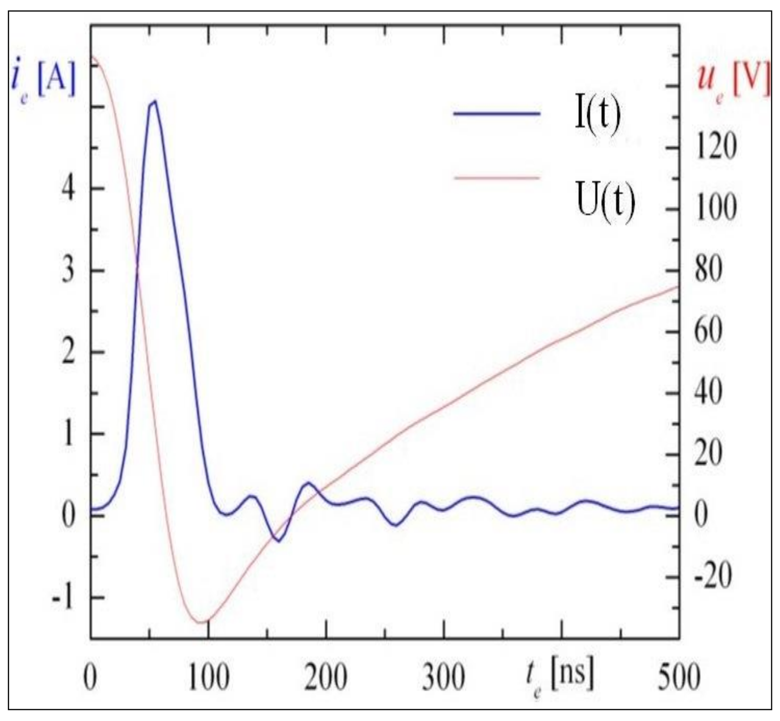

Figure 2. Voltage and current as function of pulse time of a needle pulse

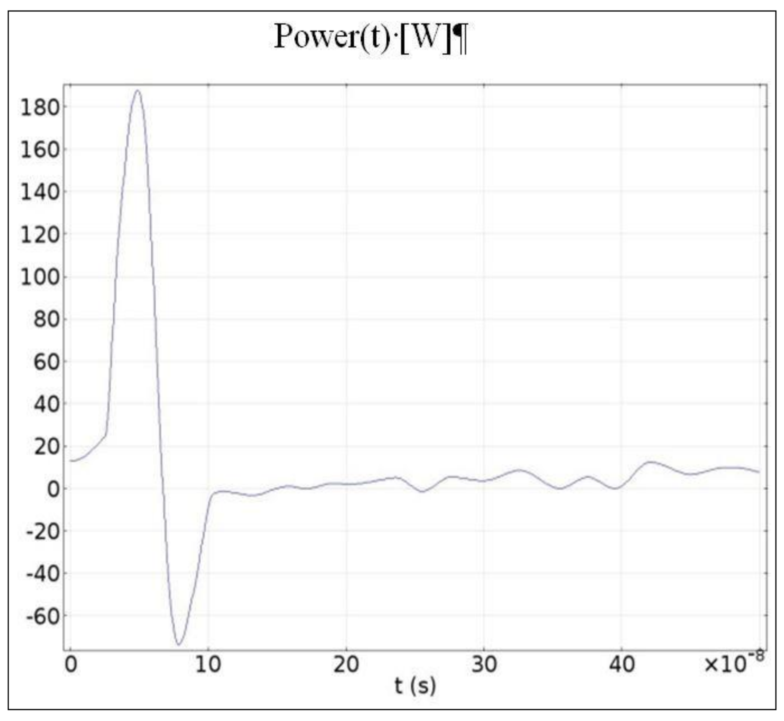

Figure 3. Power as function of pulse time of a needle pulse

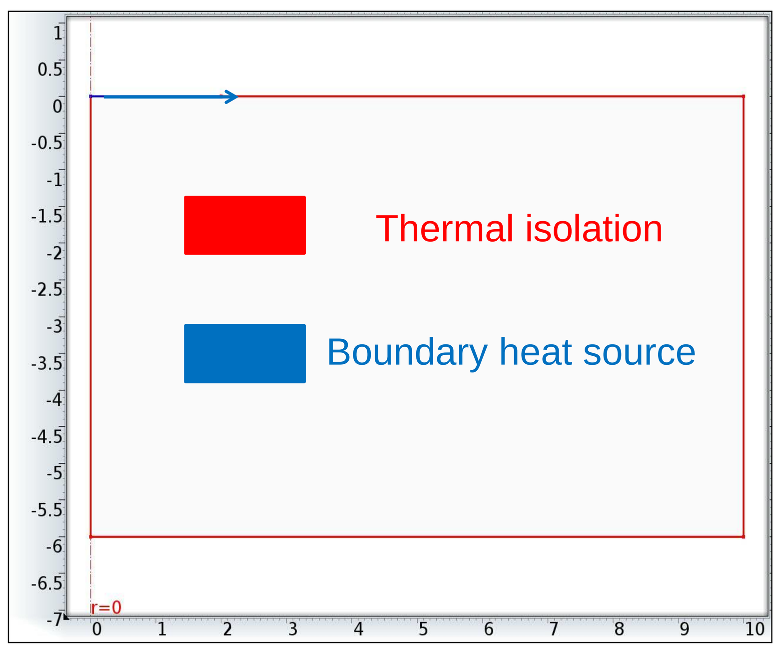

Figure 4. Model geometry and boundary conditions

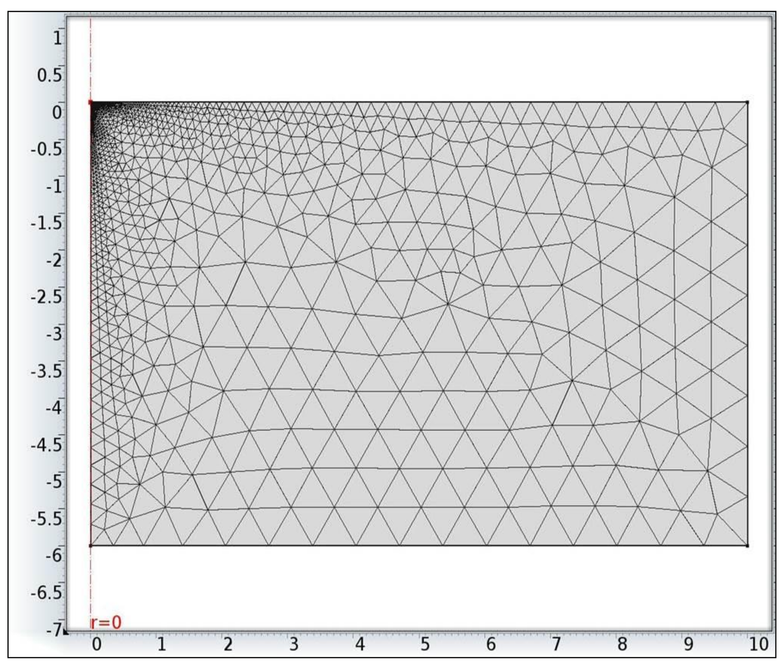

Figure 5. Mesh of the geometry with 2947 elements

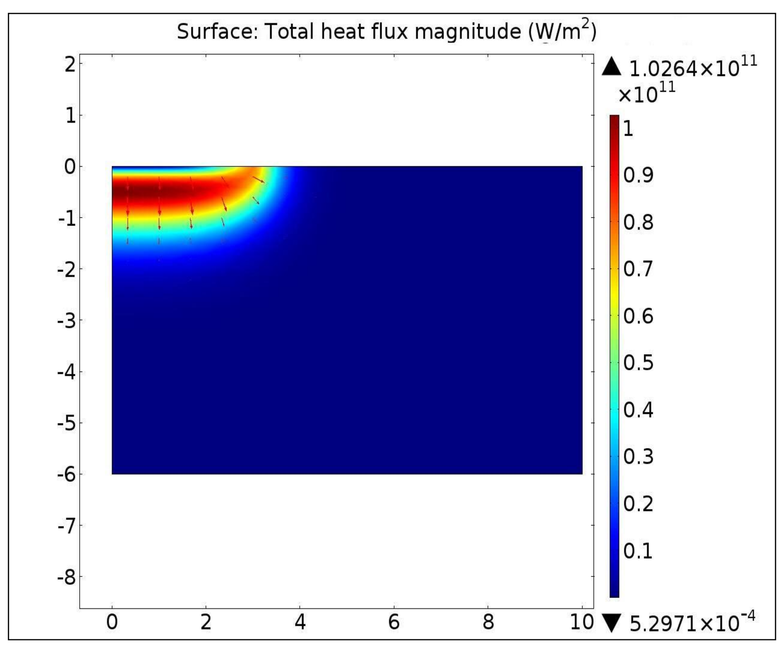

Figure 6. Surface plot of the total heat flux inside the work piece at 67 ns

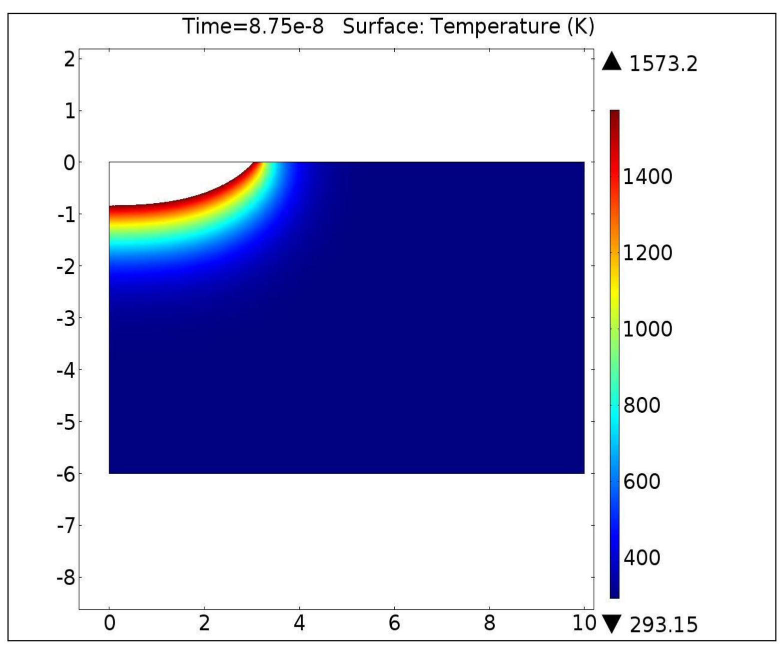

Figure 7. Surface plot of the temperature field and incurred crater generated by one needle pulse

References:

[1] H.P. Schulze et al., Nonconventional Technologies Review, 2007

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