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Simulation-based Analysis of a Microstructuring Process for Serrated Surfaces with Higher Friction

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Introduction:

- Single crater formation of electrical discharge machining (**Figure 1**) is studied
- Electric spark leads to high local input of thermal energy
- Major challenge: several physical phenomena occur in short time range:
  - Heating, melting and vaporization of workpiece material
  - Heat-Transfer with phase change and fluid dynamics
  - Change in surface topography
- Resulting surface and workpiece forming is a consequence of a large number of single discharges

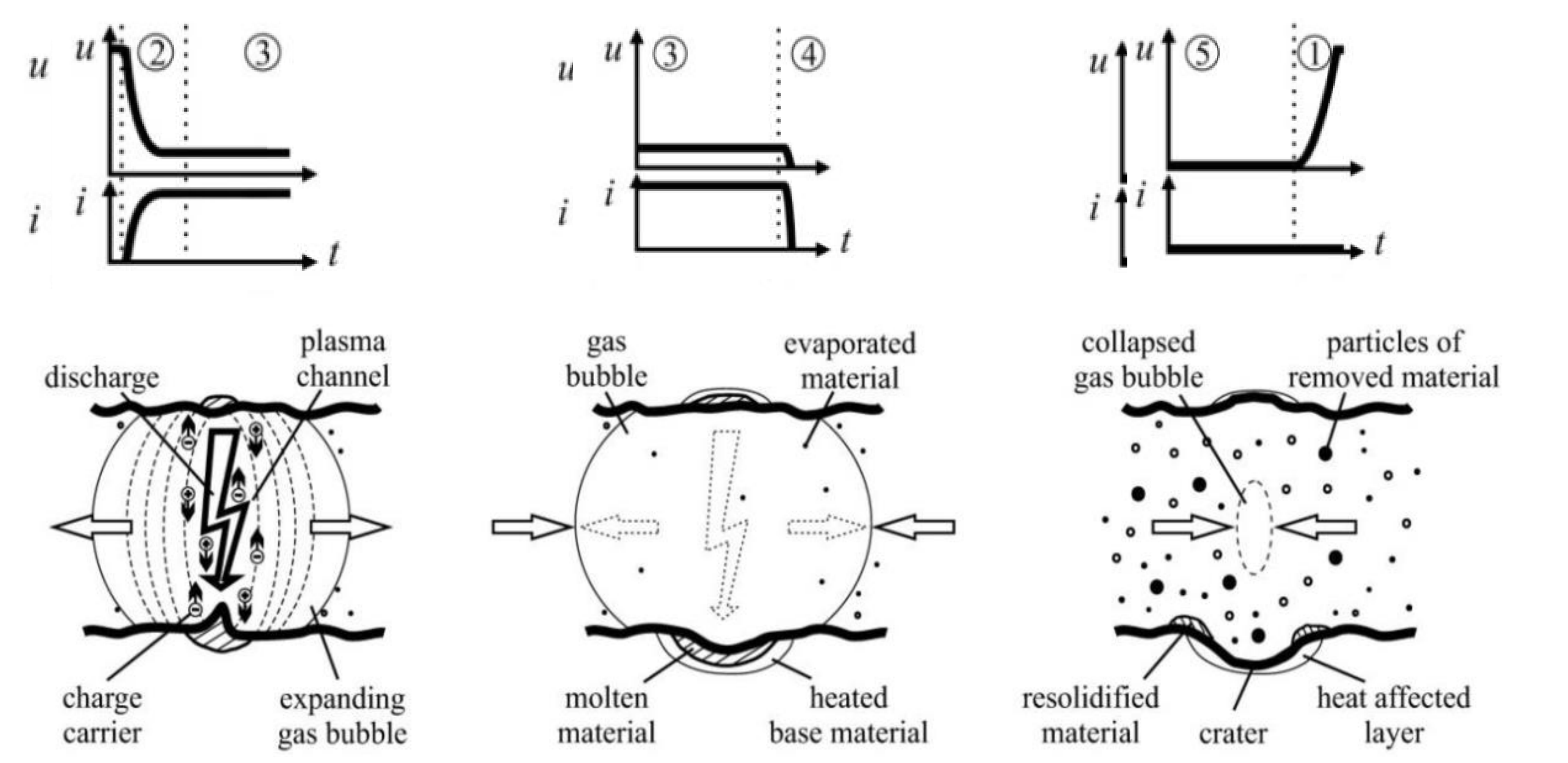


Figure 1. Principle of the single crater formation during the electrical discharge machining [Schubert et al, Journal of Mechanical Engineering, 2012]

Computational Methods:

- Heat source Q_{Sp} defined as Gaussian distribution at the workpiece surface (**Figure 2**)
- Mesh: 10199 triangular elements, refinement in area of expected crater formation (**Figure 3**)
- Heating leads to vaporization phenomena (phase change) and introduces a pressure into the Navier-Stokes equations
- Velocity field and vaporization phenomena are connected to the equations of the level-set method
- Convection of level-set variable ϕ describes change of surface topography
- Material removal and surface generation by superimposition of single pulse ablations using a livelinked MATLAB® implementation
- Geometrical surface description by the help of dexel („depth-element") model

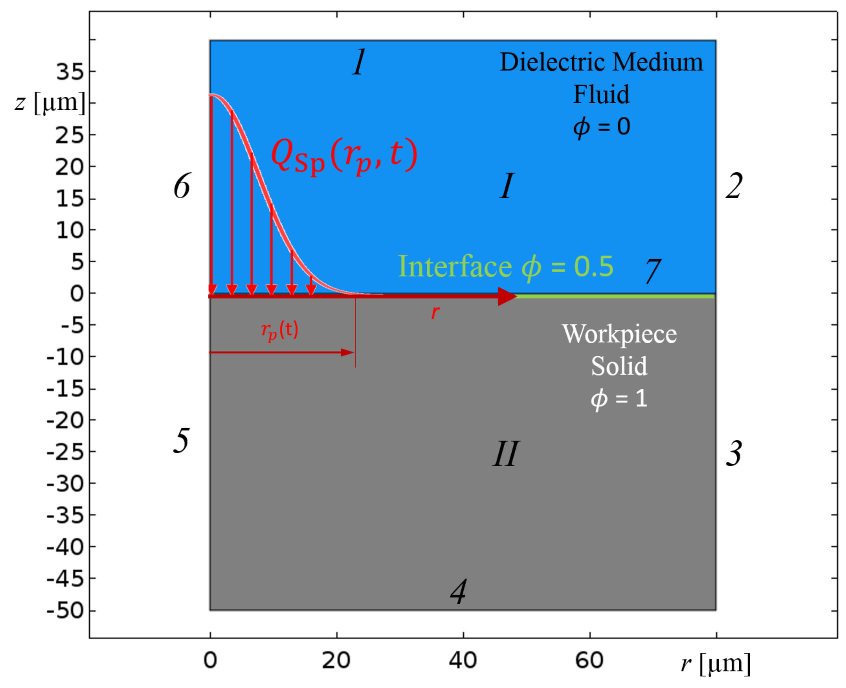


Figure 2. Simulation geometry and initial conditions

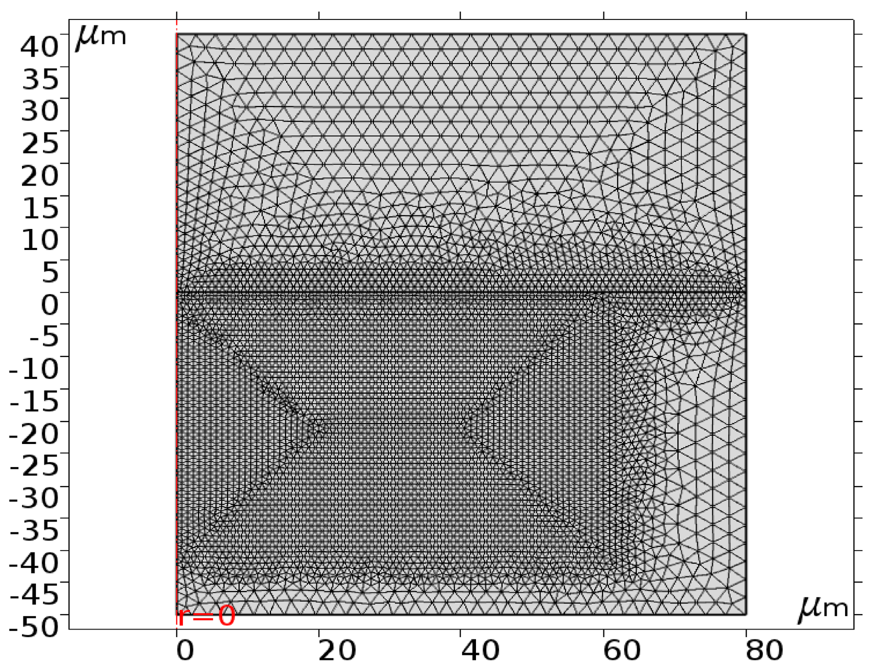


Figure 3. Mesh with 10199 triangular elements

Results

- Successful simulation of single crater formation in electrical discharge machining during 10 µs discharge time (**Figure 4**)
- Discharge energy E_D = 3.5 mJ :
  - Depth of discharge crater: 3 µm
  - Radius of discharge crater: 8 µm
- Discharge energy E_D = 5.25 mJ :
  - Depth of discharge crater: 7.8 µm
  - Radius of discharge crater: 22 µm
- Surface structures with superimposed single discharges calculated with low computation effort (**Figure 5**)
- Calculated surface roughness increases from Sa = (0.54 ± 0.01) µm to Sa = (1.25 ± 0.10) µm with increasing pulse energy from E_D = 3.5 mJ to E_D = 5.25 mJ

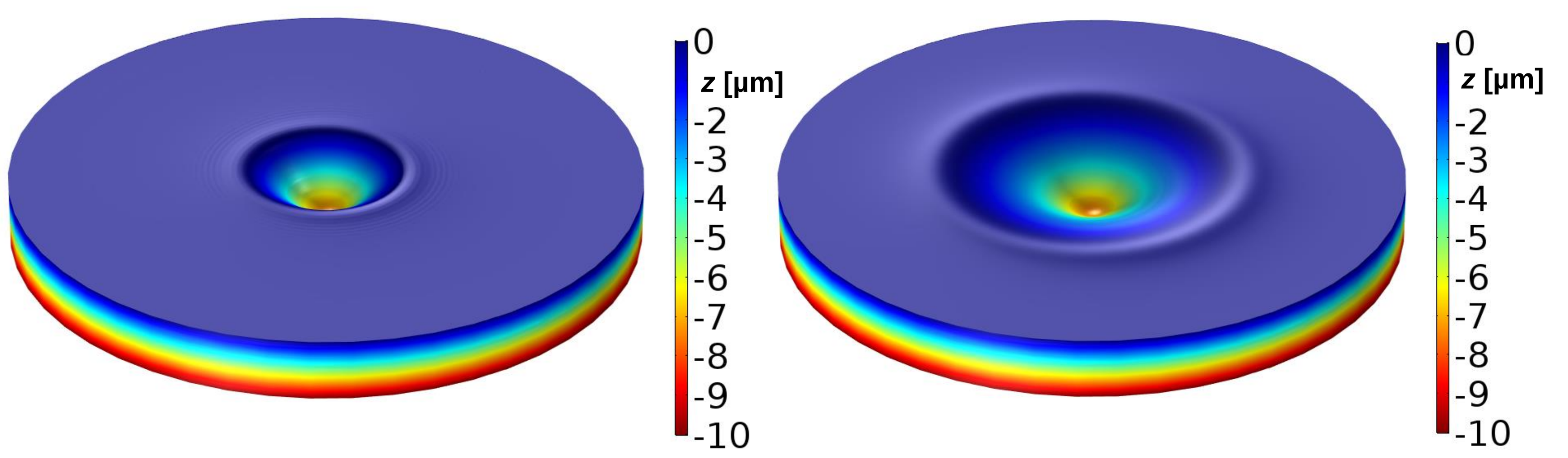
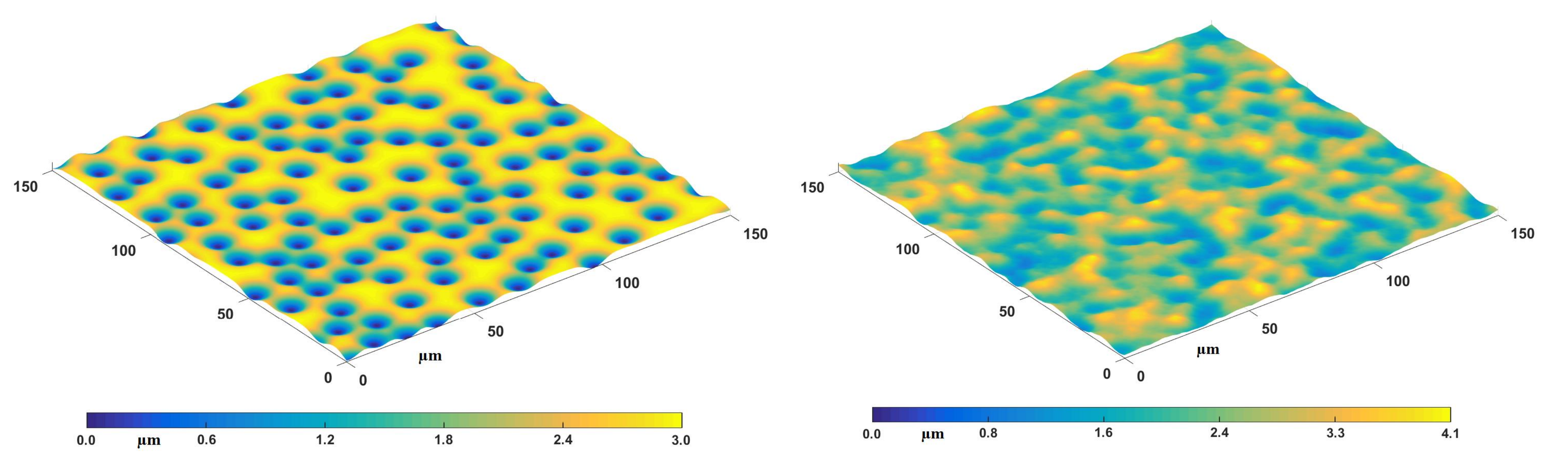


Figure 4. Results of crater formation simulation for the higher pulse energy of 5.25 mJ; Left: t = 7.5 µs; right: t = 10 µs

a) Superimposed pulse ablation with lower pulse energy of 3.5 mJ



b) Superimposed pulse ablation with higher pulse energy of 5.25 mJ

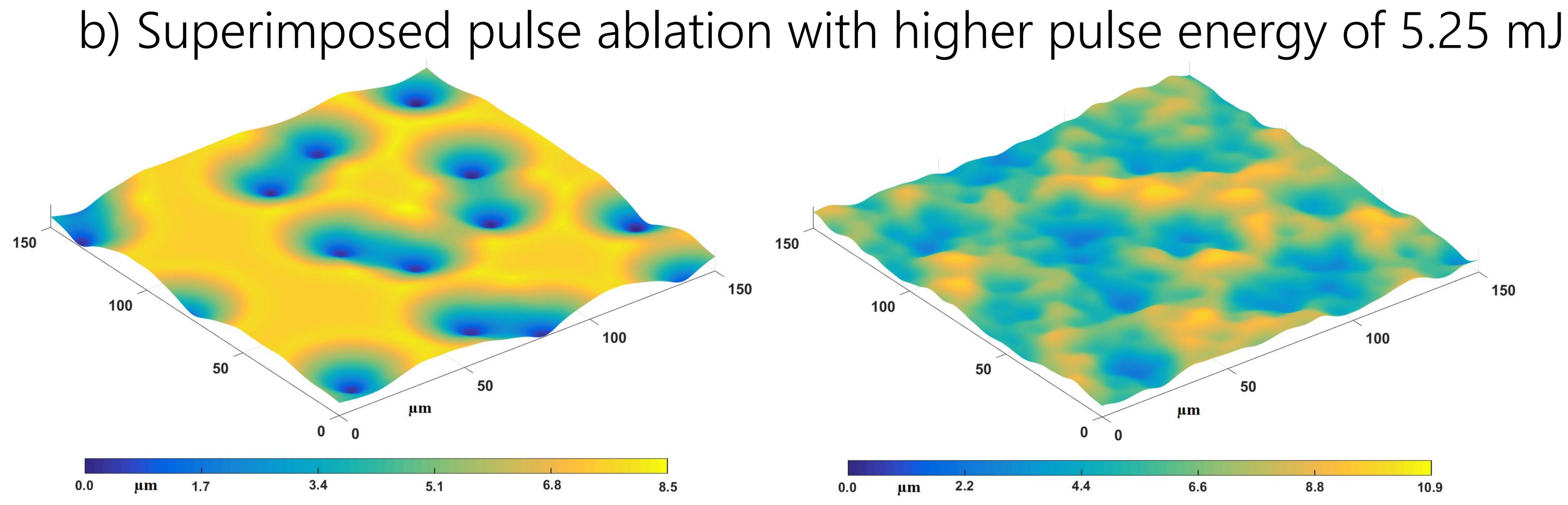


Figure 5. Calculated surfaces with multiple superimposed single craters

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