Analysis of 3D Biocompatible Additive Structures Using COMSOL Multiphysics®

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Introduction: Biocompatible prosthetics manufacturers have to find the best way to correlate process parameters and material properties as to meet the unique needs of individuals. 3D Additive Manufacturing - DMLS technique aims at creating complex biocompatible structures able to overcome the present shortfalls of the metal and metal alloys implants related to cytotoxicity, corrosion or stress shielding effects. DMLS and SLS are attractive solutions as the technological path downsizes to micro- and even nanosize interface phenomena.

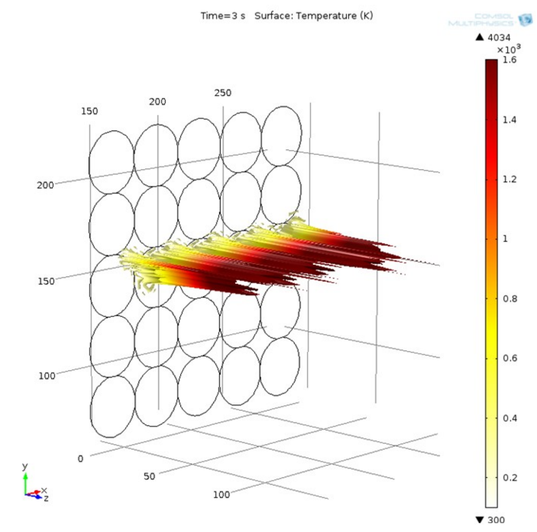

Figure 1. Thermal radiation peaks within active layer

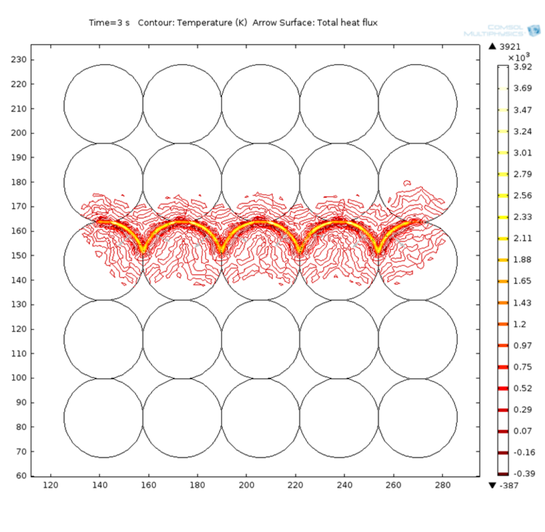

Figure 2. Solid-liquid interface under DMLS beam

Computational Methods: The surface irradiation equation at any point with the depth (y) value to the scan line:

$$E_{(y,0)} = \frac{\sqrt{2}\,P/_{w_0 S_{scan}}}{\pi} exp\left(-2y^2/_{w_0^2}\right)$$

Laminar flow (and Marangoni effect):

$$\rho(u \cdot \nabla)u = \nabla \cdot [-pI + \mu(\nabla u + (\nabla u)^T)] + F$$

The time for the powder active layer to absorb the laser energy (99.99%):

$$t_{eff} = \frac{\sqrt{R^2 - y^2}}{S_{scan}}$$

Results: Heat conduction as a function of laser scanning time and directivity was suggestively illustrated using Marangoni convection in COMSOL Multiphysics®.

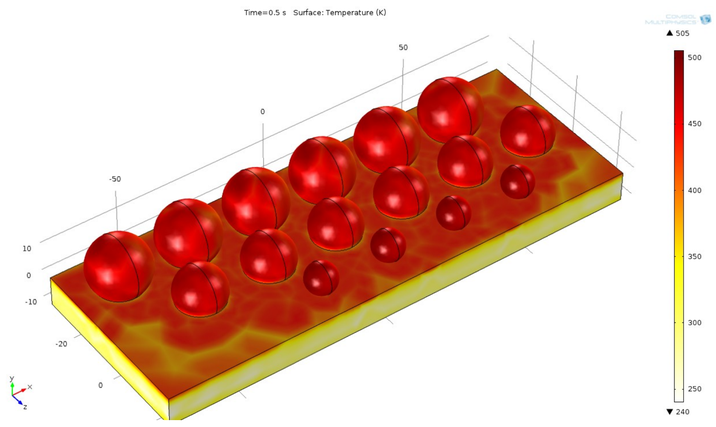

Figure 3. Isosurface temperature for rough active layer (t=0.5s)

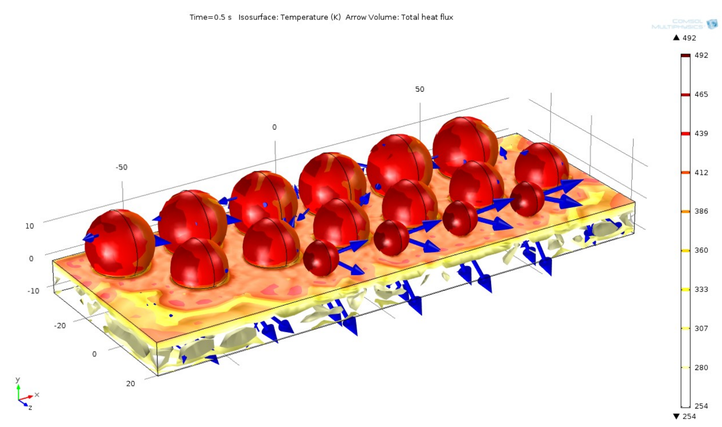

Figure 4. Total heat flux for rough active layer (t=0.5s)

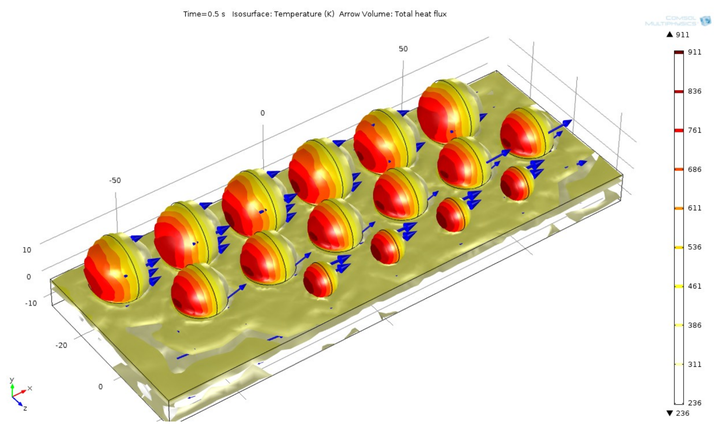

Figure 5. Dynamic heat flux for rough active layer (t=0.5s) (*Marangoni effect*)

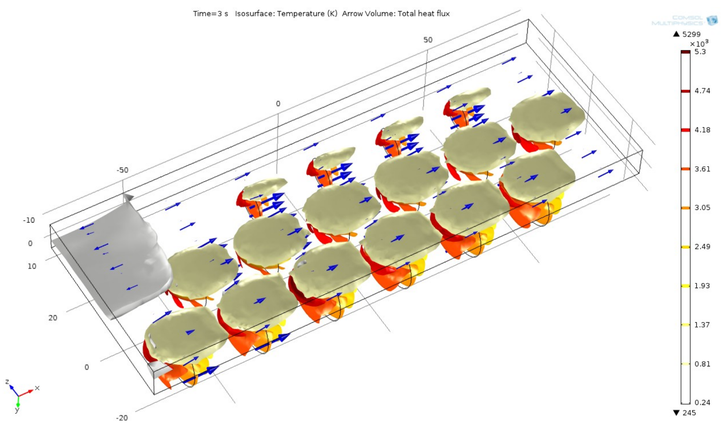

Figure 6. Effective wetting distribution on the rough active layer during the dynamic heating (t=3s)

Conclusions: Using the COMSOL Multiphysics® analysis and simulations a new path of energy distribution and soldering geometry was designed and modelled for 3D additive growth of biocompatible substances with impact on personalized medicine.

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