Comsol simulation of flash lamp annealed multilayers for solid state electrolyte fabrication

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Introduction: flash lamp annealing (FLA) technique is key technology for advanced battery components processing. In this work, temperature variations across solid multilayers during thermal treatment using FLA is computed, as well as the maximum temperatures for various flash conditions are carried out.

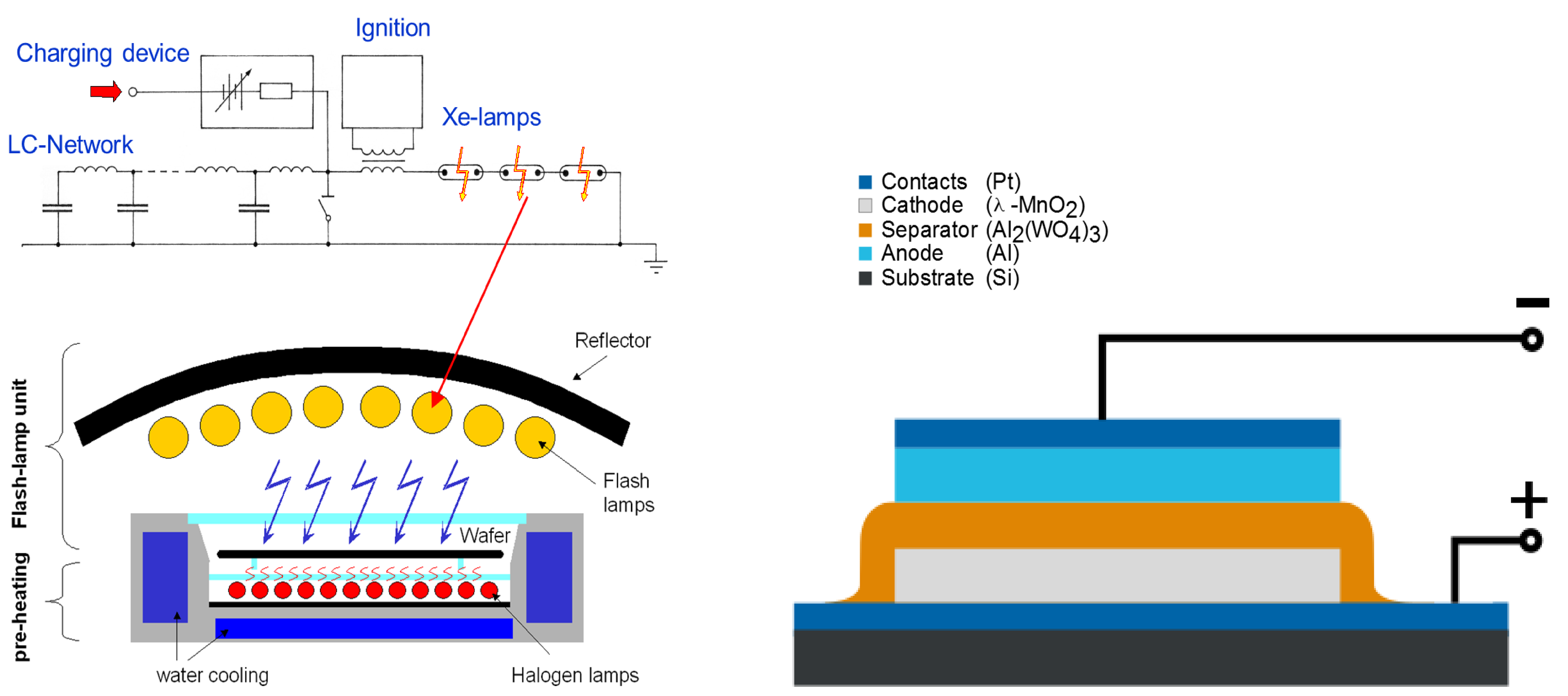

Figure 1. Flash lamp apparatus for subsecond annealing of solid state materials (left) and aluminum solid state battery structure (right)

Computational Methods: FEM was utilized using the Comsol Multiphysics code. The heat transfer with surface-To-surface radiation interface contains the heat transfer in solid (eq.1) and irradiative flux of the external source (eq.2) as well as a diffuse surface boundary including on the radiation process (eq.3):

$$\rho C_p \frac{\partial T}{\partial t} + \rho C_p u \cdot \nabla T + \nabla(-\kappa \nabla T) = Q \quad (1)$$

$$G_{ext} = F_{ext}(x_s) \cdot P_s \quad (2)$$

$$x_s = (0,0,d_z = 10cm)$$

$$e_b(T) = n^2 \cdot \sigma \cdot T^4 \quad (3)$$

Mesh:

The flash lamp annealing process of $Al_xW_yO_z$ multilayers was modeled in 3D geometry. The top thin layer was finer meshed by sweeping perpendicular to the sweep direction.

Results:

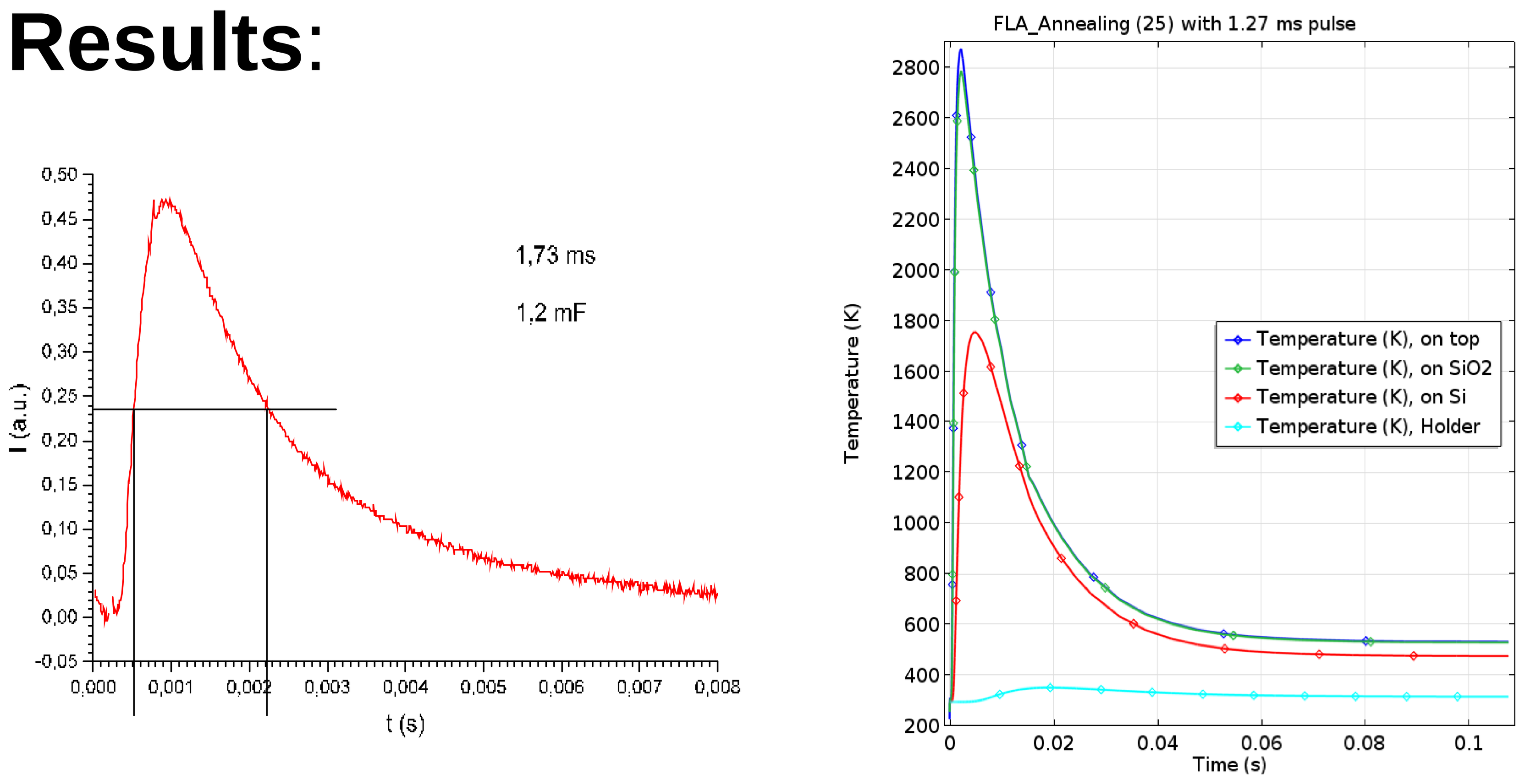

Figure 3. A subsecond pulse of FLA from experiment (left) and the calculated *T(t)* field on thin film layers (right)

- Two time regimes **1.7** (left) and **20 ms** of FLA were used
- Maximum of *T(t)* function (right) is affected by flash conditions (pulse period, form and power of the flash)

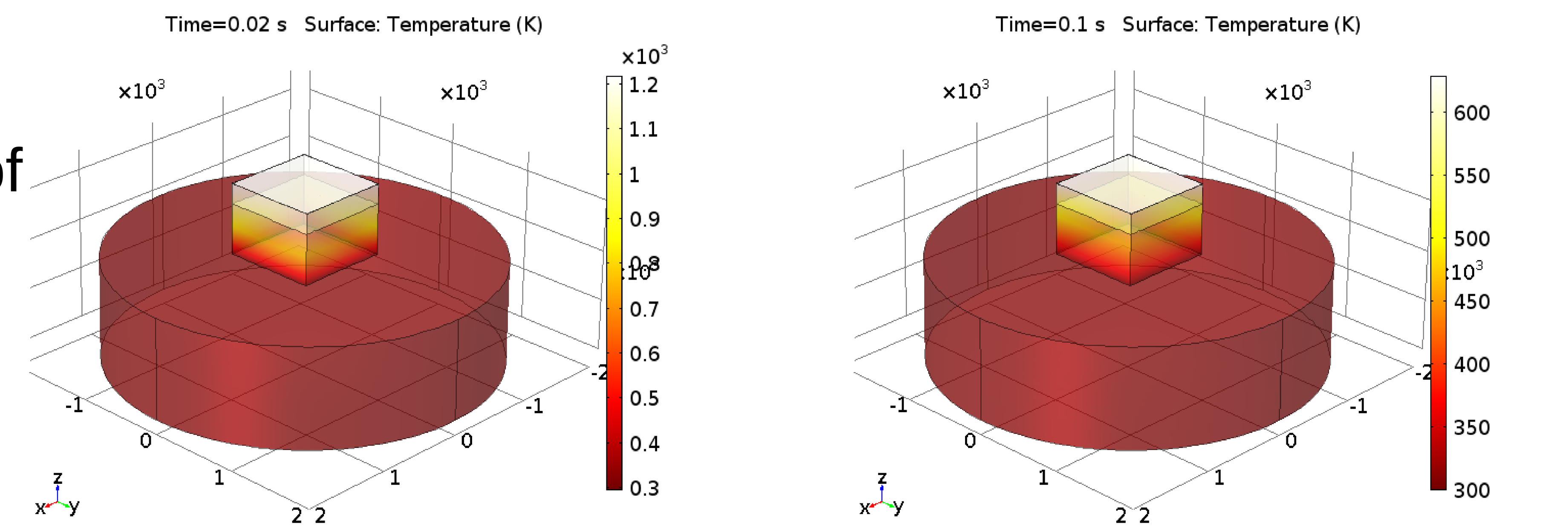

Figure 4. 3D-**T(t=0.02s, 0.1s)** distribution on $Al_xW_yO_z$ multilayers structure

– Wavelength dependence emissivity is constant

– Band gap of layers as well as wavelength of FLA spectrum depending on the refractive index have to be included in the model.

Conclusions: *T(t)* simulation on the multilayers shows more than 2000 K temperature variation for $Al_xW_yO_z$ and SiO_2 layers and 1000 K for Si layer after 20 ms of the FLA process using one band spectrum of the flash, respectively. A multiple bands spectrum with variable emissivity including parameters like band gap, layer thickness as well as the preheating variation have to be added to the model.

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