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APPLICATION OF COMSOL MULTIPHYSICS IN THE STUDY OF HEAT TRANSFER IN SOLIDS: COMPARATION WITH MEASUREMENTS OBTAINED BY MEANS OF INFRARED PHOTOTHERMAL RADIOMETRY

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Introduction: We applied the Heat Transfer Module of COMSOL Multiphysics software in order to obtain the temperature distribution in a solid sample as a function of time in the configuration of the Infrared Photothermal Radiometry technique, used to research the thermal properties in materials. Moreover, we compare the experimental and simulated results, obtained a very good agree between them.

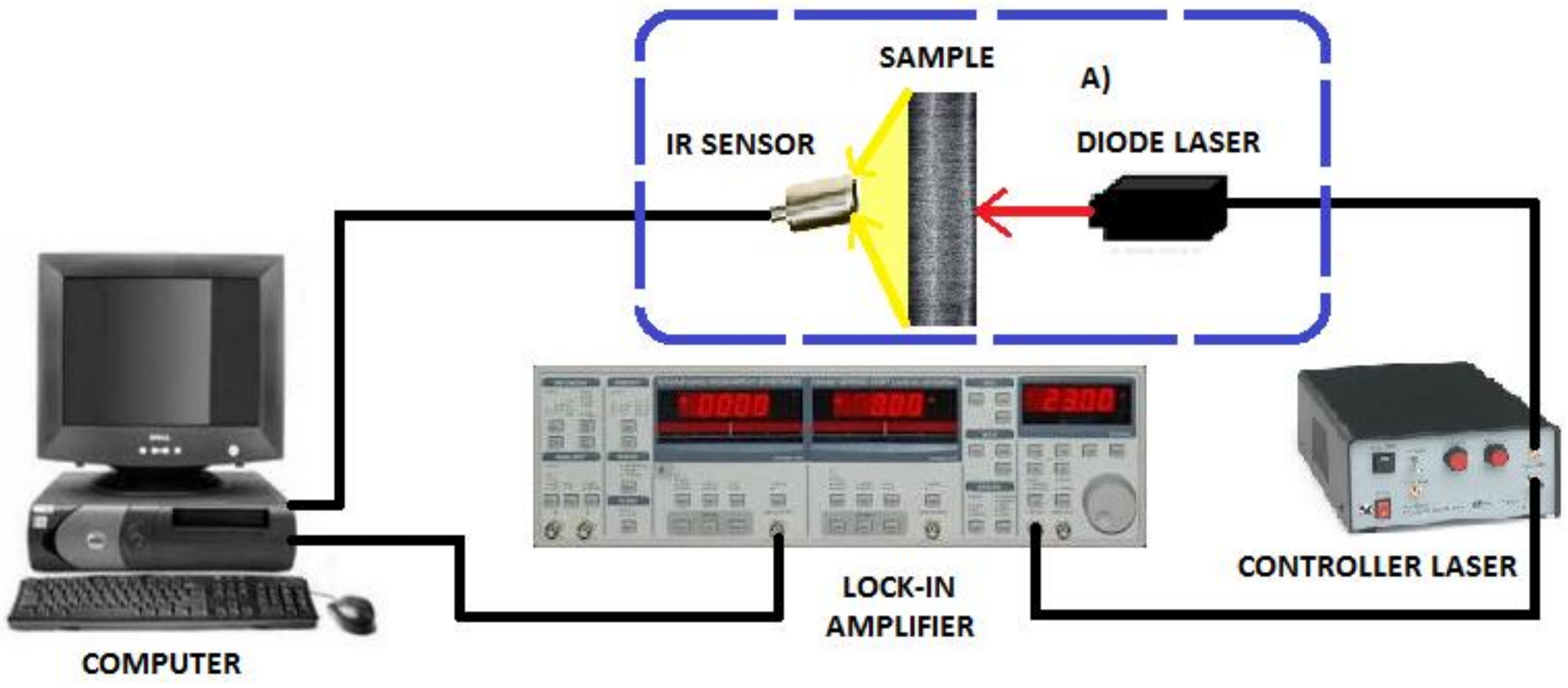

Figure 1. Infrared Photothermal Radiometry System

Computational Methods: We study the heat transfer of a homogeneous and isotropic solid material excited by a periodic laser beam on the front side of the sample, and an infrared detector on the rear side in order to obtain the evolution of the temperature difference with the exposure time. The heat diffusion equation was solved by finite element analysis with a boundary conditions corresponding to the physical situation of the problem:

$$-\frac{\partial}{\partial x}\left(k\frac{\partial T}{\partial x}\right)+\dot{q}=\rho c\frac{\partial T}{\partial \tau} \qquad (1)$$

$$\Delta T\big|_{x=0}=T_i\left[1+\cos(2\pi f t+\pi)\right] \qquad (2)$$

$$-k_s\Delta T\big|_{x=L}=-k_a\Delta T\big|_{x=L} \qquad (3)$$

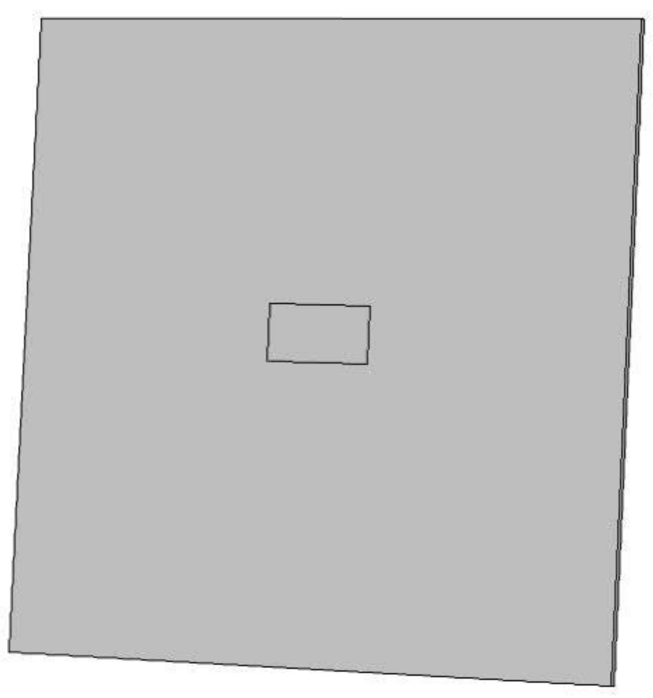

Figure 2. 3D model of the sample

Results: It was considered a crystalline silicon sample with 400 μm thickness, illuminated by 1 W laser (λ = 473-532nm), the laser beam has a rectangular spot which impinges on the sample front face of 15mm^2.

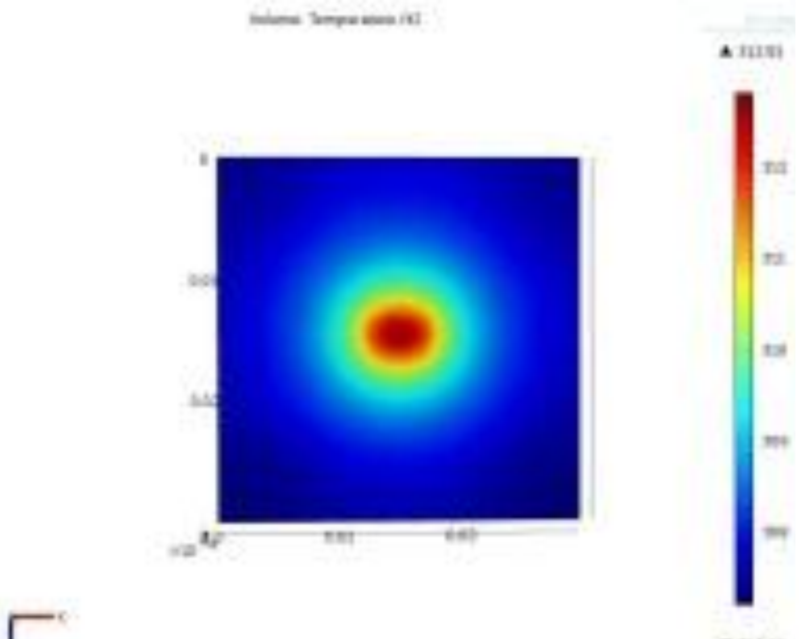

Figure 3. Temperature distribution 0.1 Hz 10s

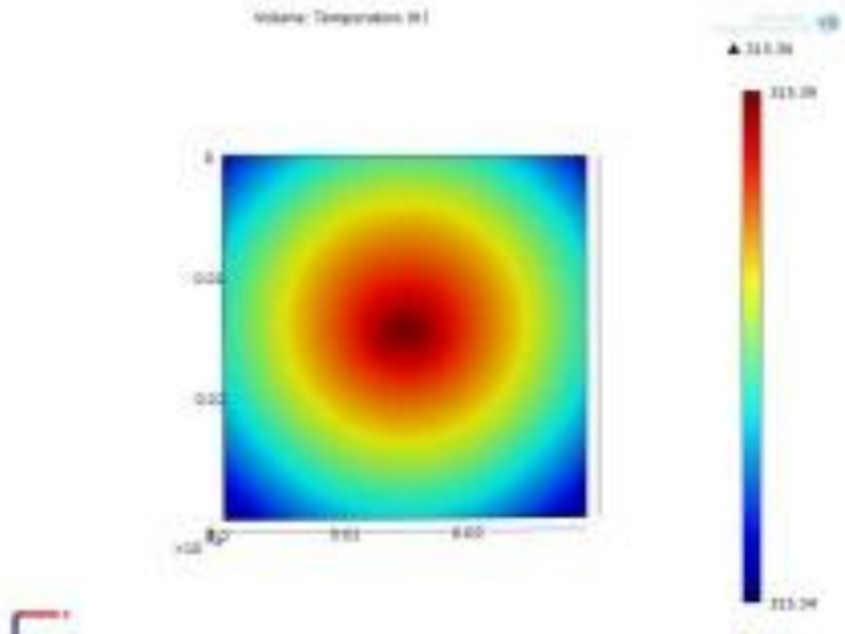

Figure 4 Temperature distribution 0.1 Hz 50s

Variable	Value	Units
Density	2330	Kg/m^3
Thermal Conductivity	148	W/m K
Heat Capacity	794	J/Kg K

Table 1. Silicon properties

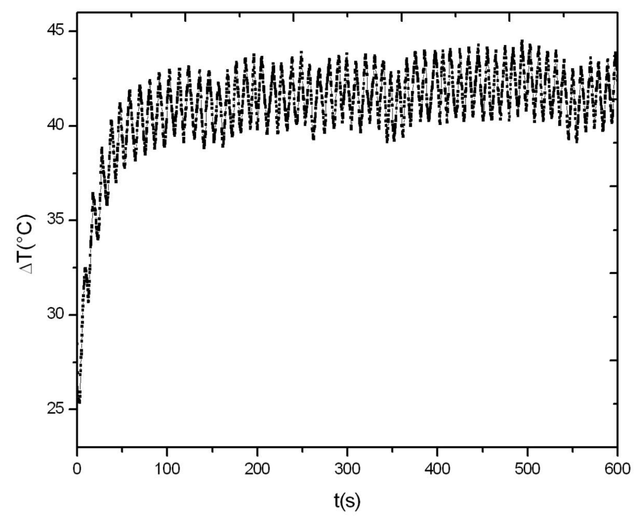

Figure 5. Temperature difference in PTR System, 600s, 0.1 Hz

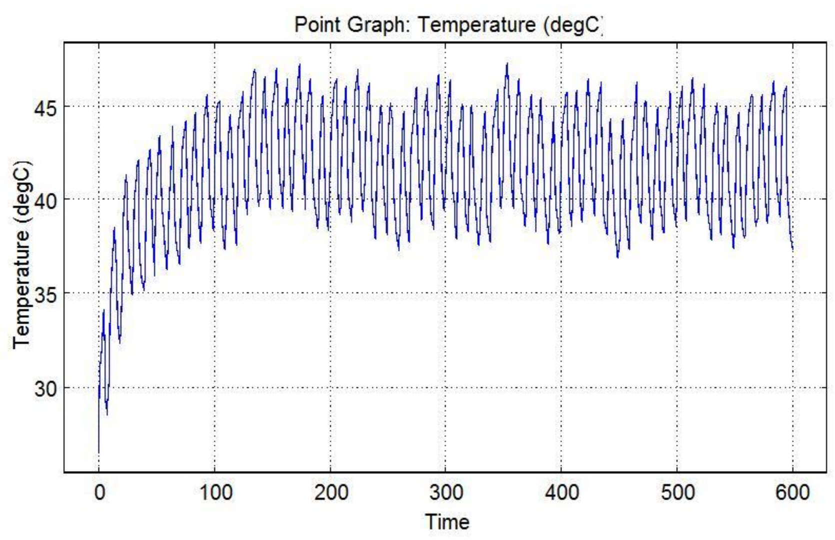

Figure 6. Results of COMSOL 600s, 0.1 Hz

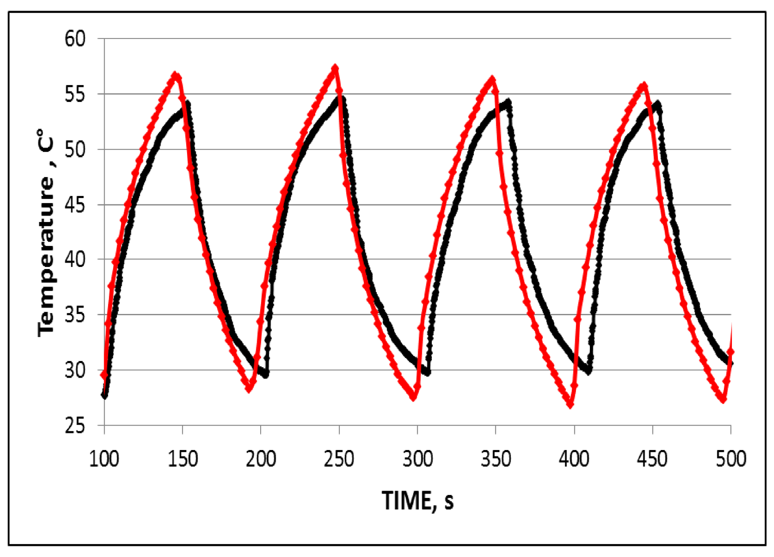

Figure 7. Comparison of results

Conclusions: We obtained a good agree between the experimental and simulated results, showing the utility of the COMSOL simulation in the study of Heat Transfer process in the configuration of the Infrared Photothermal Radiometry technique.

References:

1. E. Gutierrez-Miravete, An Analysis of the Thermal Effects of Focused Laser Beams on Steel, Excerpt from the Proceedings of the COMSOL Conference, Boston (2007).
2. S. Andre, B. Remy, D. Maillet, and A. Degiovanni, J. Modulated photothermal radiometry applied to semitransparent samples: Models and experiments Appl. Phys. 96, 2566 (2004).