Analysis of Heating Processes in Domain of Double-Layered Thin Metal Films Using a Hyperbolic Two-Temperature Model

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KEYWORDS: *Double-Layered Thin Metal Films, Hyperbolic Two-Temperature Model, Laser Pulse, Finite Difference Method.*

The heating of thin double-layered (gold-copper, gold-chromium) film that has been exposed to an ultra-short laser pulse is considered. The system of equations determining the electron and lattice temperatures, as well as the dependences between the intensities of the heat fluxes and the temperature gradients in which the phase lag appears, for the first and second layer, respectively, provide the mathematical foundation for the description of this process (a hyperbolic two-temperature model) [1]. In the first version, a condition of perfect contact at the interface of layers was assumed, while in the second version, a condition of imperfect contact was adopted. A no-flux condition was accepted on the external surfaces. The initial condition is also known.

The main goal of the work is the correct wording of the mathematical form of ideal and imperfect contact conditions for hyperbolic two-temperature model presented here. In literature, the conditions of ideal or imperfect contact corresponding to the macroscopic Fourier model is most often applied, which does not take into account the relaxation time of free electrons in metals and the relaxation time in phonon collisions.

The finite difference method's implicit scheme is used to solve the issue [2]. Comparisons were made between the solutions obtained using the hyperbolic and parabolic models (Figure 1) and on this basis appropriate conclusions were formulated.

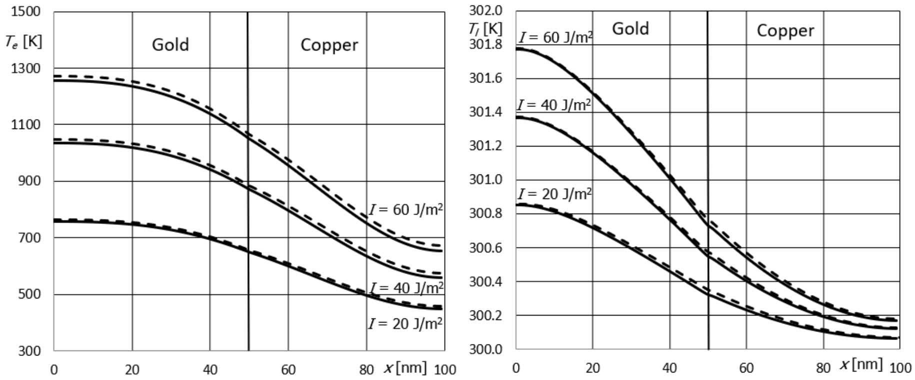

Figure 1. The distribution of temperature of: a) electrons, and b) lattice after 0.3 ps, $t_p = 0.1$ ps for hyperbolic ideal contact condition (solid lines) and parabolic ideal contact condition (dashed lines)

ACKNOWLEDGEMENT: The research was founded from financial resources from the statutory subsidy of the Faculty of Mechanical Engineering, Silesian University of Technology.

[1] Z.M. Zhang, Nano/Microscale Heat Transfer, McGraw-Hill, New York, 2007

[2] J.Dziatkiewicz, E.Majchrzak, *JTAM*, **62** (2), 405-413, 2024. https://doi.org/10.15632/jtam-pl/185352