Simulating a laser heatsink design made from aluminum and copper using FEATool

Ammiel S. Majan[1], Mary Diane A. Pilapil, Rommel G. Bacabac, Ph.D.*
Medical Biophysics Group, Department of Physics, University of San Carlos, Nasipit, Talamban, Cebu City 6000
[1]19104696@usc.edu.ph
*Corresponding Author: rgbacabac@usc.edu.ph

Introduction

Mechanical movement of the fans used to actively cool lasers can reduce laser stability. However, a cooling system is essential because heat in the laser will damage the diode, reducing its lifespan. By putting the laser in contact with a thermally conductive material, the laser may be passively cooled. This study simulates three heatsink designs made from either copper or aluminum for passive laser cooling.

Methodology

Two subdomains were created, (1) the laser as a steel block and (2) the heatsink with varied material and design. A 10-minute heat flux simulation was done with an initial laser temperature of 30°C and initial heatsink temperature of 20°C. The volume-averaged temperature was calculated from the integral of the subdomain's temperature over its volume.

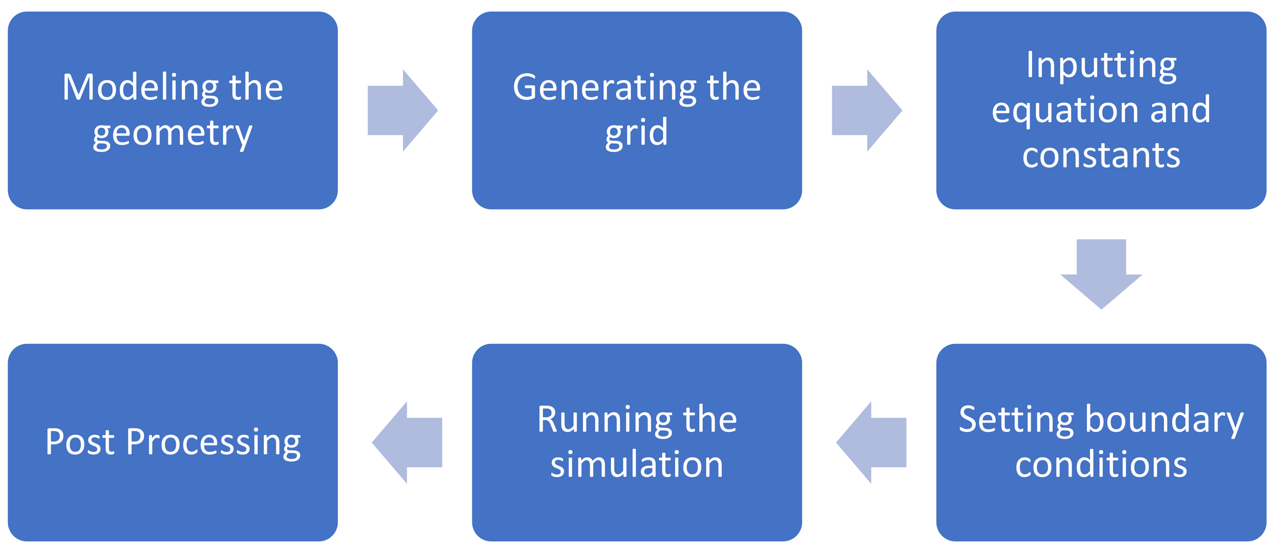

Figure 1. Simulation process flow chart

Heat Transfer (eq. 1) was used under the equations tab while Prescribed Heat Flux Equation was used for all boundaries (eq. 2). $\boldsymbol{u}$ and $Const$ were set to 0.

$$\rho C_P T' + \nabla \cdot (-K\nabla T) + \rho C_p \boldsymbol{u} \cdot \nabla T = Q \qquad \textit{eq. 1}$$

$$-\boldsymbol{n} \cdot \left(k\nabla T + \rho C_p \boldsymbol{u} T\right) = q_0 + h \cdot \left(T_{inf} - T\right) + Const \cdot \left(T_{amb}^4 - T^4\right) \qquad \textit{eq. 2}$$

Results and Discussion

A simulation was run using the time-dependent solver. Post processing was done to get the minimum and maximum temperature and the temperature density.

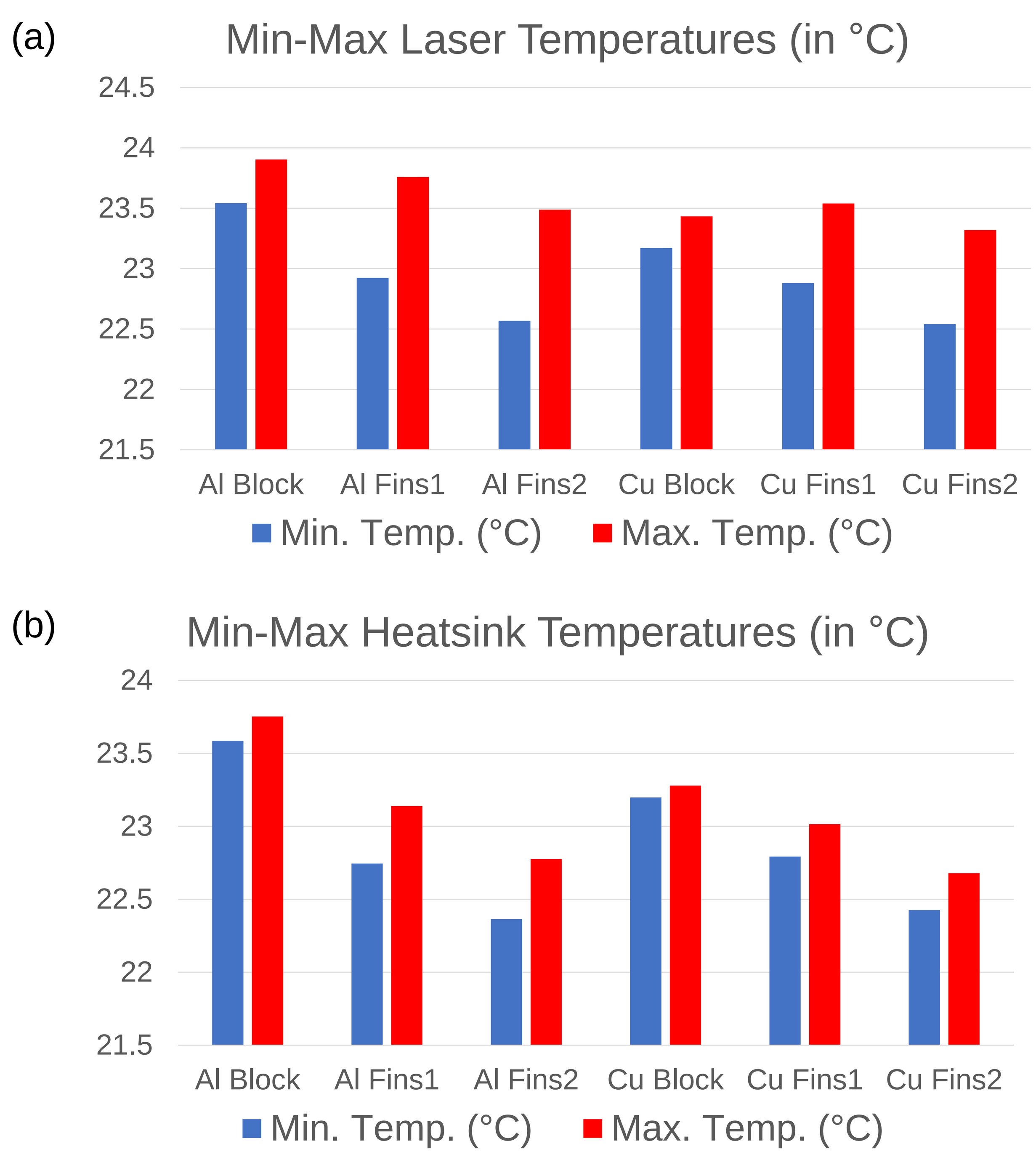

Figure 2. Minimum and maximum temperatures for (a) Laser and (b) Heatsink for the three heatsink designs

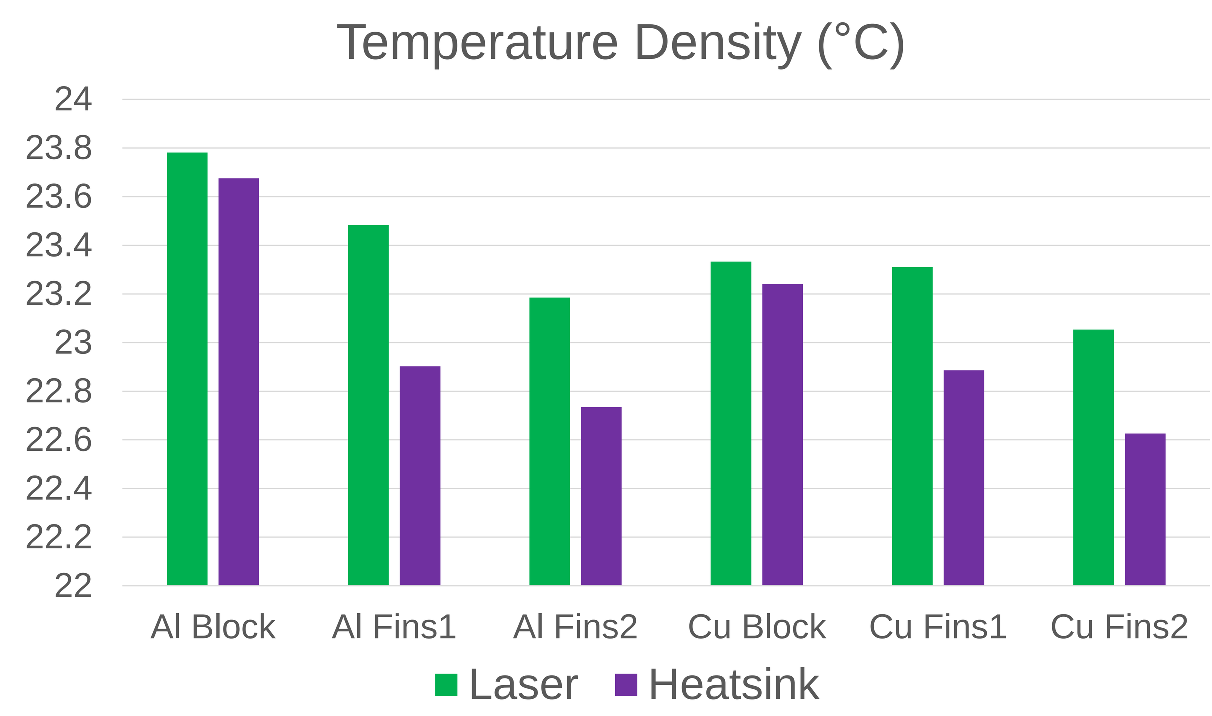

Figure 3. Temperature density of laser (green) and heatsink (violet) for the three heatsink designs

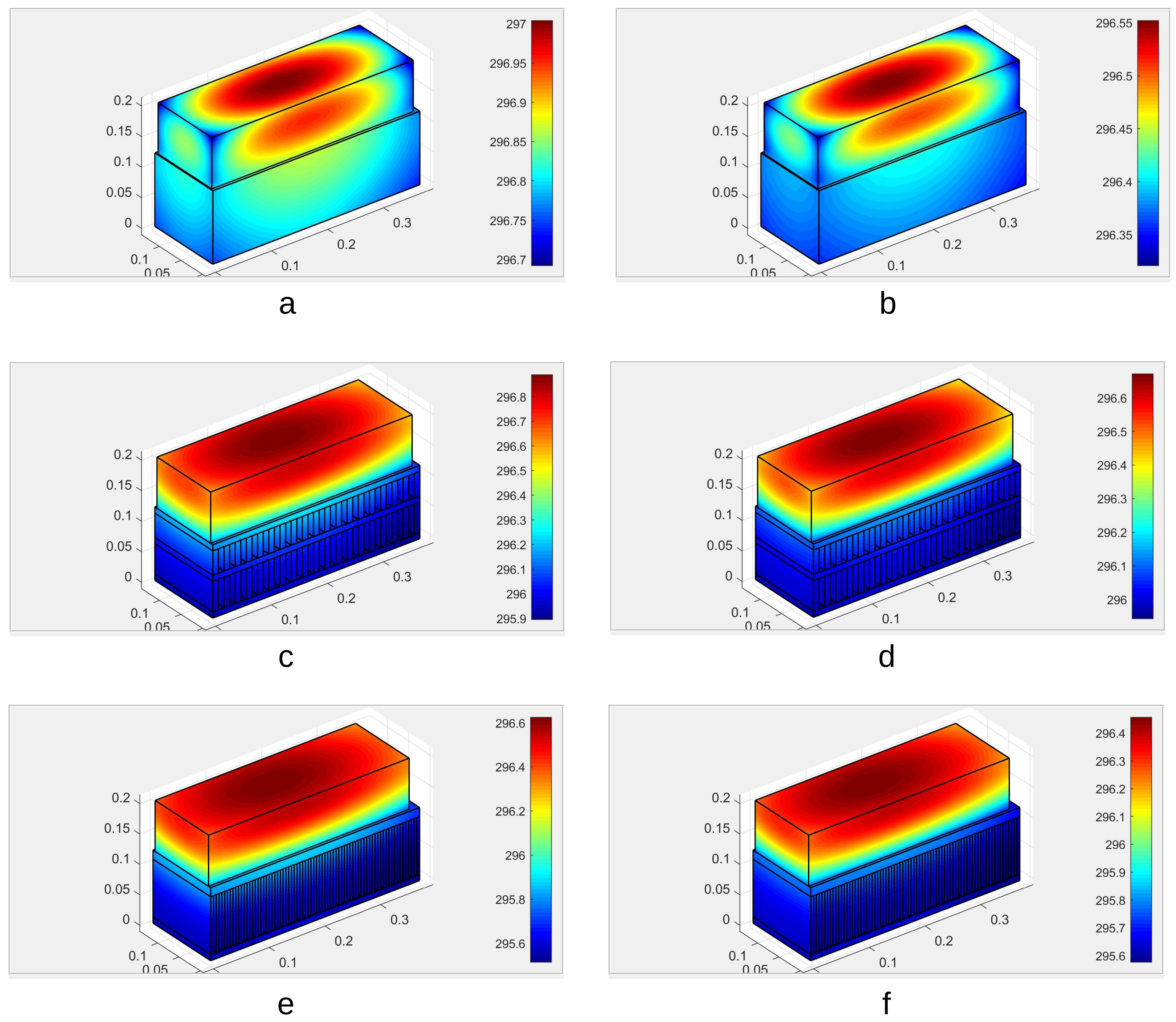

Figure 4. Results after a 10 minutes simulation for (a) Aluminum Block; (b) Copper Block; (c) Aluminum Fins1; (d) Copper Fins1; (e) Aluminum Fins2; (f) Copper Fins2

Results returned lower temperatures for the designs made of copper. This implied that copper, which has a higher thermal conductivity compared to aluminum, is a better material for heatsinks since it can dissipate heat better.

The block heatsink design proved to be least efficient in dissipating heat. It returned the highest temperature density and min-max temperatures. The fins designed were able to quickly dissipate the heat causing them to retain a temperature close to the set bulk temperature of 22°C. The fins2 design which had the highest surface area had the lower temperatures implying better cooling and faster heat dissipation from the heatsink.

Conclusion

Results show that materials with high thermal conductivity and designs with bigger surface area allow faster heat conduction and dissipation to the room temperature without the use of fans.

Acknowledgment

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