Mathematical modeling of thermal loads of x-ray adaptive optics materials

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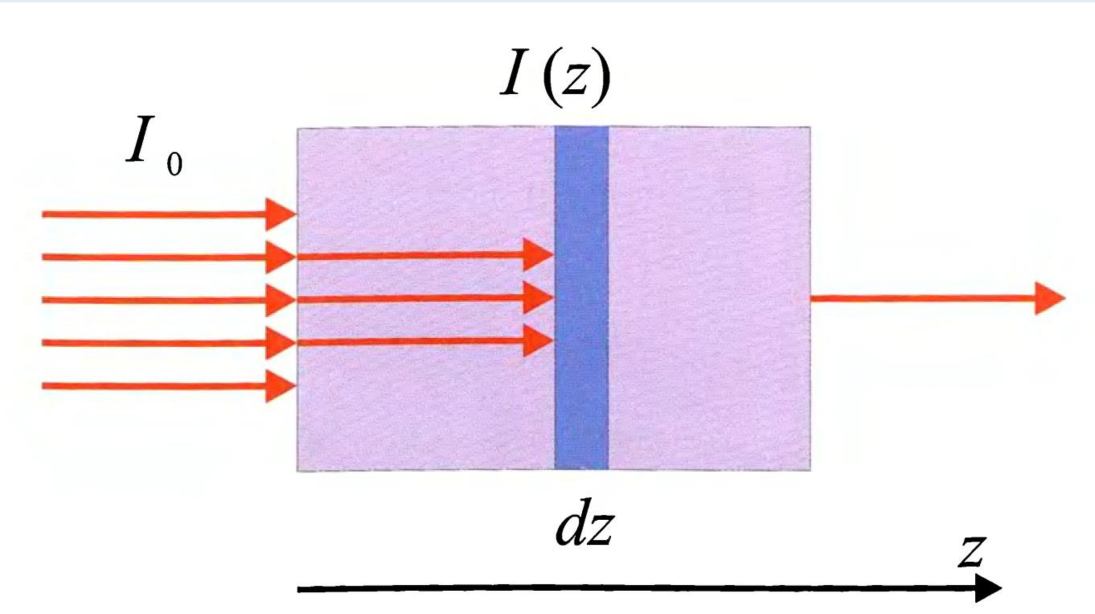
The X-rays interaction physics with matter (heat release)

Photoelectric absorption

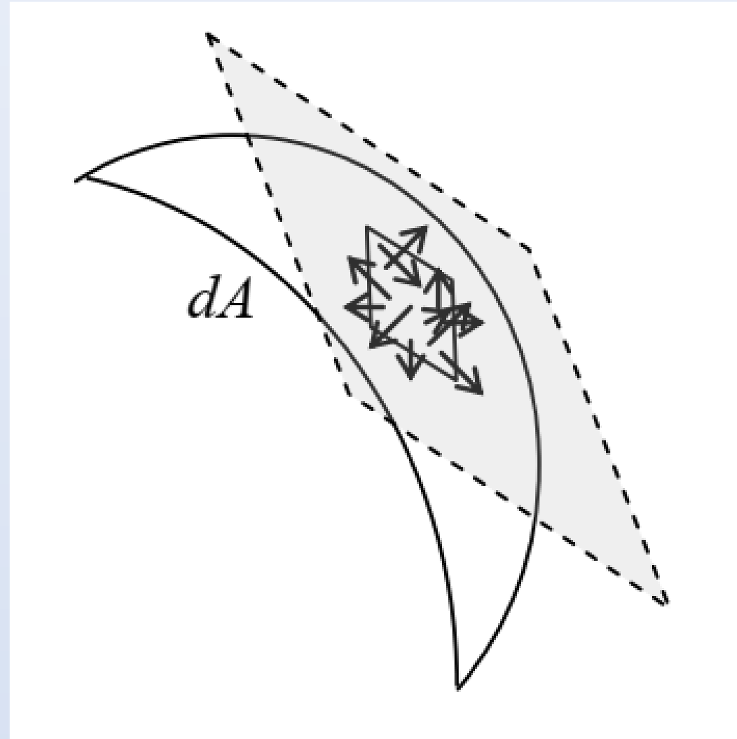


$$P = P_0 \exp(-\mu z)$$

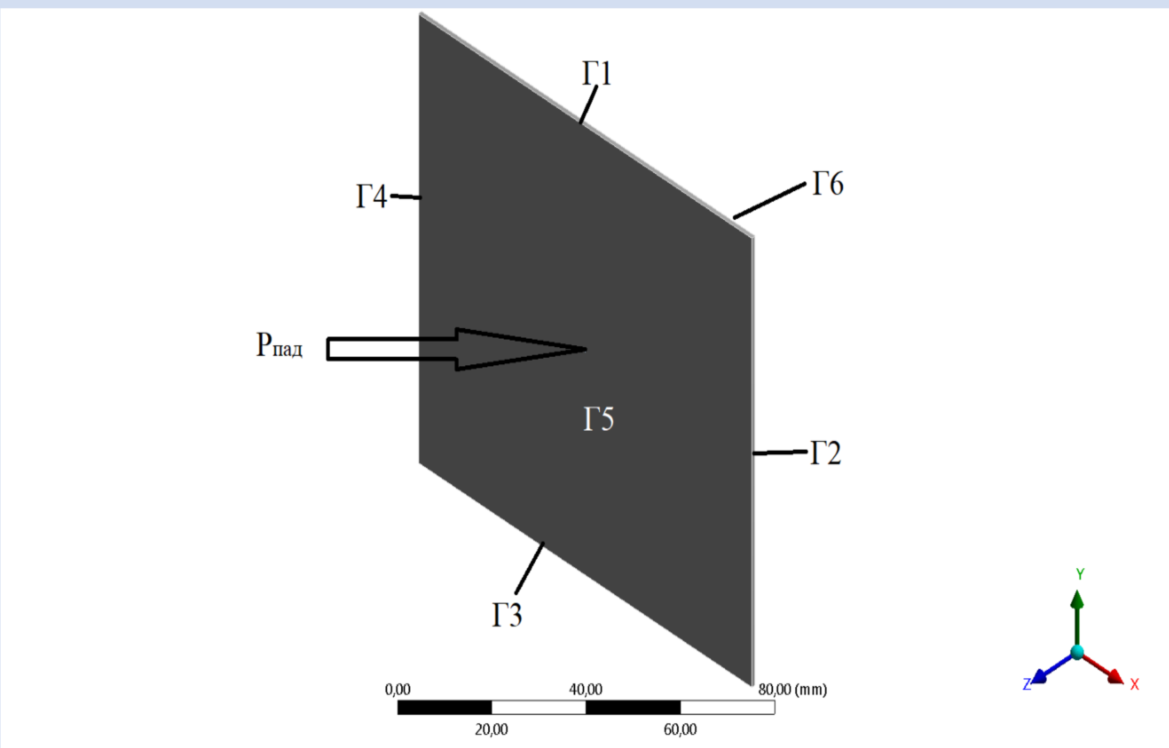
$$P_{abs} = AP_{init} \exp\left(-\frac{x^2}{\sigma_x^2} - \frac{y^2}{\sigma_y^2}\right)$$

$$P_{abs} = AP_{init} \exp\left(-\frac{x^2}{\sigma_x^2} - \frac{y^2}{\sigma_y^2} - \mu z\right)$$

Radiative heat transfer



The mathematical formulation of the problem



Fourier heat equation

$$\lambda \nabla T = -AP_{init} \exp\left(-\frac{x^2}{\sigma_x^2} - \frac{y^2}{\sigma_y^2} - \mu z\right)$$

Initial condition

$$T|_{\Gamma 1} = T|_{\Gamma 2} = T|_{\Gamma 3} = T|_{\Gamma 4} = T|_{\Gamma 5} = T|_{\Gamma 6} = T_0 = 22\ ^{o}C$$

Boundary condition

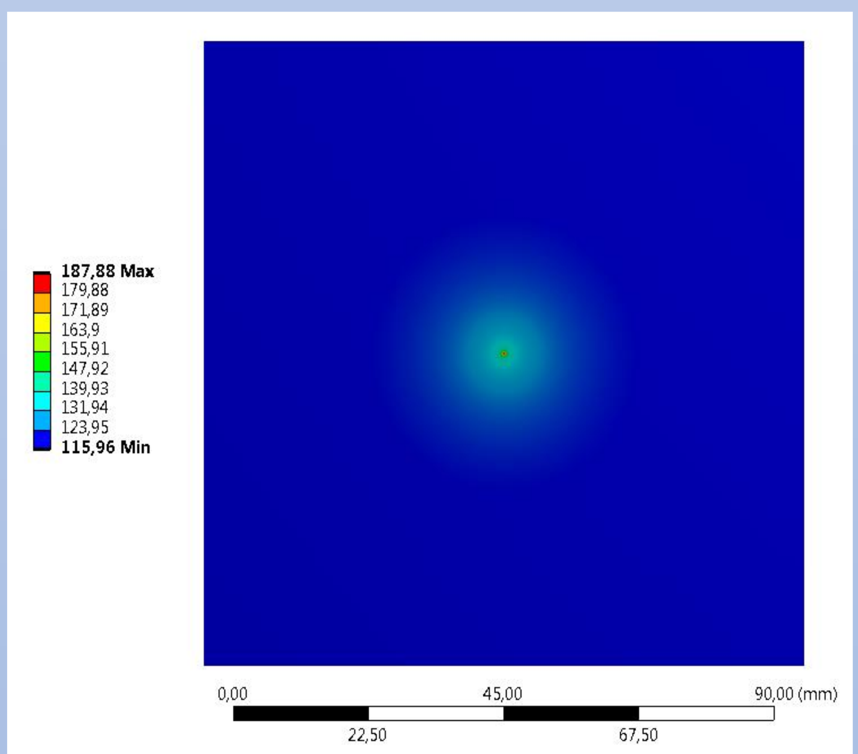
$$P|_{\Gamma 1} = P|_{\Gamma 2} = P|_{\Gamma 3} = P|_{\Gamma 4} = P|_{\Gamma 5} = P|_{\Gamma 6} = 5*10^{-6}\ W/mm^2$$

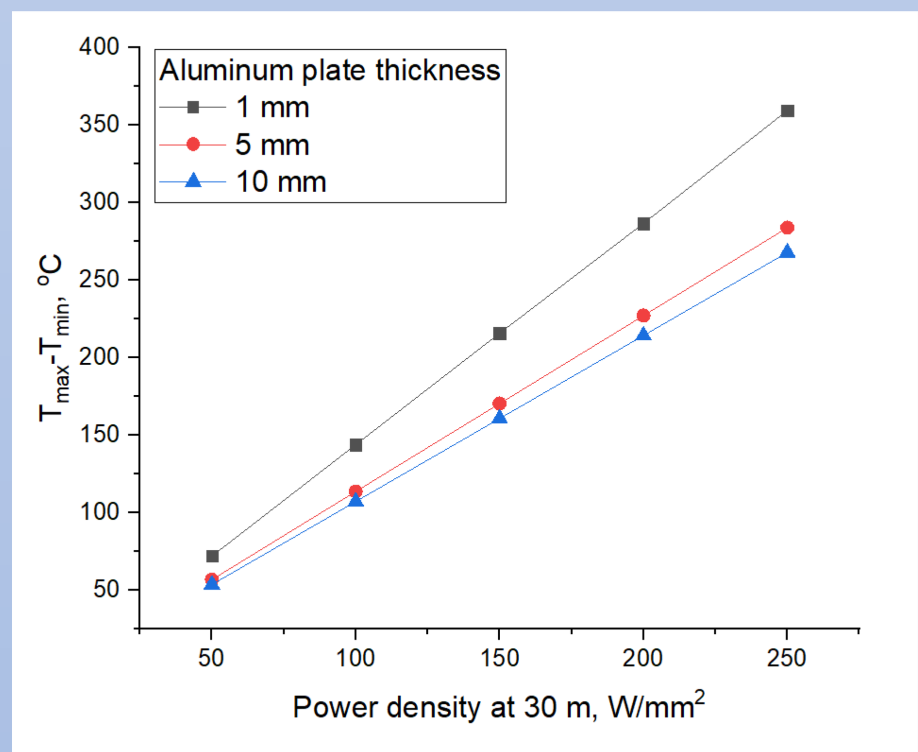
$$P|_{\Gamma 1} = P|_{\Gamma 2} = P|_{\Gamma 3} = P|_{\Gamma 4} = P|_{\Gamma 5} = P|_{\Gamma 6} = \sigma * T^4\ W/mm^2$$

Material	Wavelength, A	Material absorption coefficient, mkm^{-1}
Aluminum	1	$3.5*10^{-3}$
	0.5	$4.191*10^{-4}$
	0.25	$4.718*10^{-5}$
Beryllium	1	$3.992*10^{-5}$
	0.5	$3.954*10^{-6}$
	0.25	$3.646*10^{-7}$
Diamond	1	$3.564*10^{-4}$
	0.5	$3.460*10^{-5}$
	0.25	$3.756*10^{-6}$
UHWPE	1	$8.178*10^{-5}$
	0.5	$7.935*10^{-6}$
	0.25	$8.614*10^{-7}$

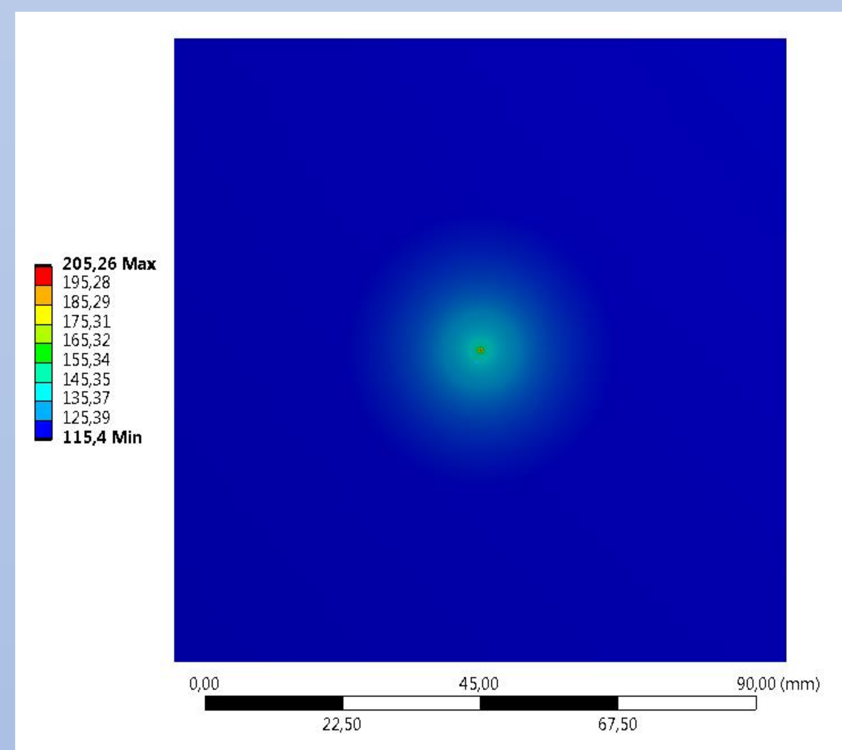
Results

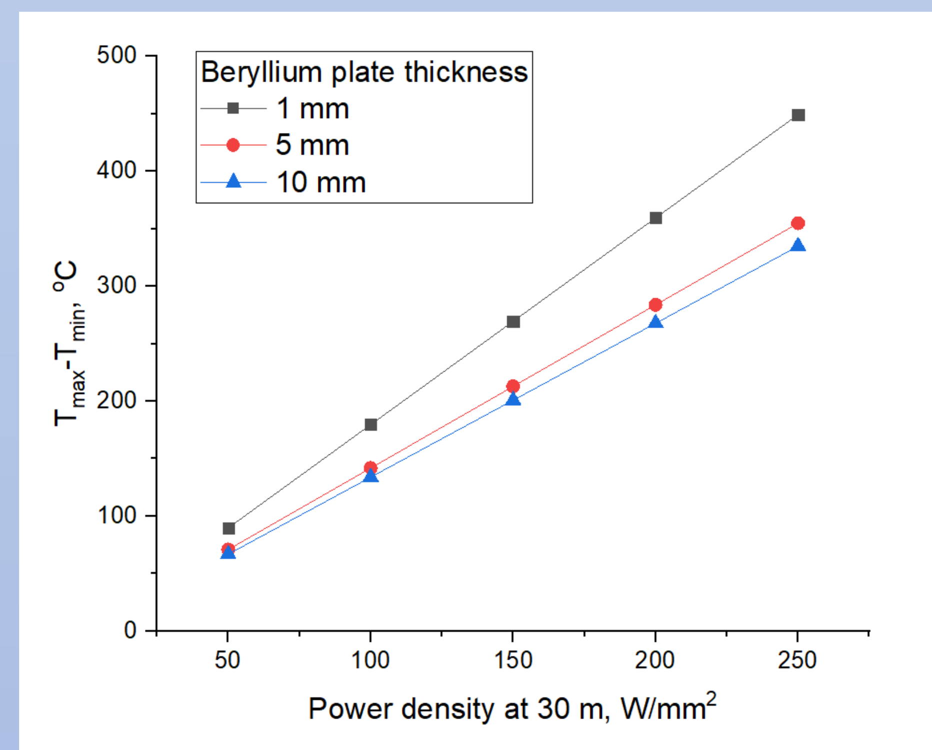
Aluminum



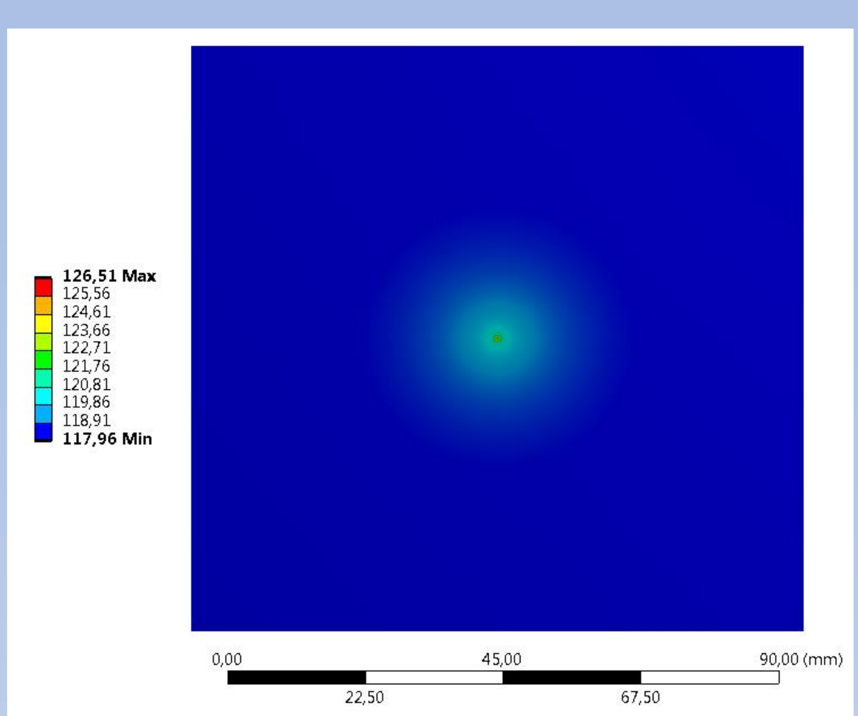


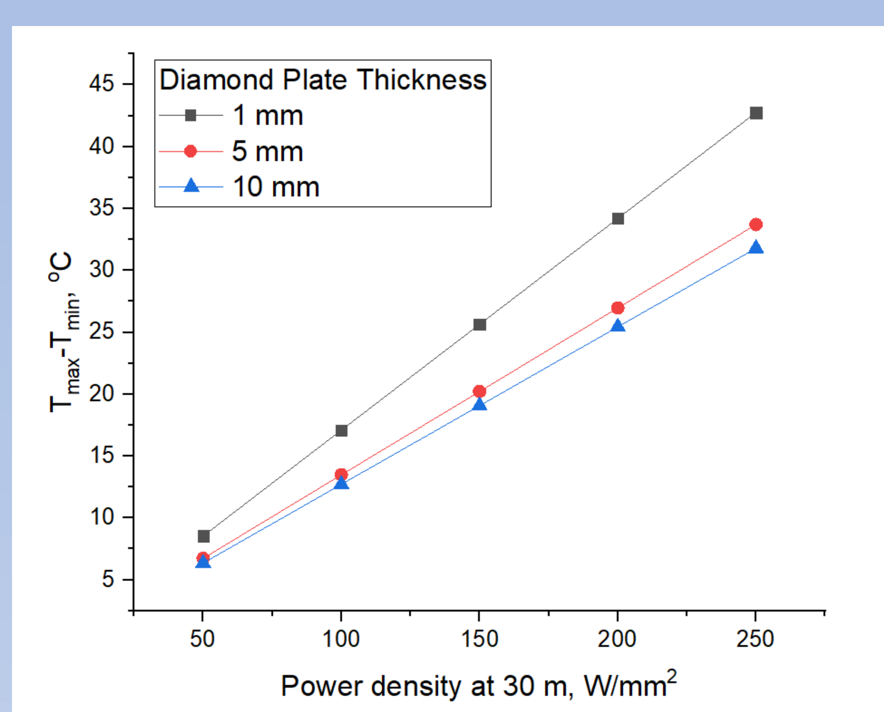
Beryllium



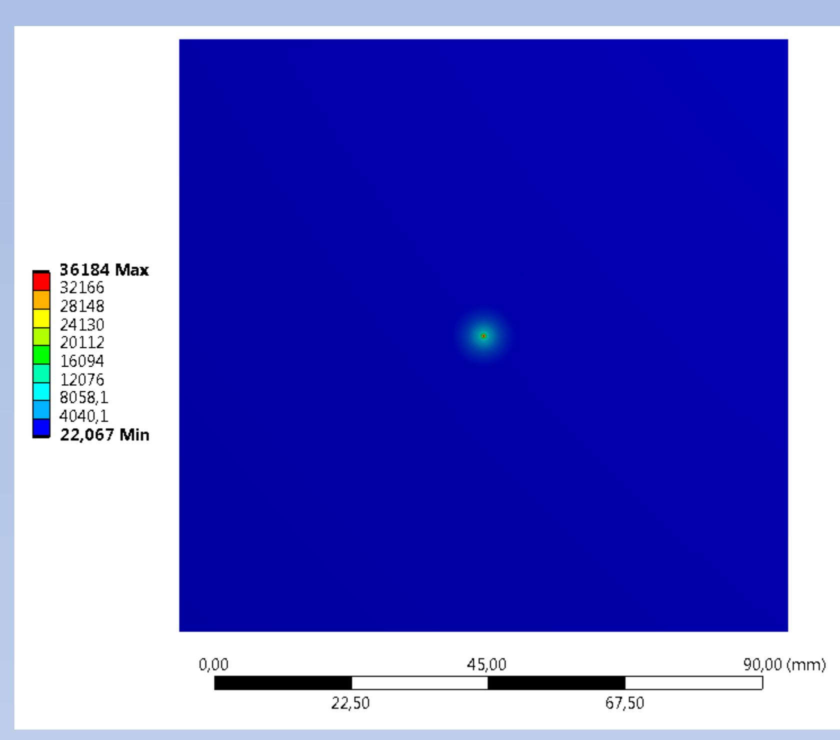


Diamond





UHMWPE



With this formulation of the problem and experimental conditions, the UHWPE plate is burned through

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