Heat Transfer for Thermal Properties

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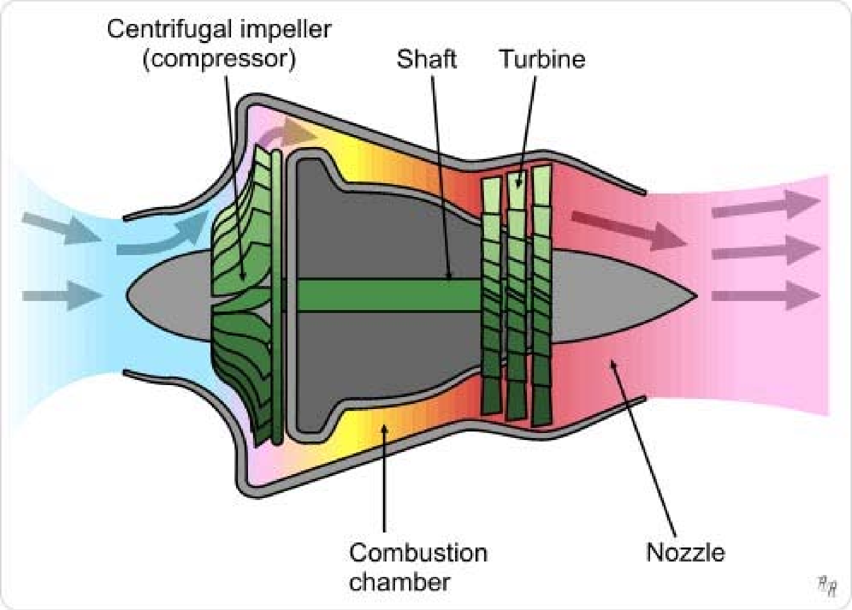
The Problem

Power Plant

Nd.edu

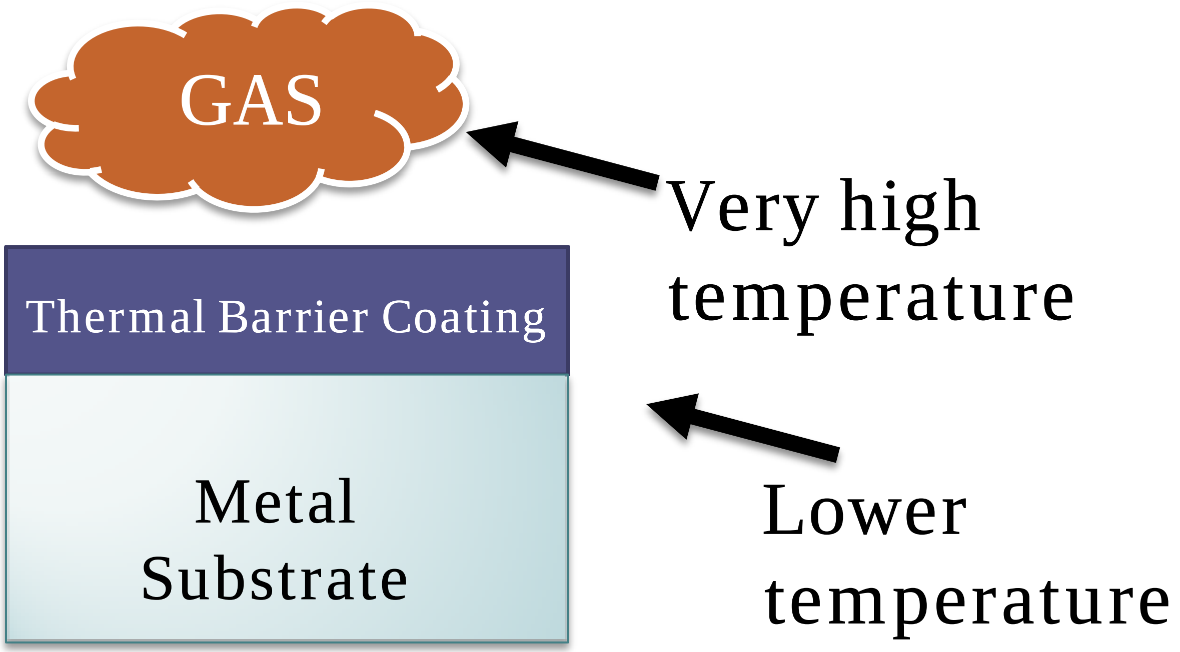
Jet Engine



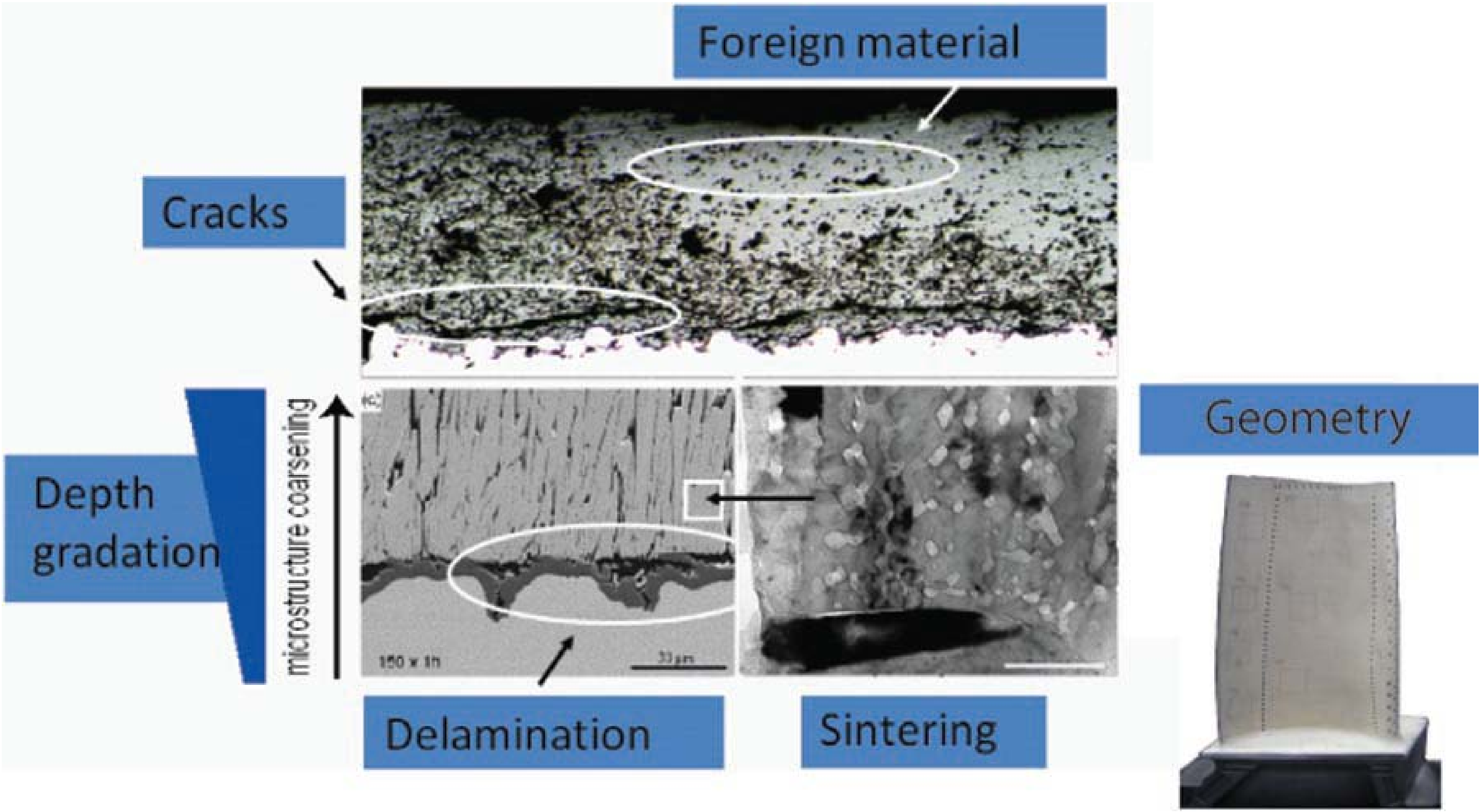
hubpages.com

Solution: Thermal Barrier Coatings

- Protect components in high temperature environments from thermal damage, increasing efficiency



Challenges with Thermal Barrier Coatings



Our Goals

- Gain familiarity with heat transfer equations to better understand Thermal Barrier Coatings

- Determine the thermal conductivity of:
    - Brass
    - Aluminum
    - Steel

Heat Transfer Equation: Fourier's Law

$$q'' = -k\frac{\Delta T}{\Delta x}$$

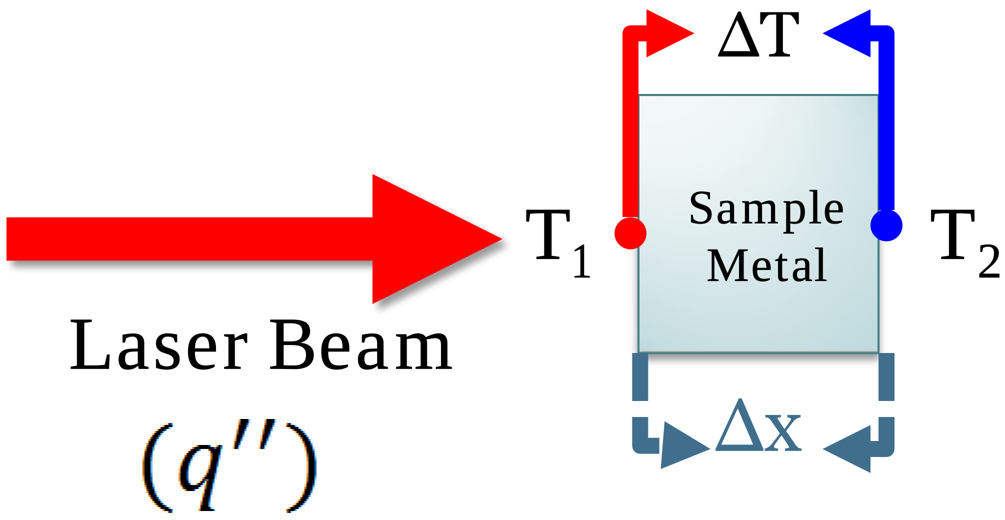
Heat Flux Rate

Thermal Conductivity

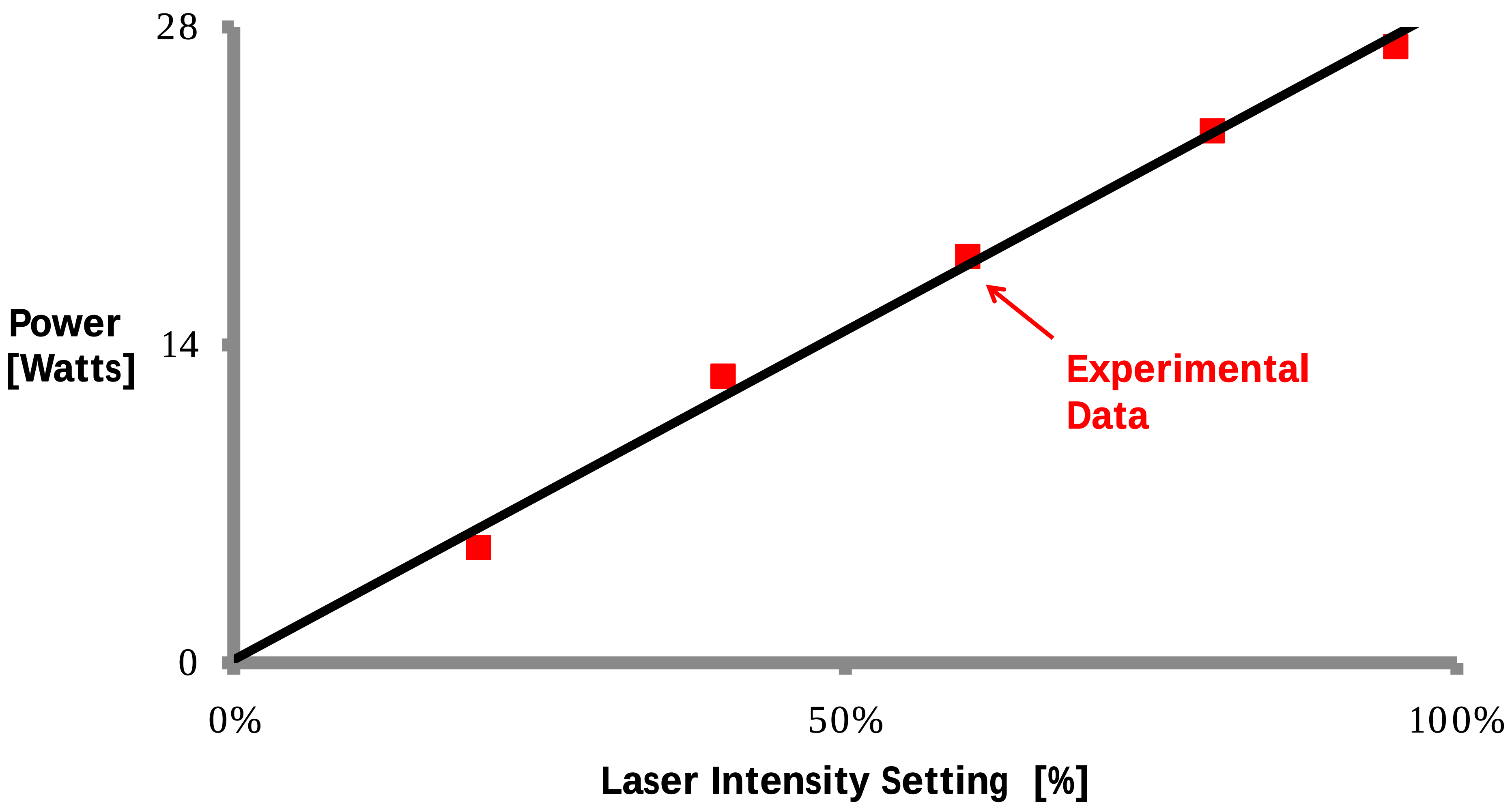
Temperature Gradient

Determining thermal conductivity

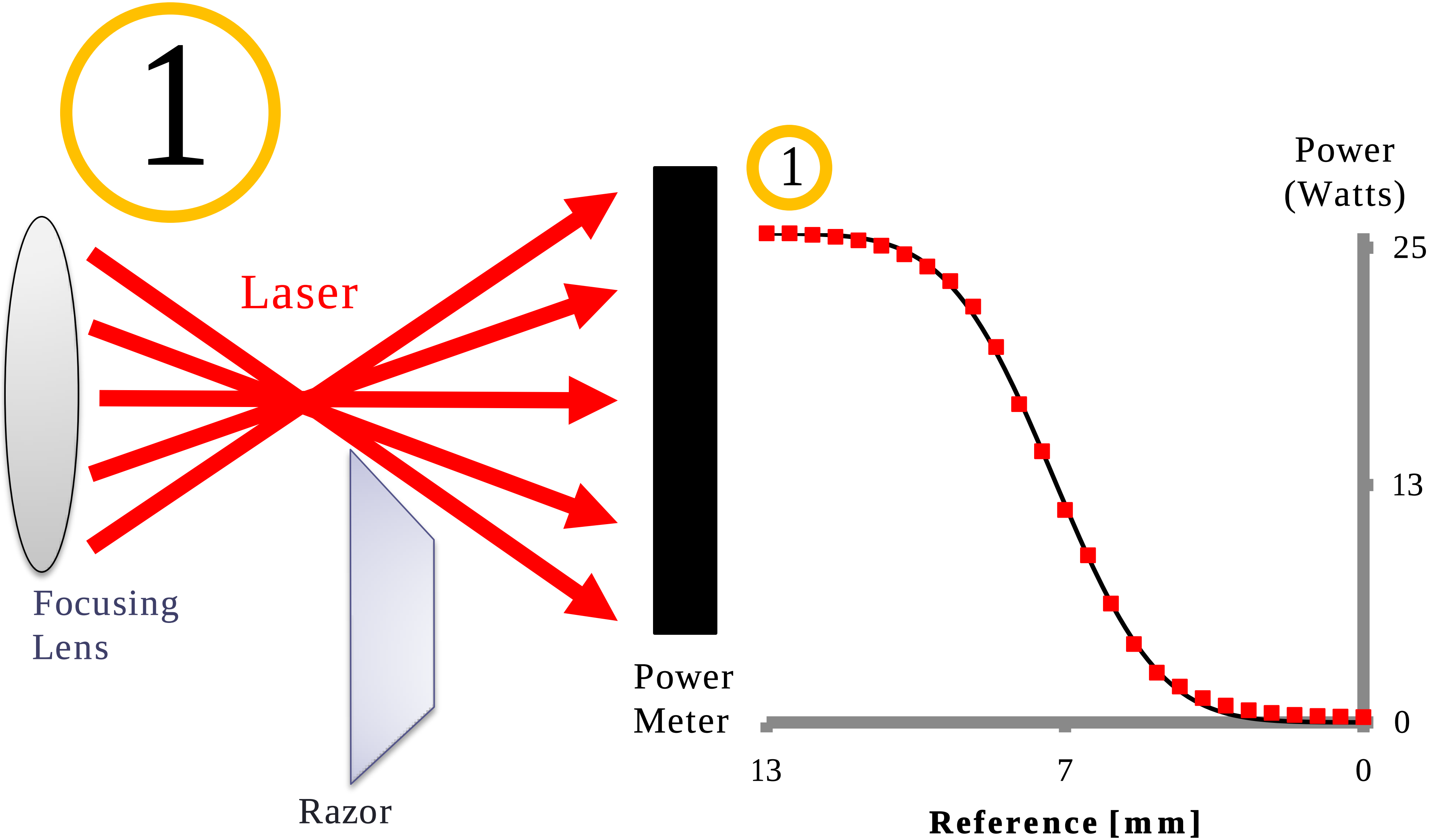
$$q'' = -k\frac{\Delta T}{\Delta x} \Rightarrow k = {-q''}\Big/\left(\frac{\Delta T}{\Delta x}\right)$$



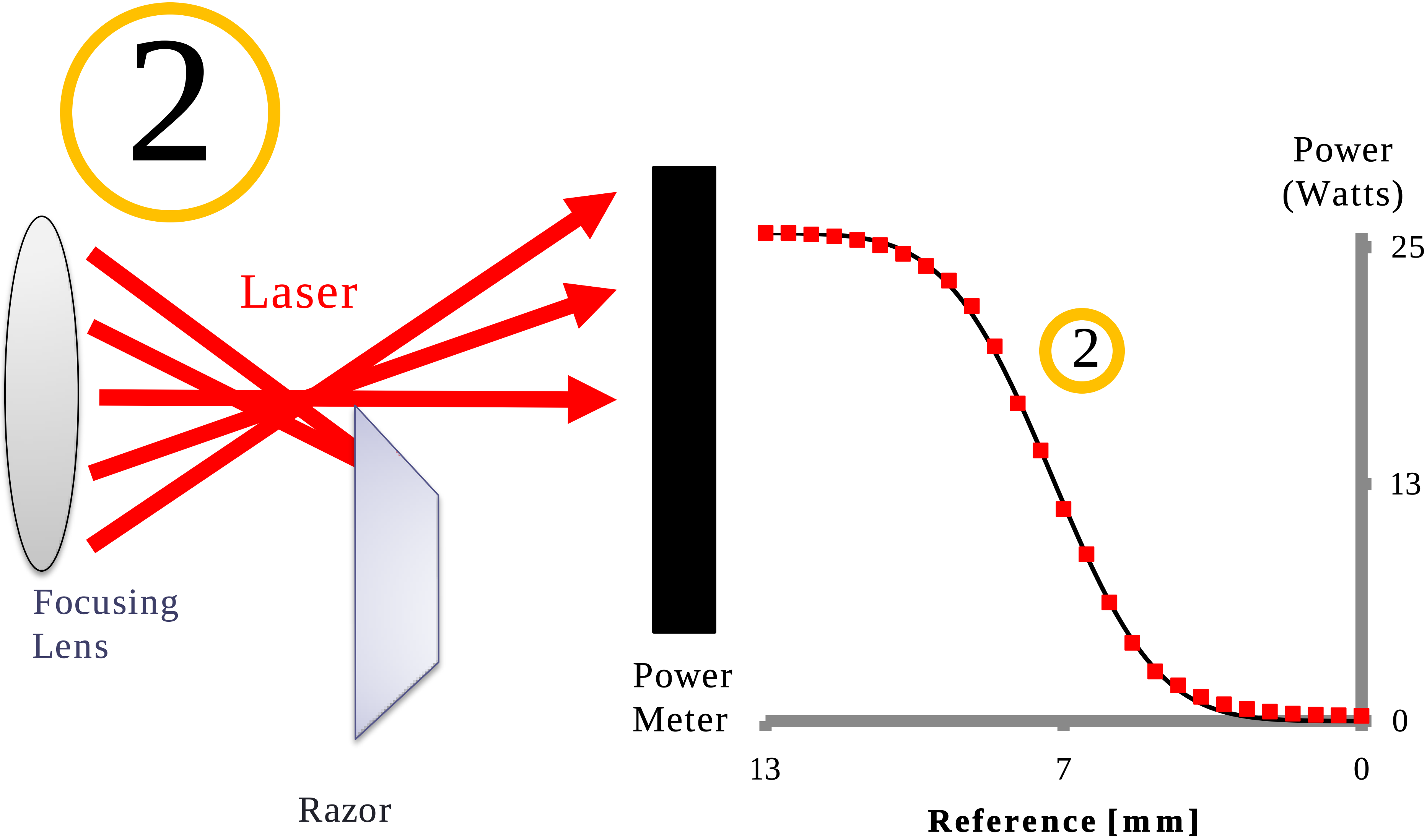
Laser Power vs. Intensity Setting



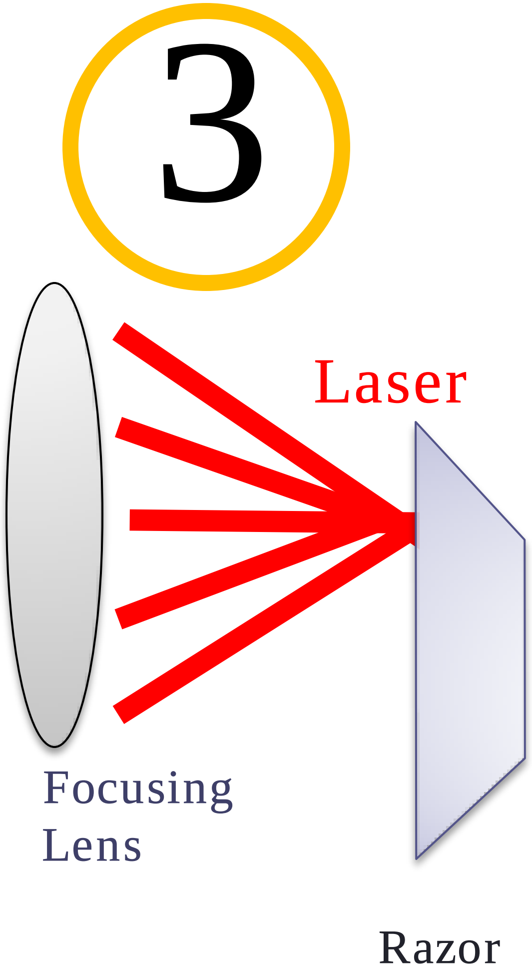
Laser Beam Characterization (q'')

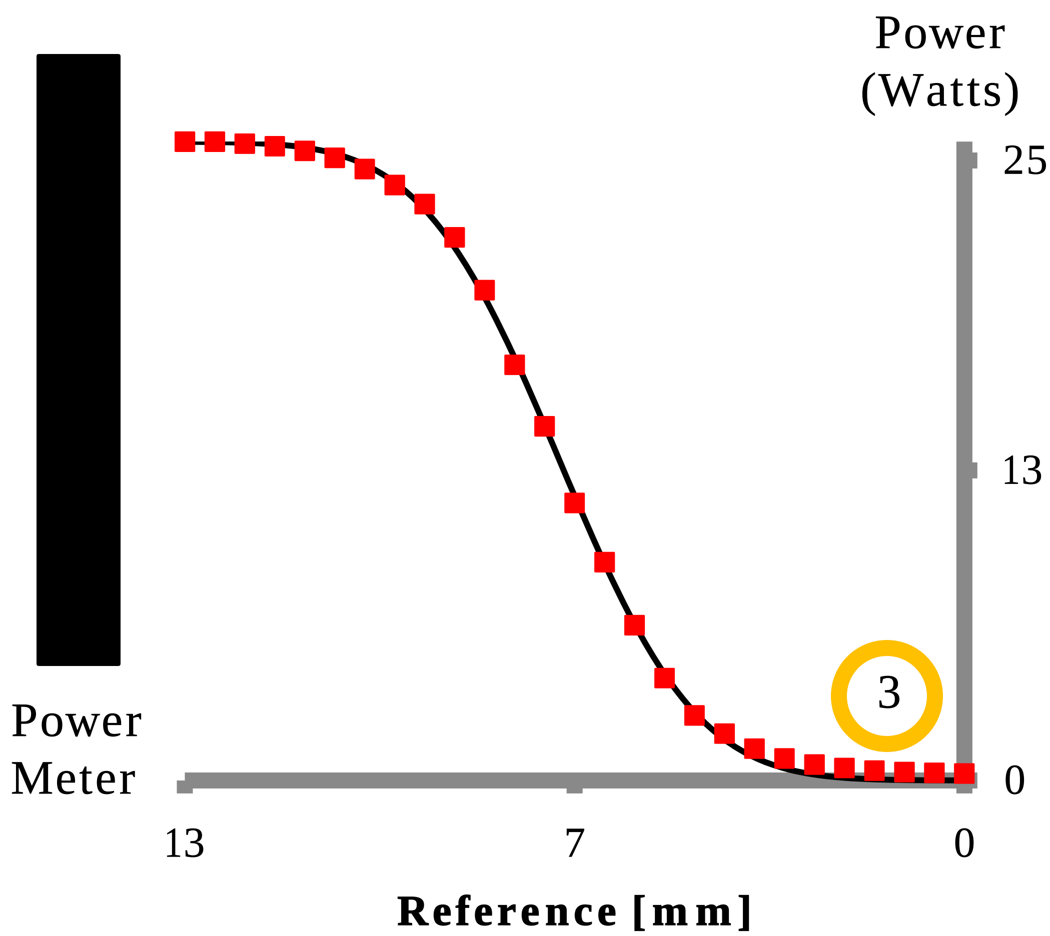


Laser Beam Characterization (q'')



Laser Beam Characterization (q'')



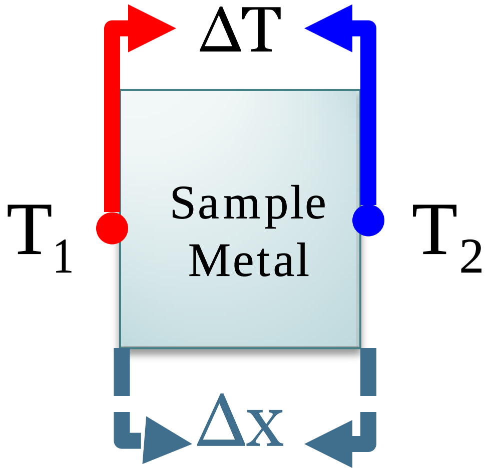


Determining Heat Flux Rate

$$k = \frac{-q''}{\left(\frac{\Delta T}{\Delta x}\right)}$$

Surface Area: 20.5 mm^2

q"= 1257 kW/ m^2



Results

Aluminum
k = 191 W / m K
% Error = 18%

Brass
k = 121 W / m K
% Error = 4.3%

Steel
k = 43 W / m K
% Error = 65%

What We Learned

- Thermal barrier coatings & their importance
- Fourier’s Law & Its Implementation

A Special Thank You To…

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- Ted Bennet
- SIMS Staff & the RA's