# Modeling of Target Radiation Heating

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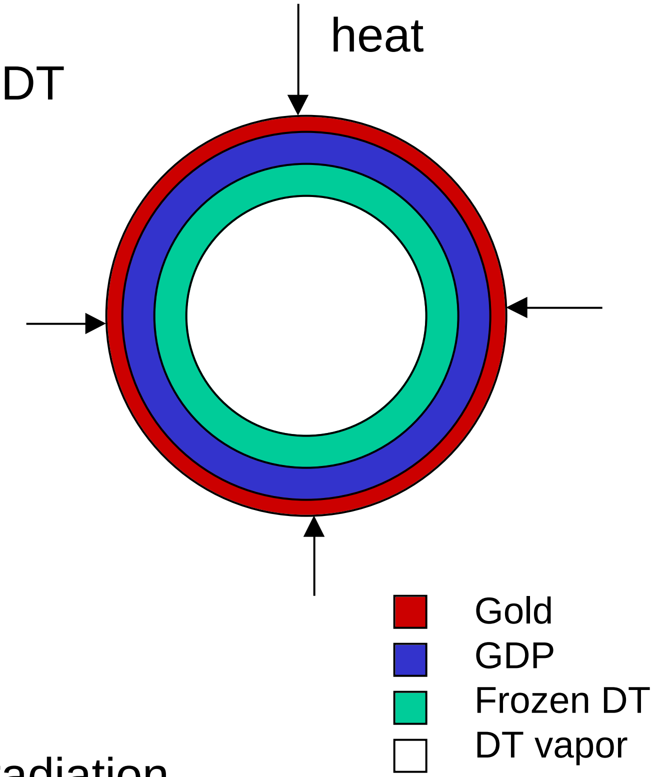
# OUTLINE

- Overview
- Modeling Approach
- Initial Results for Au/GDP/Si Target
- Future Plans

# Radiation Target Heating - An Overview




- Target composition : Au / GDP / solid DT / vapor DT

- Minimize target heating inside chamber before beam irradiation : $T_{fuel}$ < DT triple point (21 K)

- Sombrero study showed :

  Radiation heating from chamber wall
  >> Convective heat transfer from chamber gas

- Target is illuminated by heat radiation uniformly.

- Radiation heat load is assumed to be from black radiation power produced by chamber wall at temperature $T_W$:

$$e_b = \sigma T_W^4$$

where σ is Stefan-Boltzmann constant.

# Development of Analysis Tool, TARAH

- Objective is to analyze radiation heating of inertial fusion target during injection and before beam (laser or HI) irradiation. Specifically calculate:
  (1) Power reflectivity on target
  (2) Local power deposition on various layers.

- Assume incident black body radiation spectrum:

$$i'_{\lambda b}(\lambda, T) = 2C_1 / \lambda^5 (e^{C_2/\lambda T} - 1)$$

- Include both S- and P-polarization components. Assuming random polarization mix, we have for reflectivity:

$$R = 0.5 ( R_S + R_P )$$

- Calculate reflectivity averaged over incident angles by

$$\langle R \rangle_\theta = 2\int_{\theta=0}^{\pi/2} R(\theta)\sin\theta\cos\theta\, d\theta$$

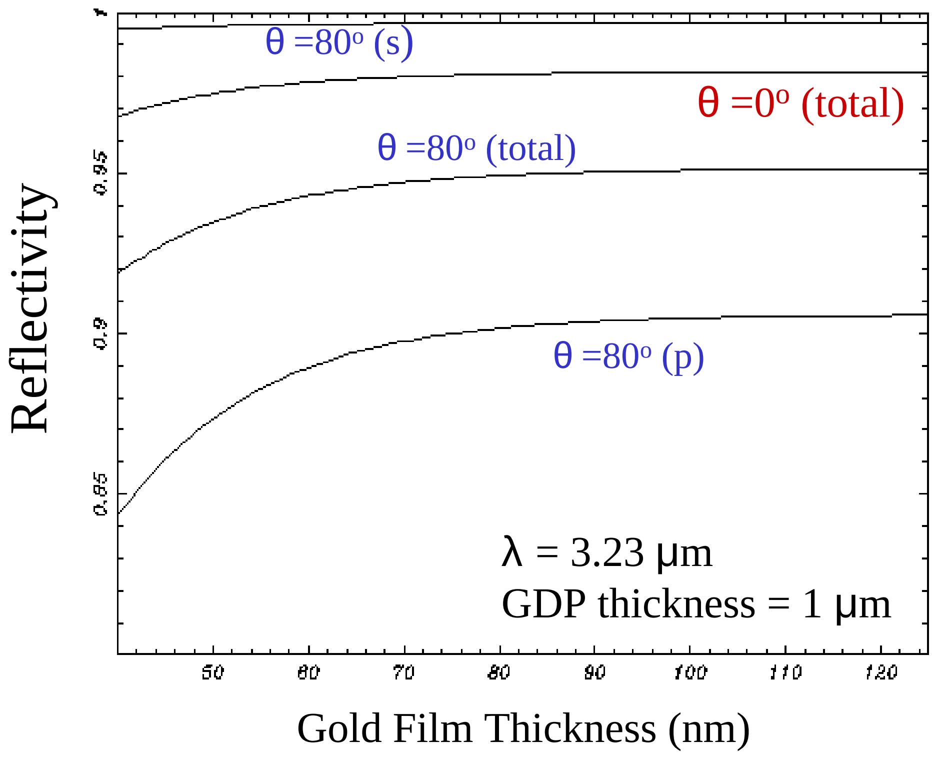
- Integrate over radiation spectrum to obtain total reflectivity:

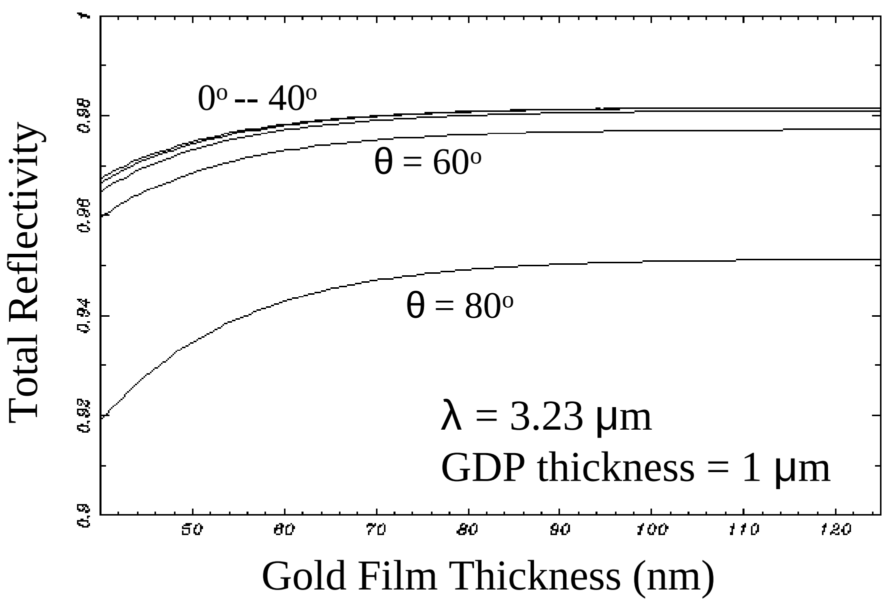
$$(T) = \pi \int_0^\infty d\lambda \langle R \rangle_\theta i'_{\lambda b}(\lambda, T) \Big/ \sigma T_W^4$$

# Target Reflectivity for S- and P-Polarization of Incident Radiation

- The target shell is composed of Au/GDP/Si(DT). At a wall temperature of 625$^{o}$C, blackbody radiation intensity is peaked at $\lambda$ = 3.23 μm.

- To calculate reflectivity for p-polarization, we substitute $n_j \cos \theta_j$ in Fresnel formulae for S-polarization by $\cos \theta_j / n_j$, and define total reflectivity as $R = (R_s + R_p)/2$.

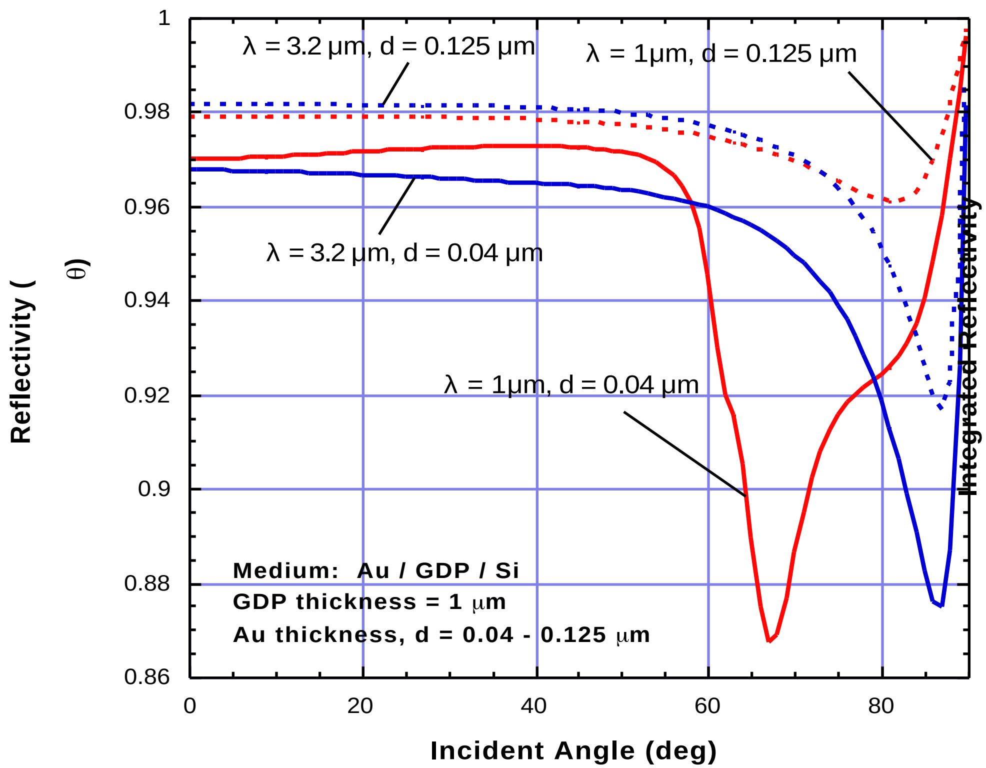


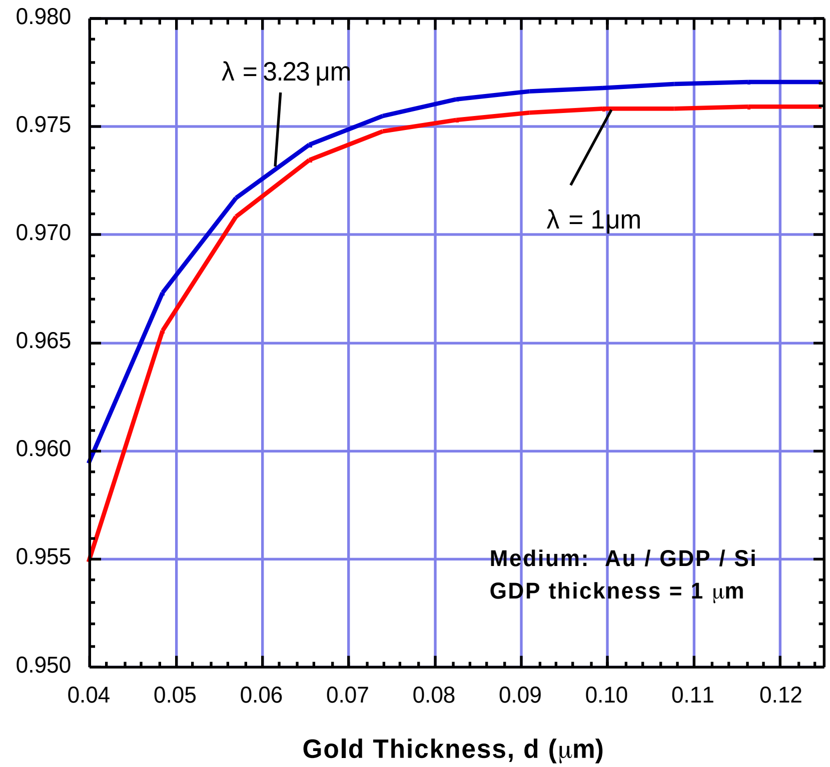



# Target is Highly Reflective in the Infrared Spectrum With Gold Film Thickness > 0.04μm

- Reflectivity (S+P polarization) exhibits minimum as $\theta_{inc} \longrightarrow 90^o$ for polymer thickness of 1 μm.

- Angle-averaged reflectivity variation with gold thickness is similar for λ = 1, 3.2 μm; rises and levels off at <R> = 0.976 as d $\longrightarrow$ 0.1 μm.

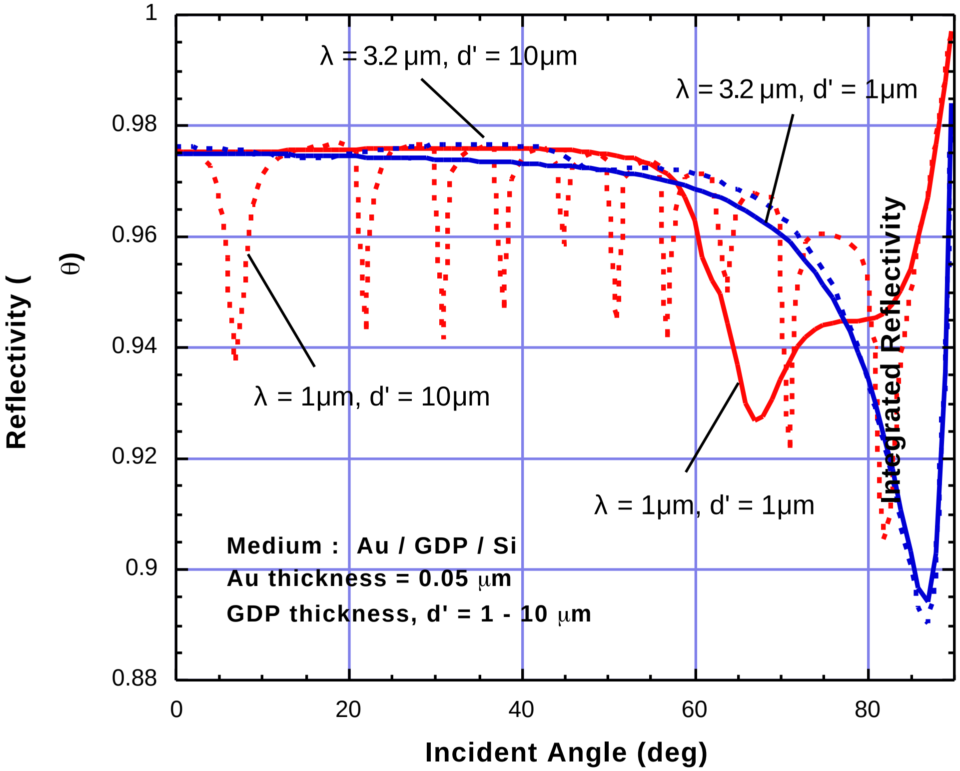


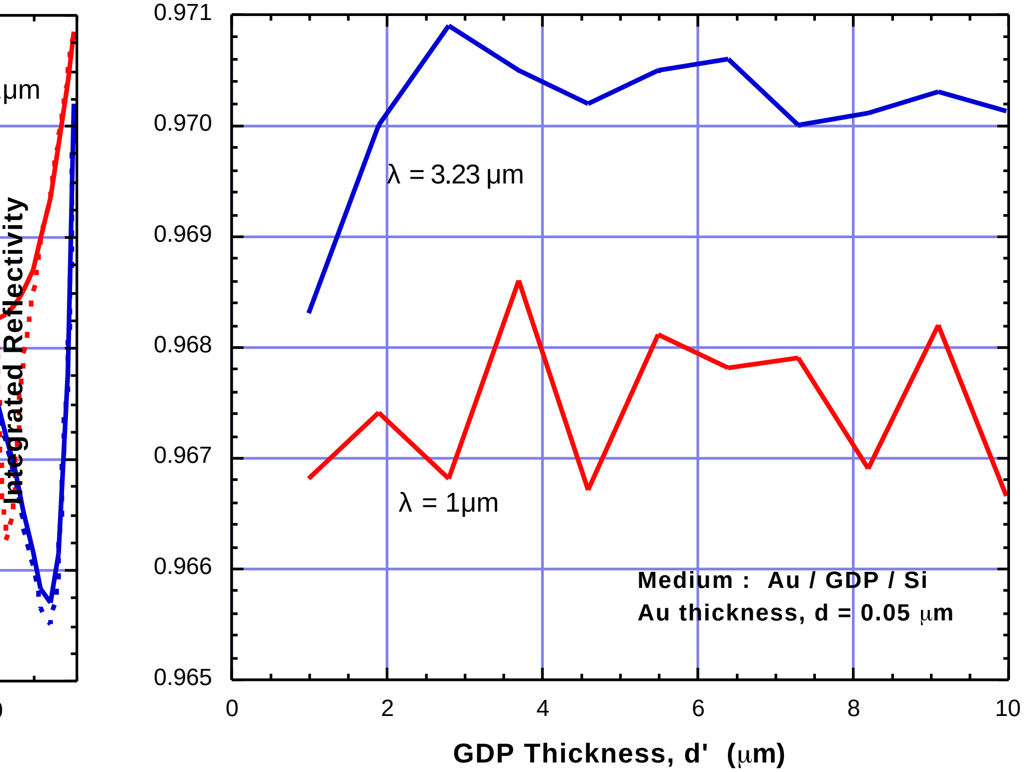



# Target Reflectivity is High in Infrared Spectrum, and Insensitive to Polymer Layer Thickness in 1-10 μm Range

- Reflectivity (S+P polarization) exhibits a minimum close to tangential incidence. Periodic interference effects are seen for 10 μm GDP thickness incident angle is varied.

- Angle-averaged reflectivity ~ 0.97 for GDP thickness = 1 - 10 μm.



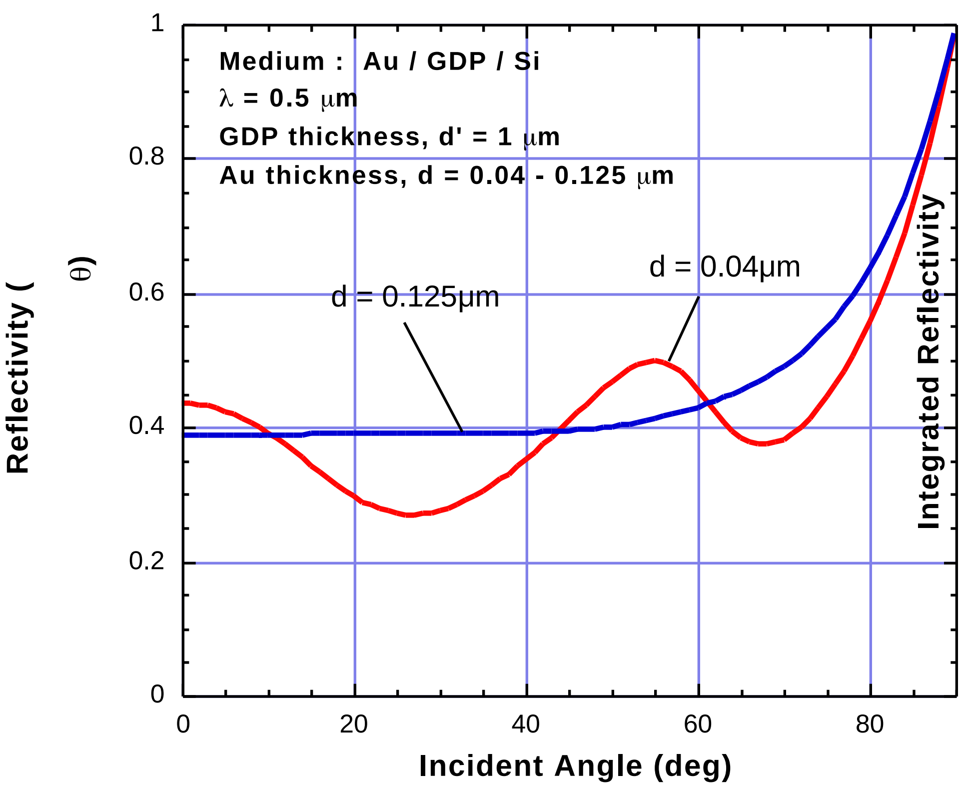



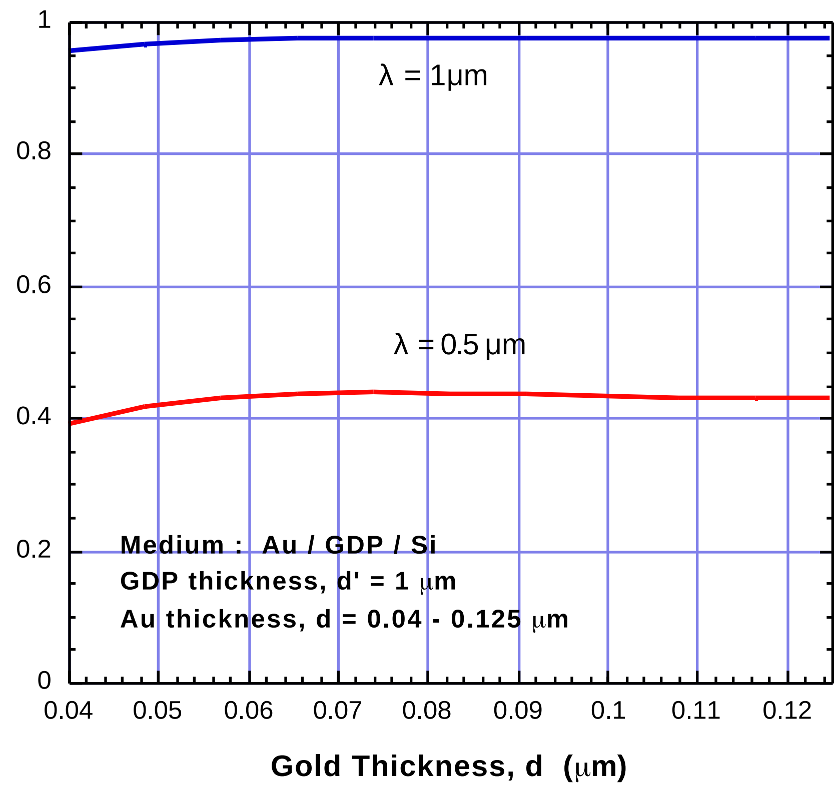
# Target Heating is Strong in Visible Spectrum

- Radiation absorption is strong over all angles of incidence.
  R < 0.6 for $\theta_{inc} < 80^o$.

- Angle-averaged reflectivity drops drastically as λ = 1mm ⟶ 0.5 mm.

  Since $\lambda_{max} \sim T_{wall}$, this implies low first wall temperature is desirable.



# FUTURE PLANS

- Calculation of total reflectivity integrated over radiation spectrum and fractional power deposition in various layers
- Comparison of Silicon substrate with DT
- Extrapolation to low temperature
  - n and κ values at room temperature have been used
- Correct accounting of geometry and surface roughness
- Sensitivity studies w.r.t. wall temperature and fuel temperature