High-Absorptance, Thermally-Robust Surfaces for Receivers

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Massachusetts Institute of Technology

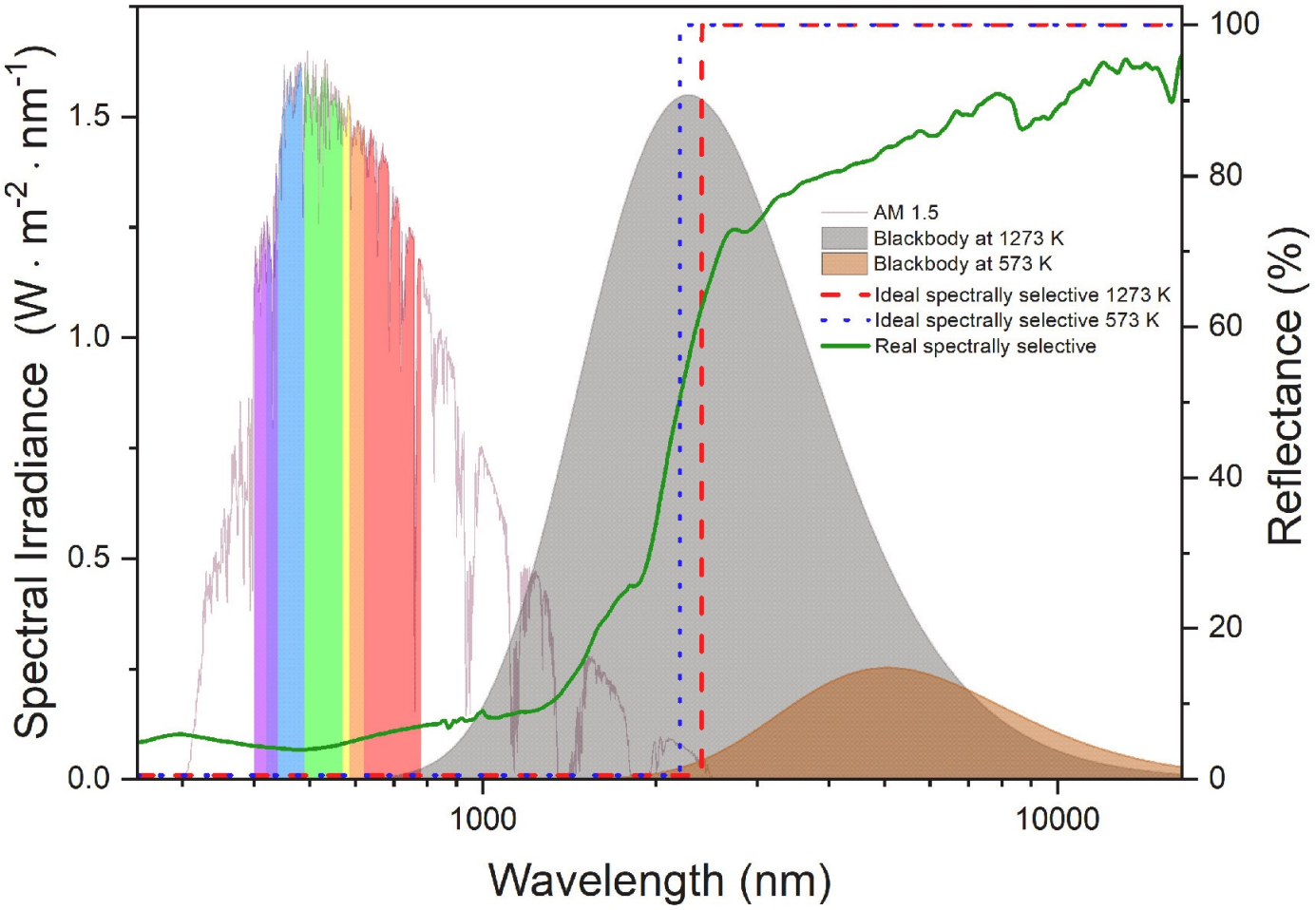
1. Why does receiver absorptance matter?

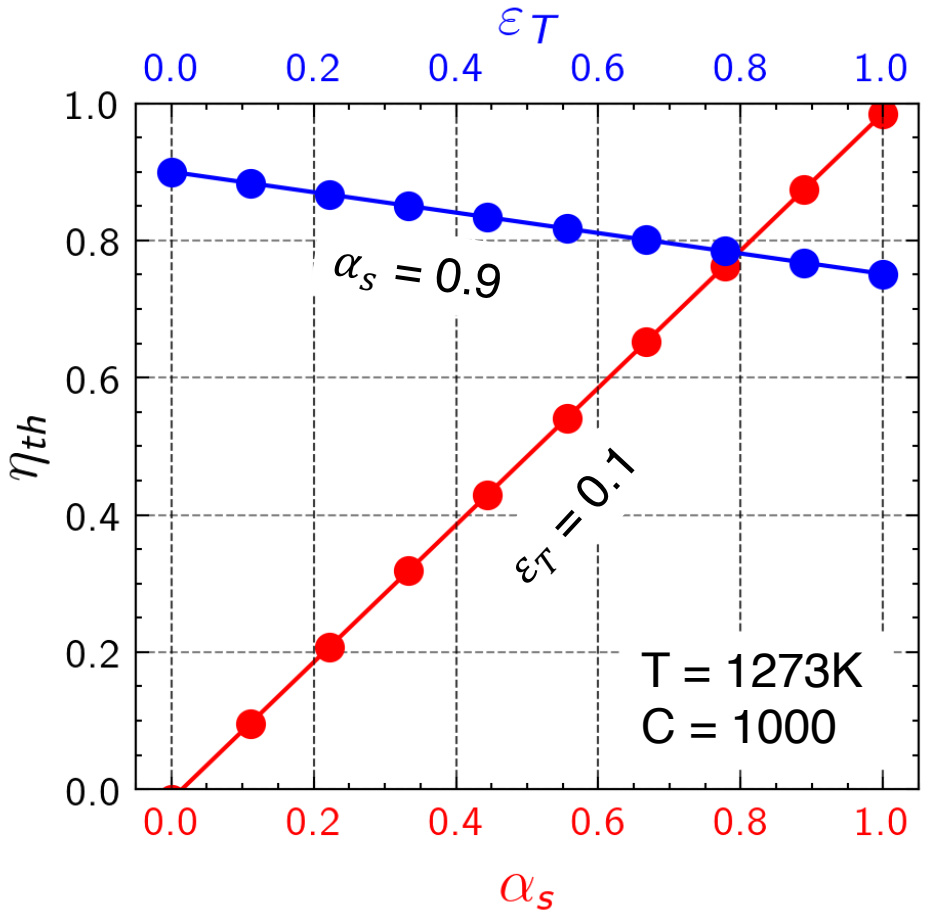
2. How can we create high-absorptance materials?

3. How do these materials perform at high temperatures?

4. How long do the absorbers last?

CSP receivers – solar absorption vs. IR emission

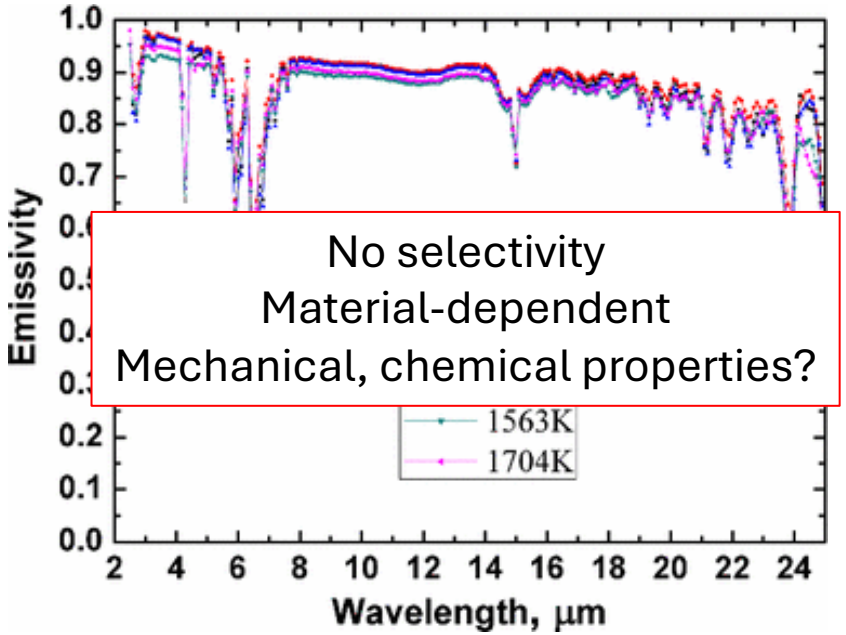




Noc and Jerman, *Sol. Eng. Mat. Sol. Cell.* 238, 111625 (2022)

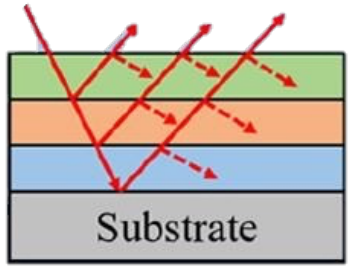
Options for improving receiver absorptance

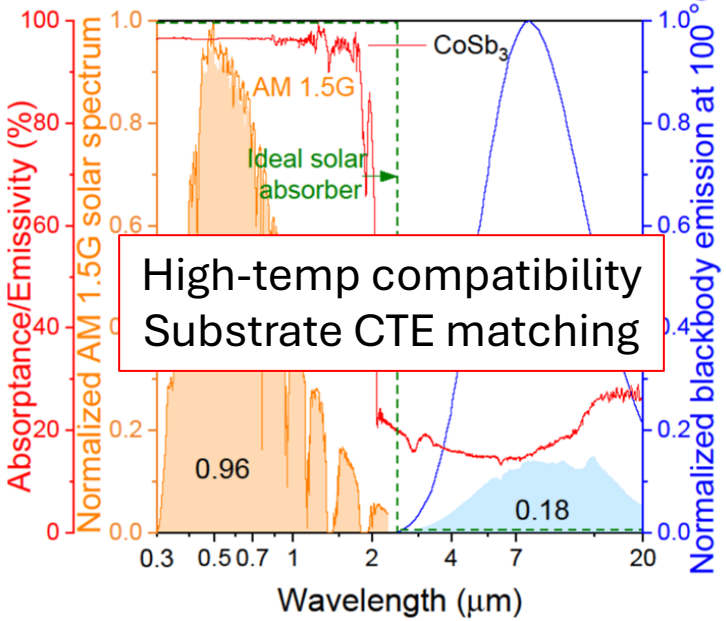
High-absorptance materials



No selectivity
Material-dependent
Mechanical, chemical properties?

Coatings





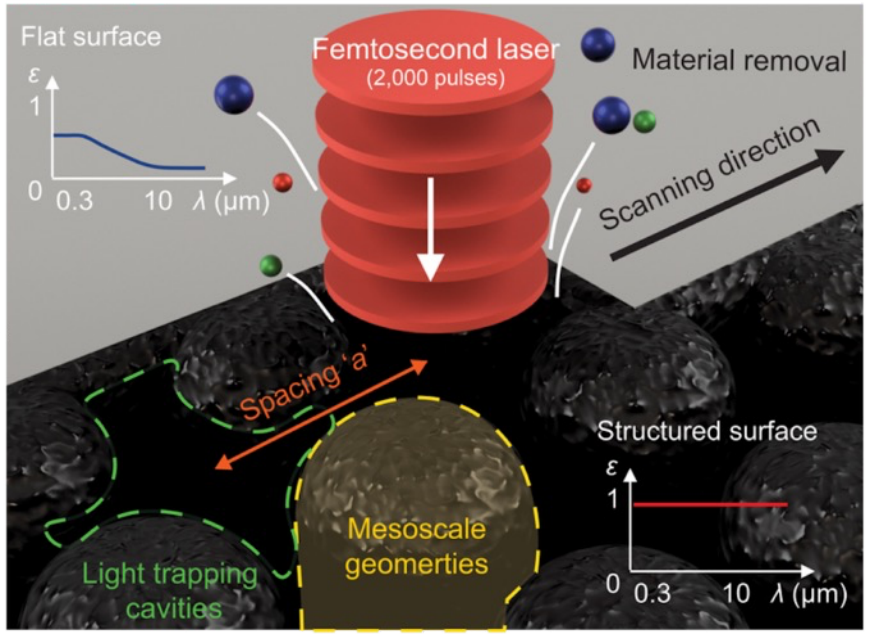
High-temp compatibility
Substrate CTE matching

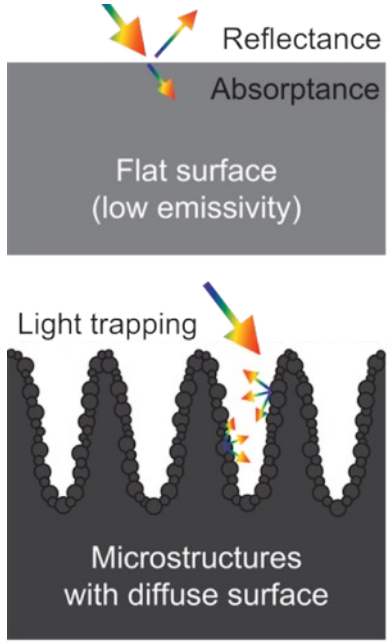
Taranova et al., *Nat. Commun.* 14(1), 7280 (2023)

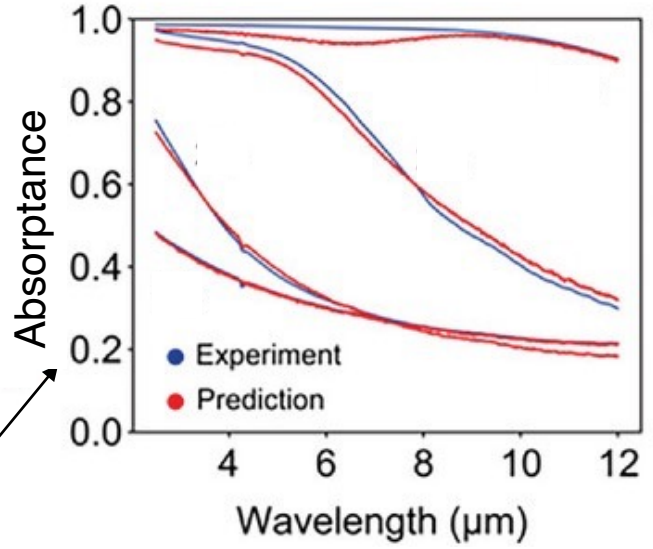
Surface engineering?

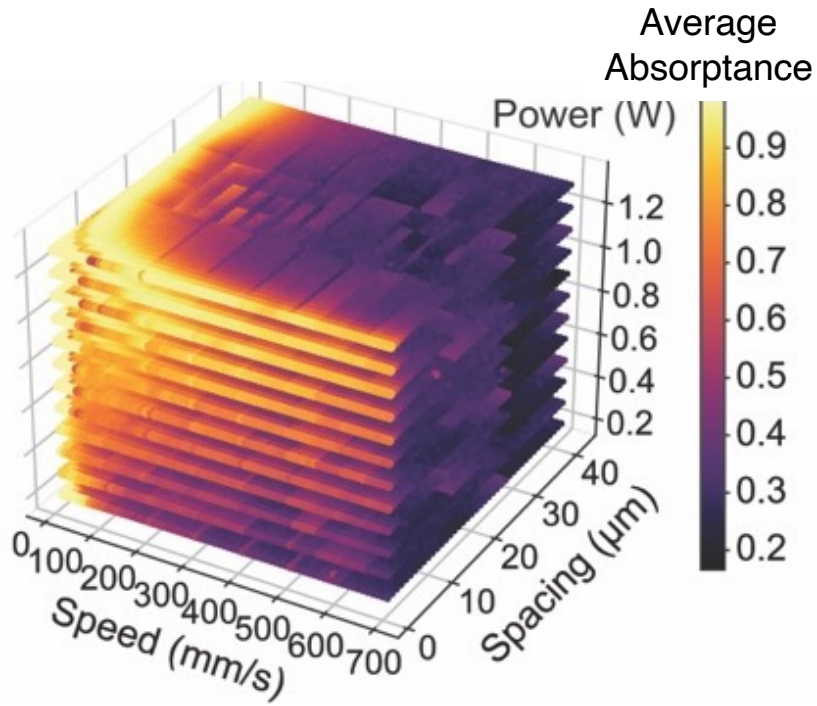
Graphite emissivity, metal cubes

Laser ablation can tune absorptance



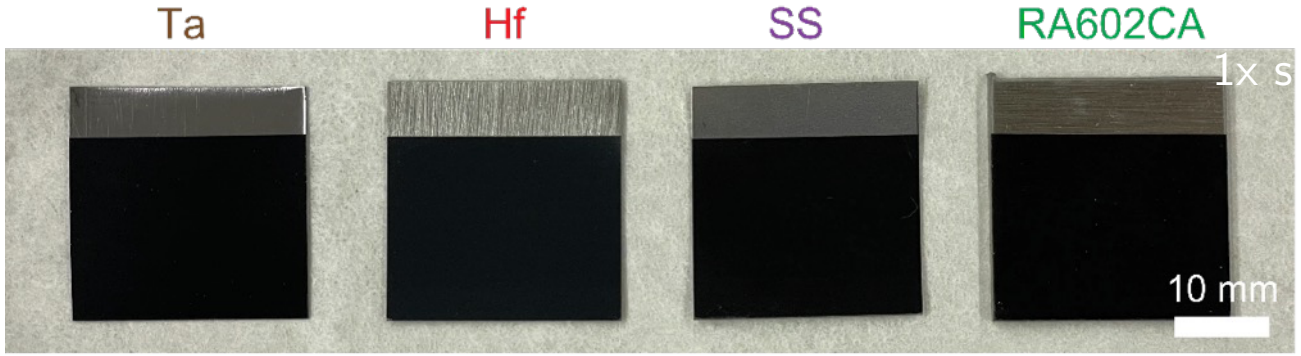


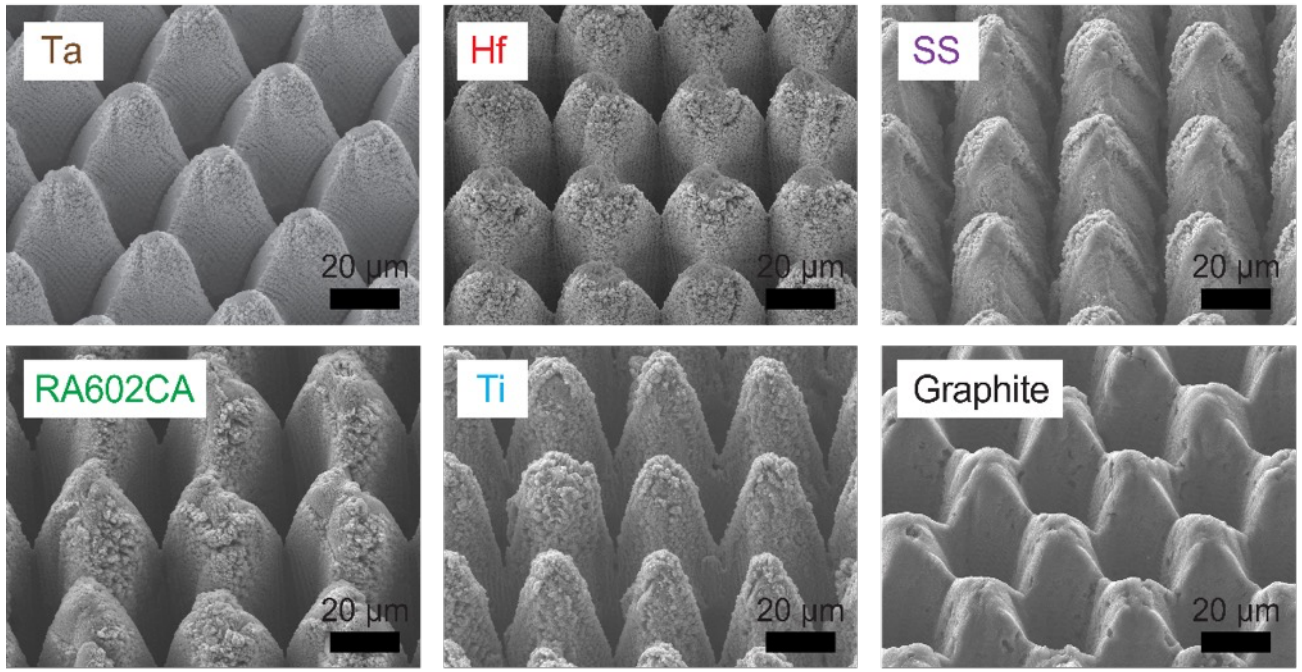


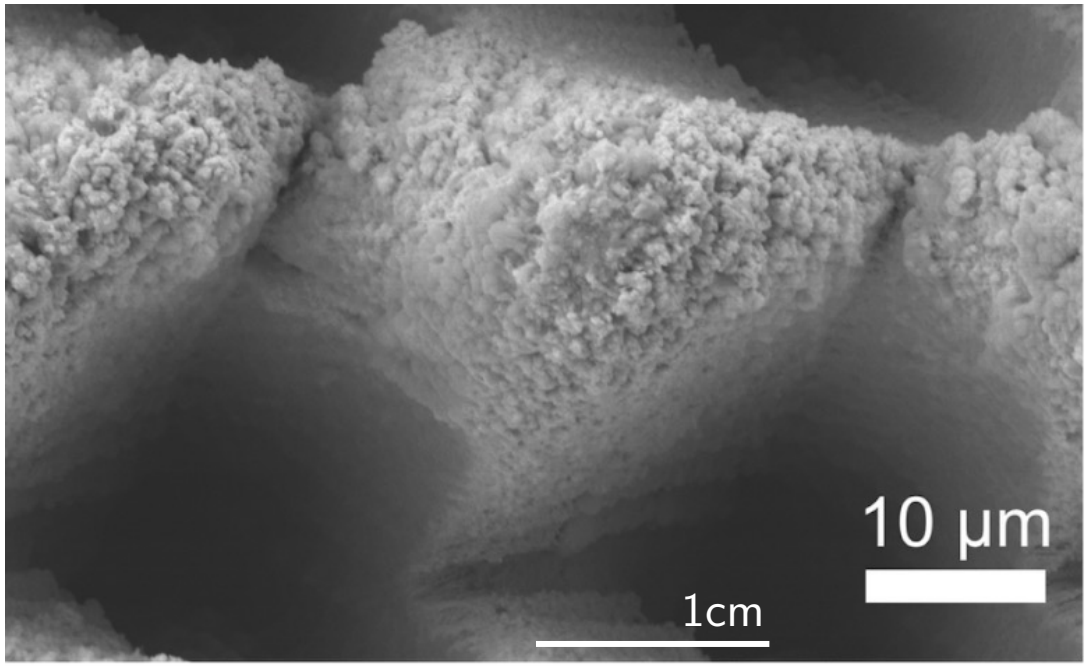


Park et al. *Advanced Science* (2024)

We can make any surface black

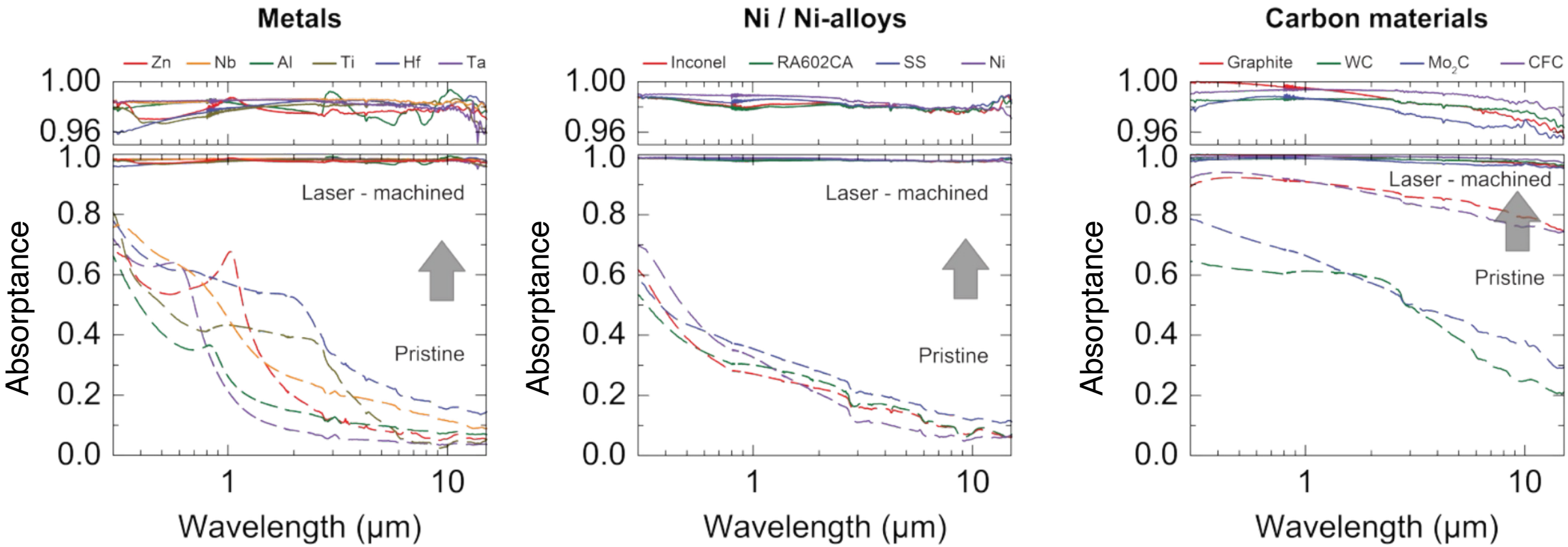






Park and Verma et al. *Joule* (2025)

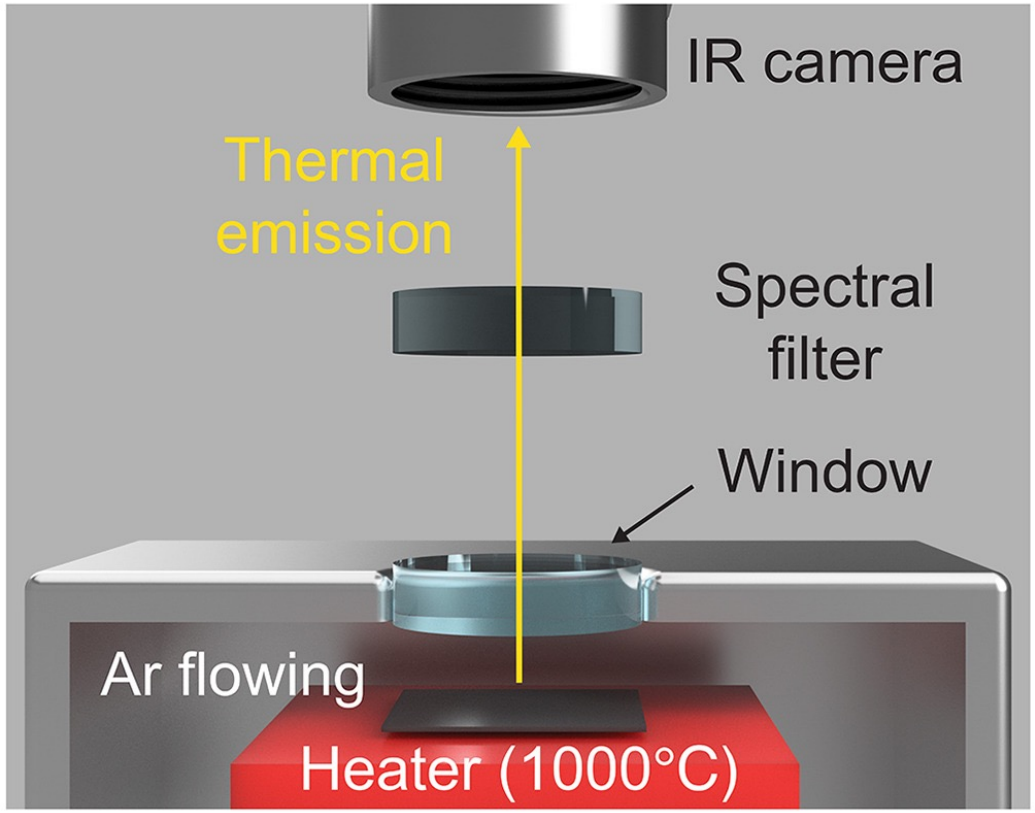
Absorptance before vs. after laser processing

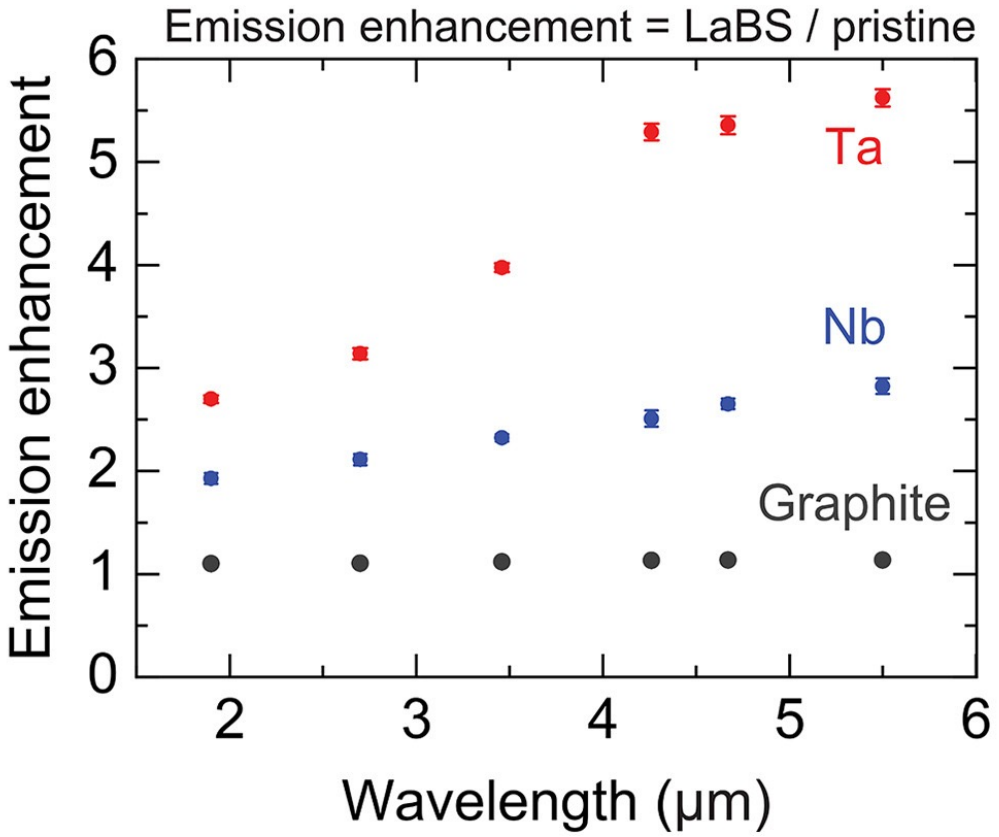


Room temperature measurements with reflectance spectroscopy

Park and Verma et al. *Joule* (2025)

Laser processed surfaces achieve high emittance (= high absorptance) at high temperatures





What about visible / NIR emittance?

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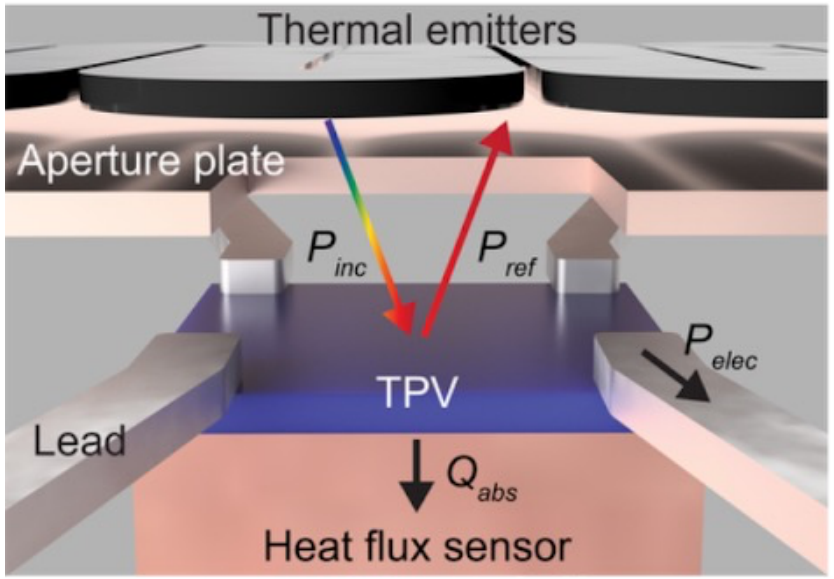
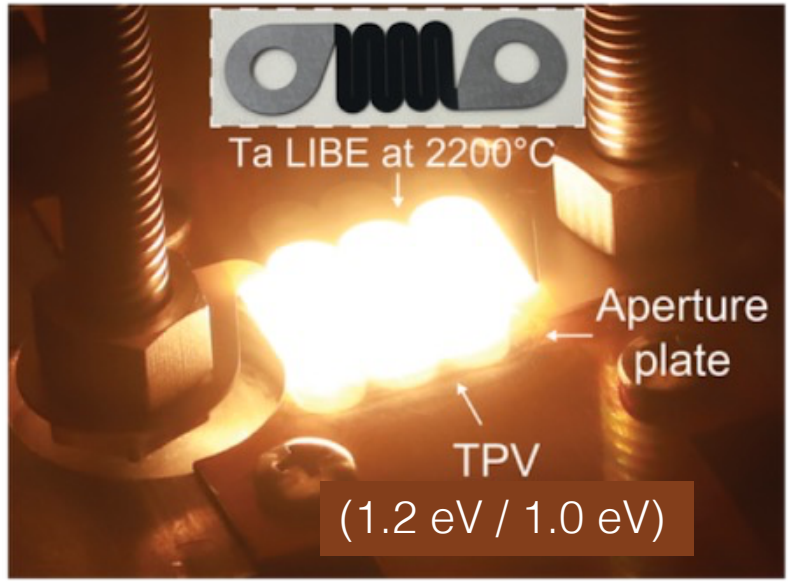
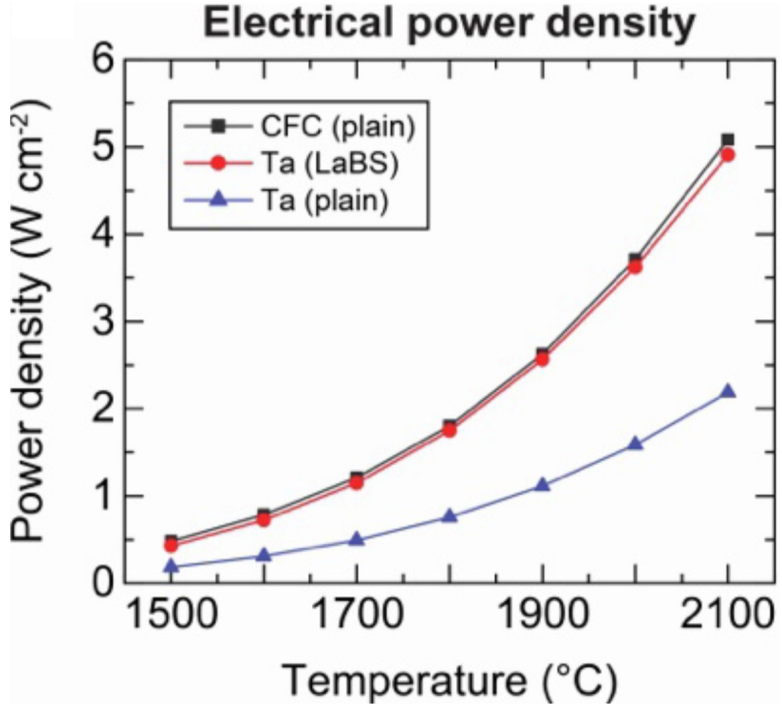
Laser processed surfaces achieve high emittance (= high absorptance) at high temperatures



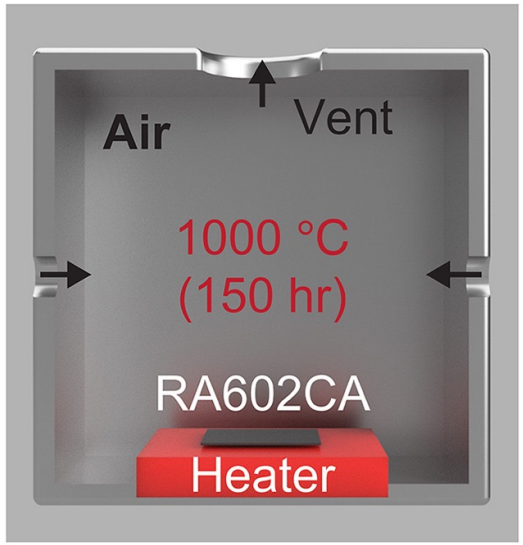


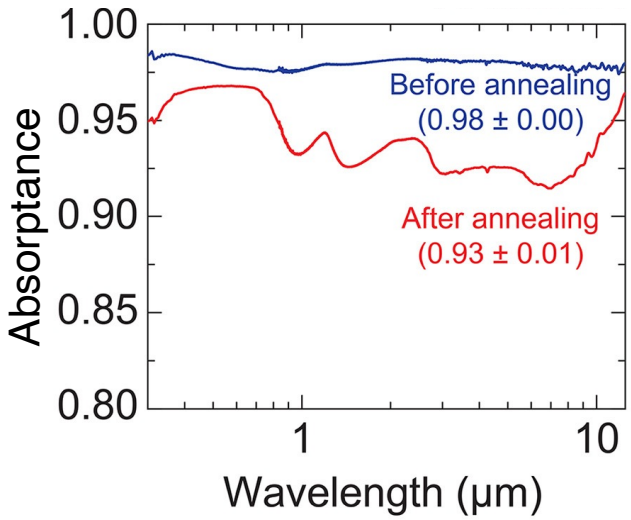
Photons < 1240 nm absorbed as current



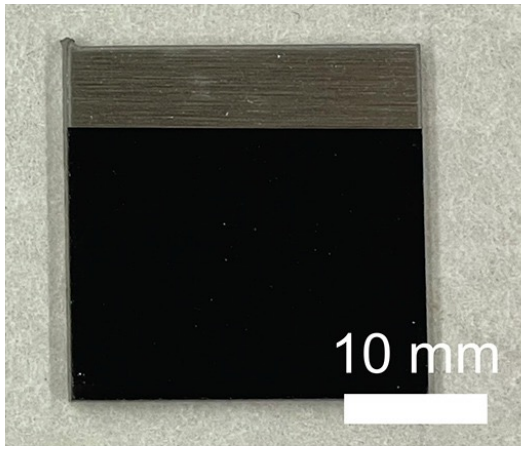
Park and Verma et al. *Joule* (2025)

Durability of laser processed absorbers in air

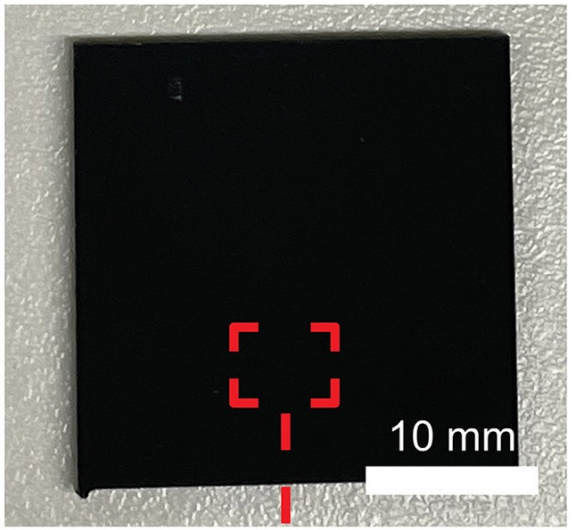


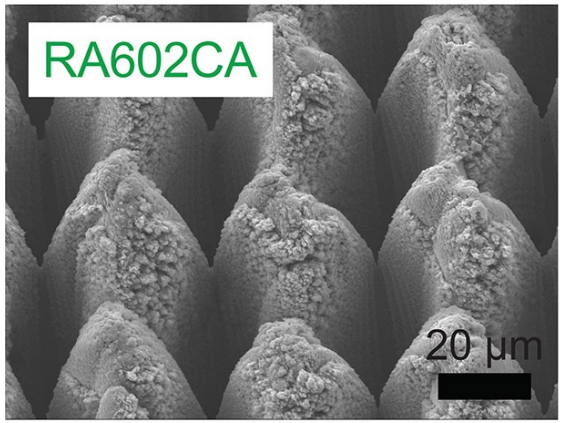


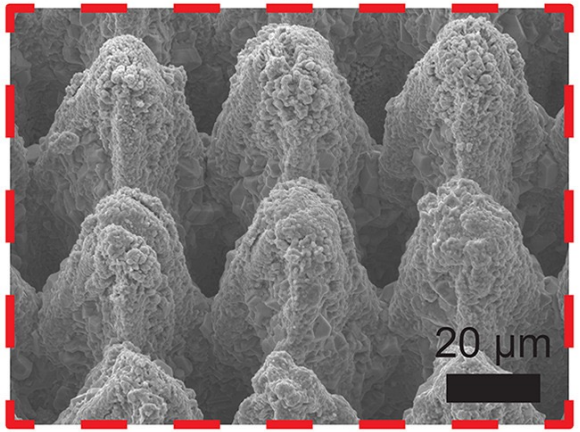
Before



After





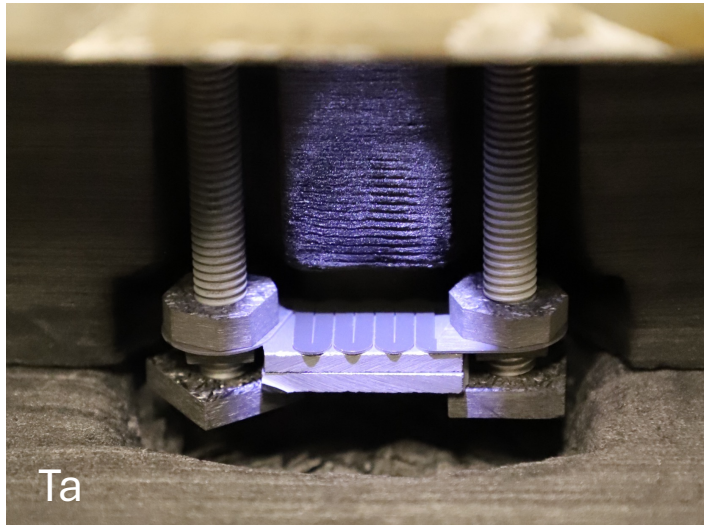


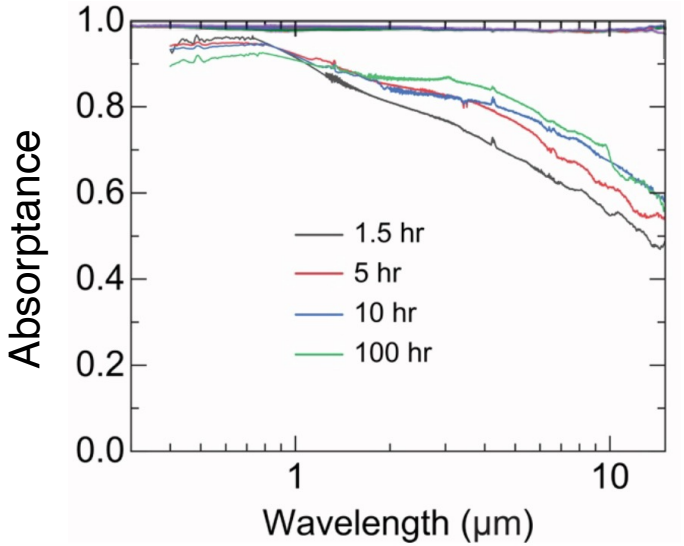
Low-temp, long-duration, oxidizing

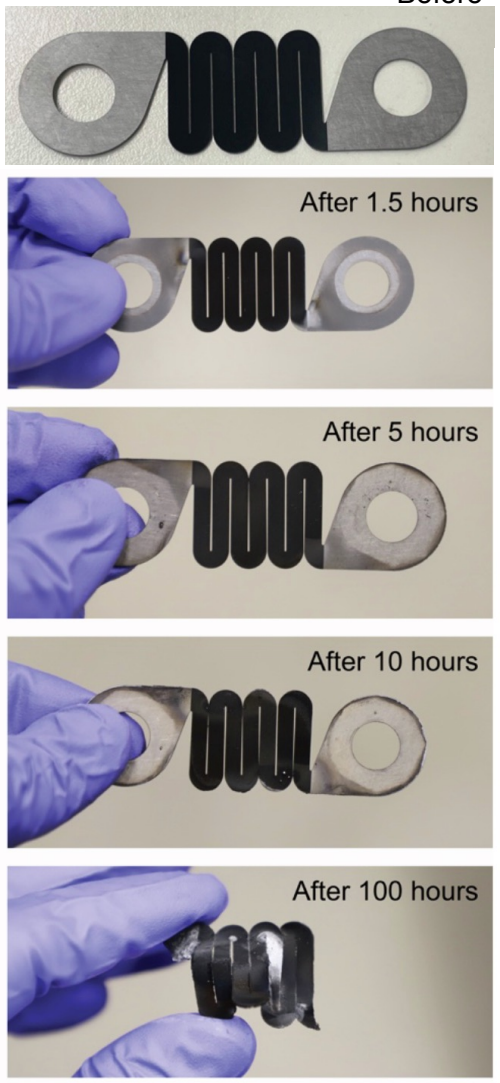
Park and Verma et al. *Joule* (2025)

Durability of laser processed absorbers in inert gas

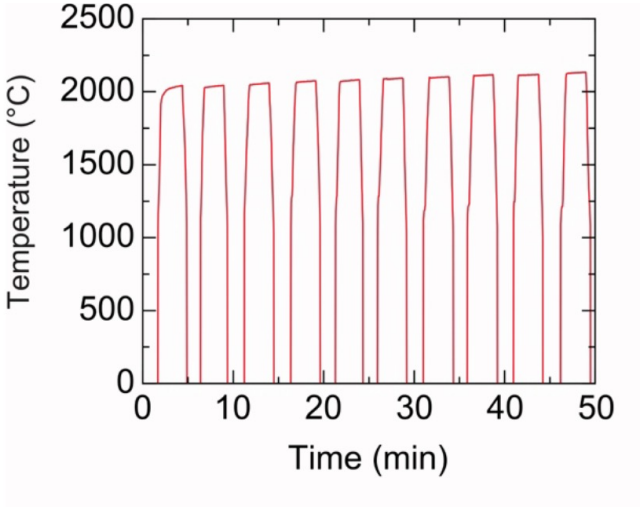
2000°C in Ar

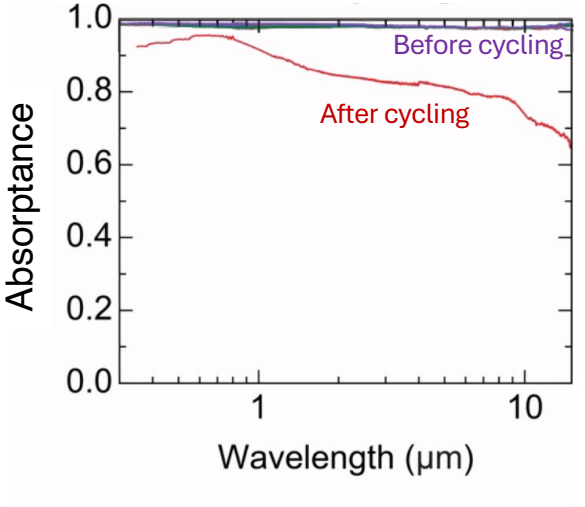




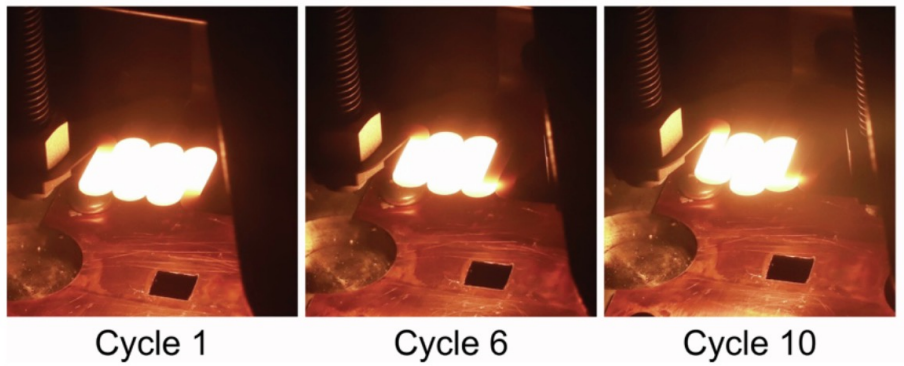


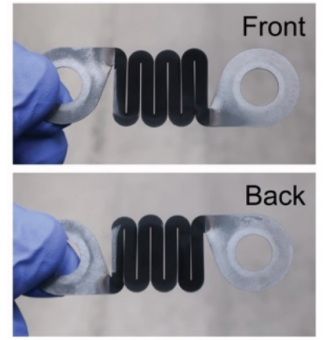
Thermal cycling tests





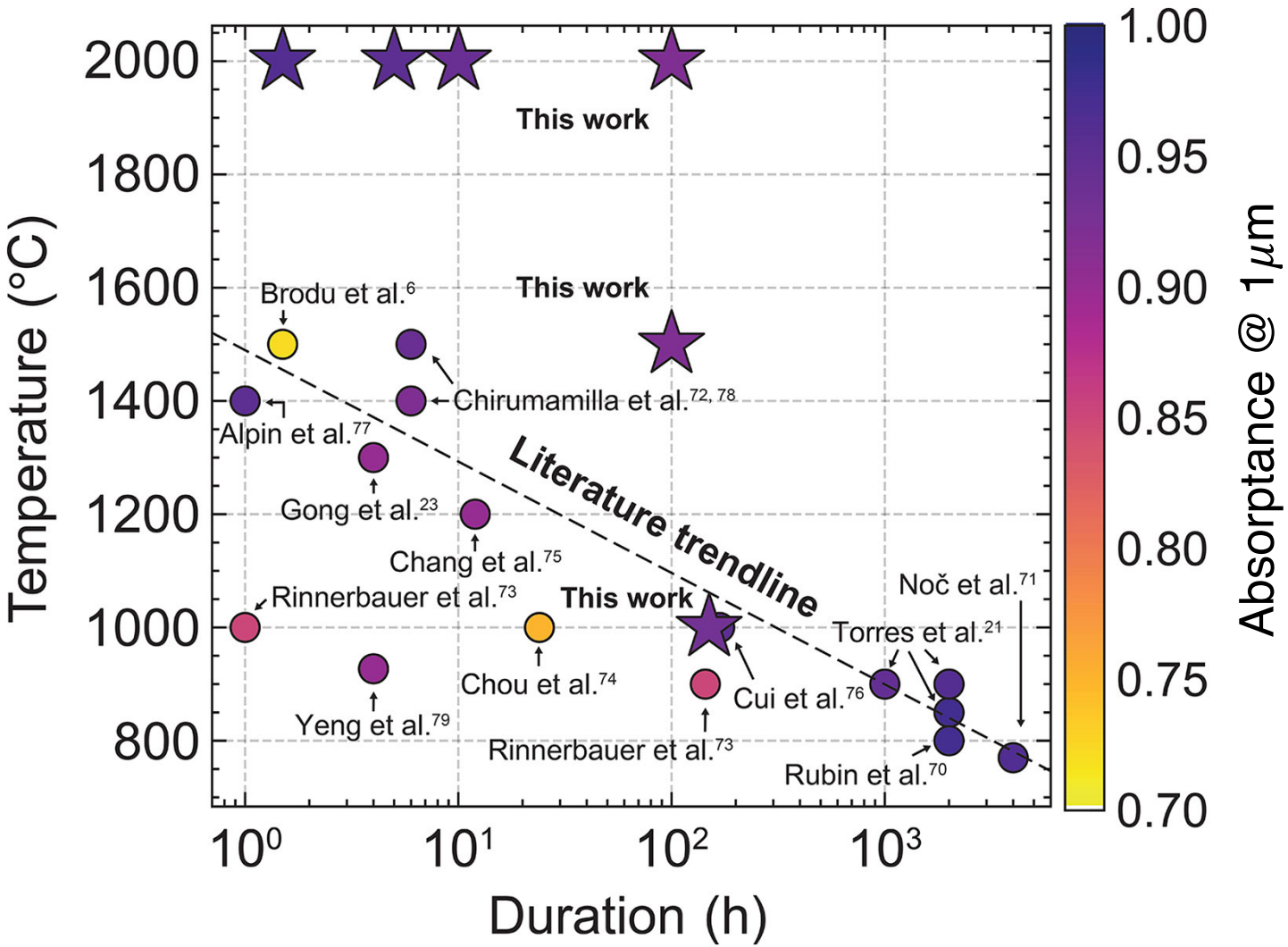
After cycling





Park and Verma et al. *Joule* (2025)

Highest-temperature, longest-duration durability tests of structured surfaces to date



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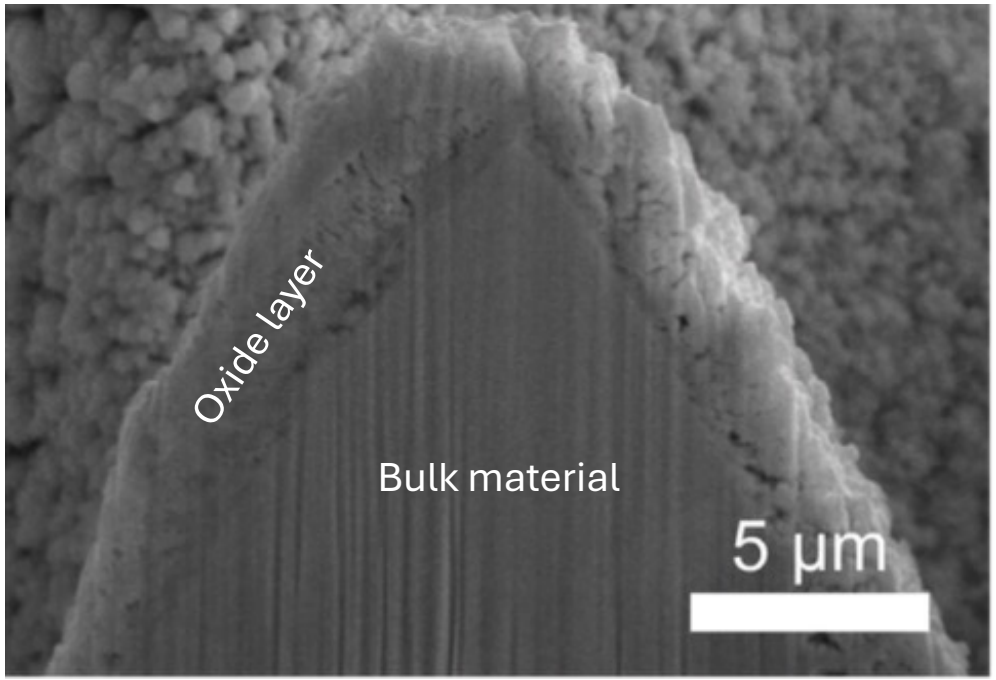
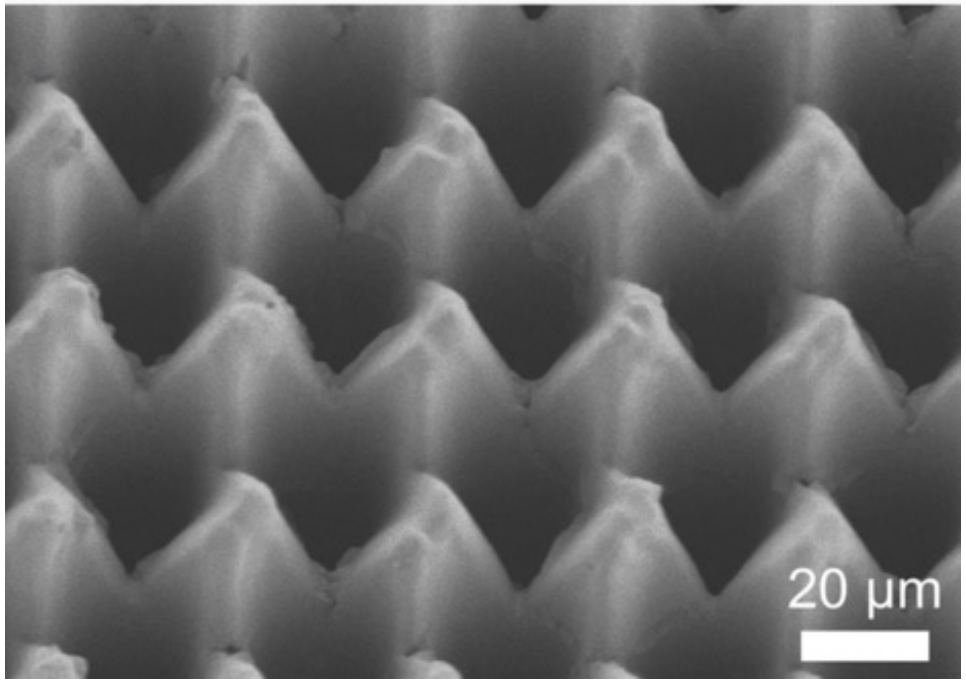
Nanoparticle sintering reduces absorptance

Before



After



Nanoparticles are sintering to form a smooth surface

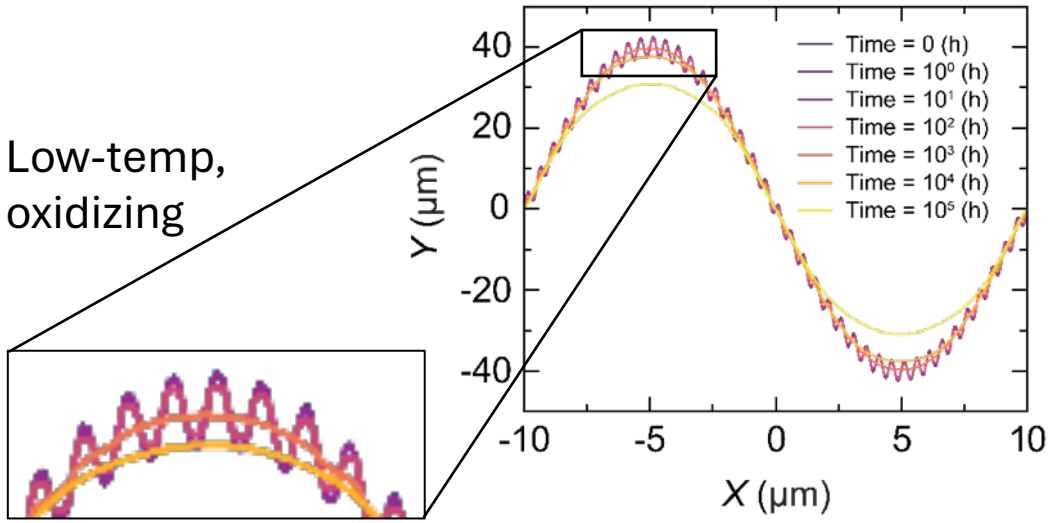
Can we model this to predict long-term behavior?

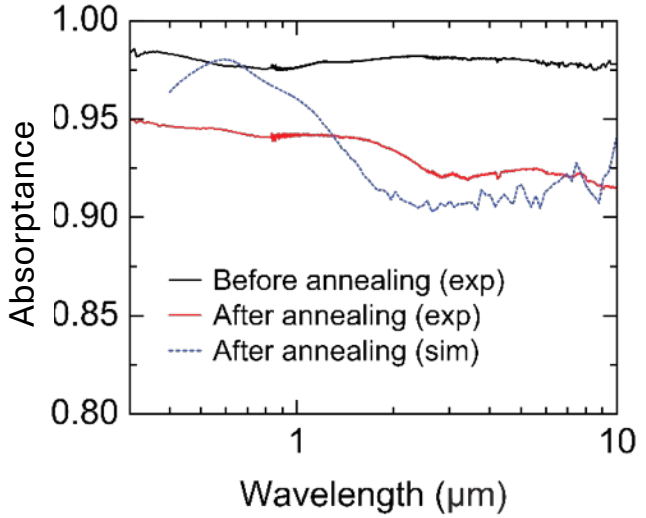
Park and Verma et al. *Joule* (2025)

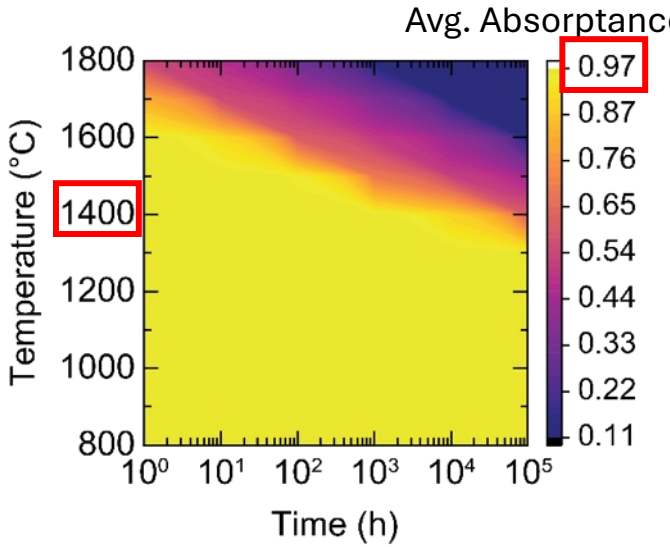
Modeling sintering to extrapolate durability testing

(Including surface diffusion + vapor pressure effects)

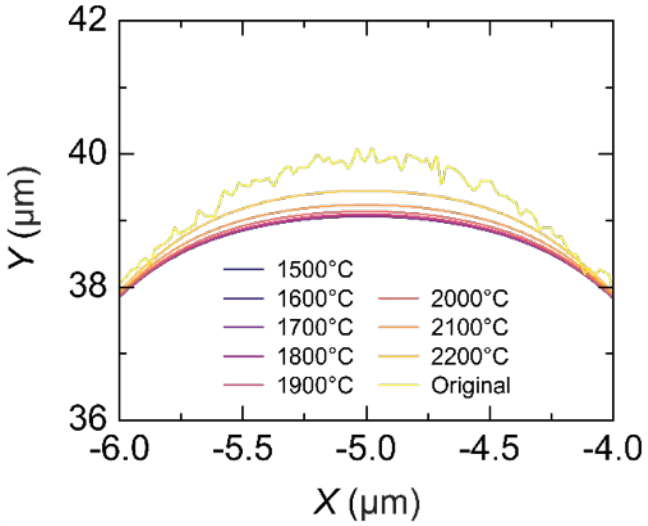
Low-temp, oxidizing

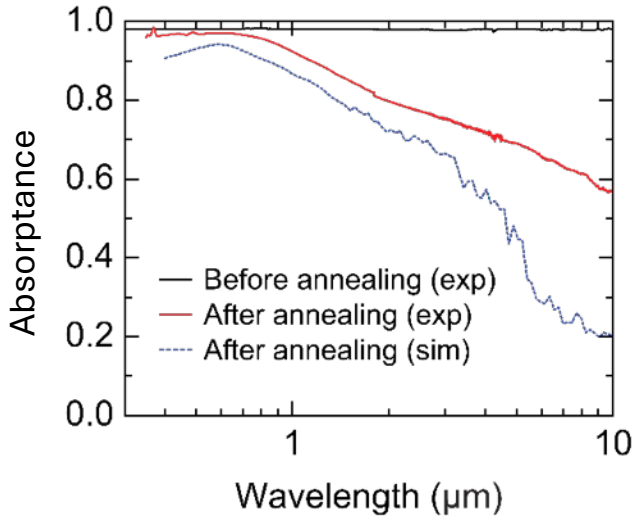


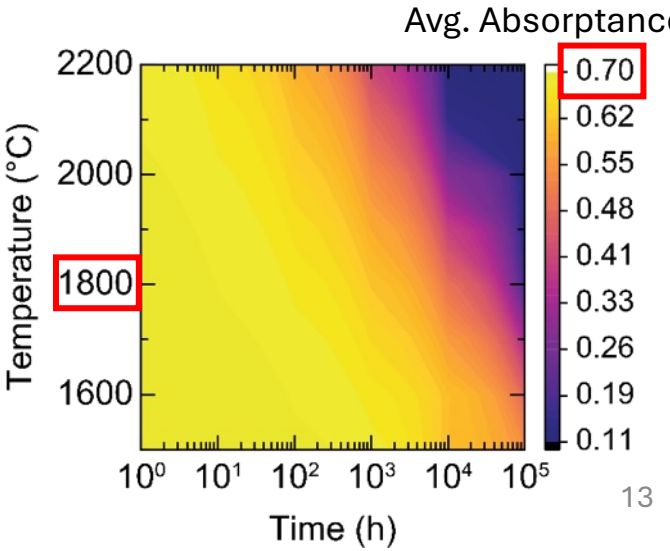




High-temp, reducing

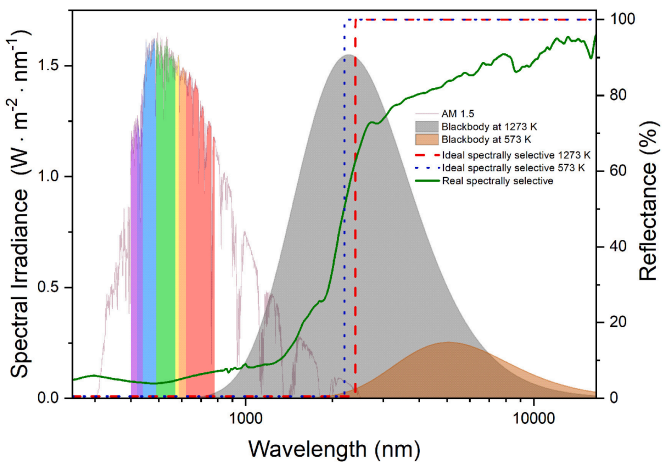


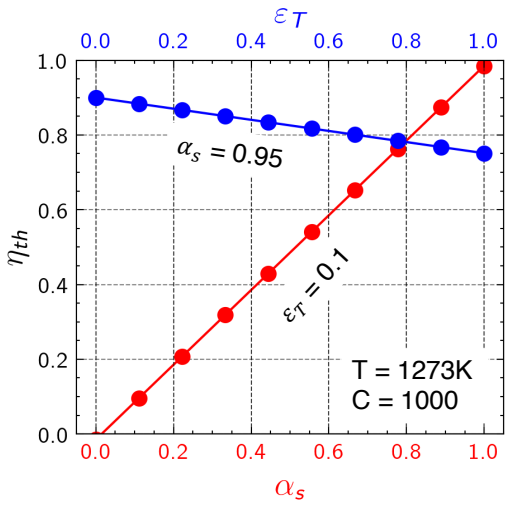




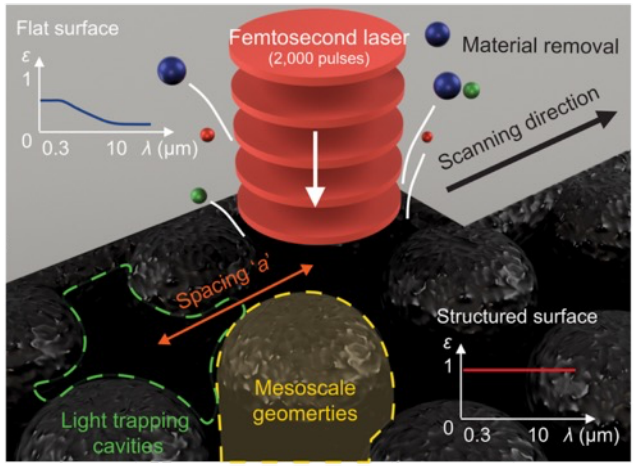
Park and Verma et al. *Joule* (2025)

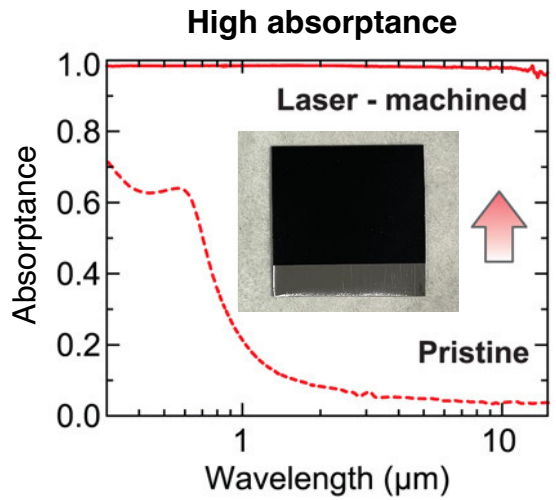
1. Why does receiver absorptance matter?





2. How can we create high-absorptance materials?





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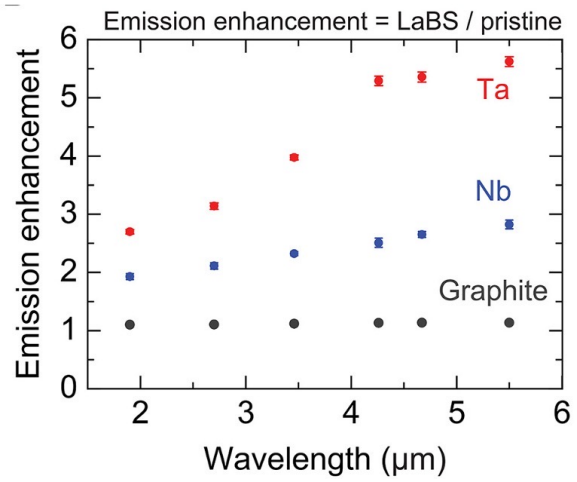

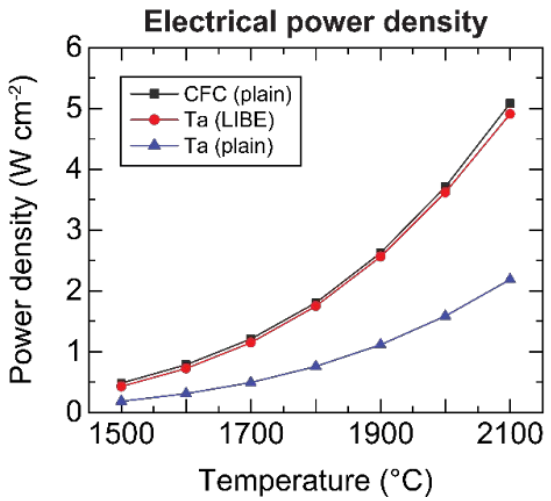

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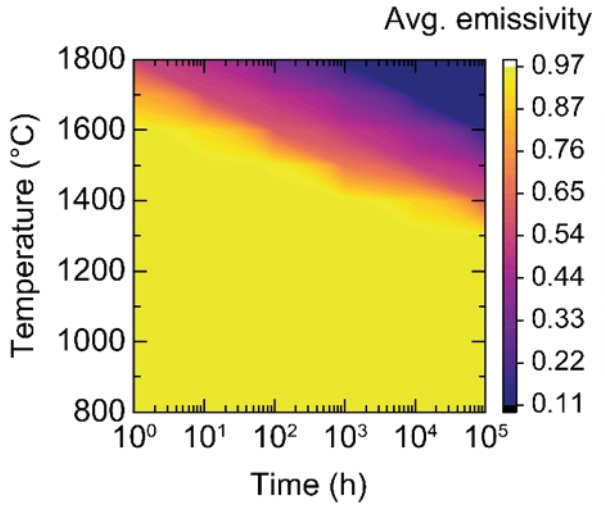

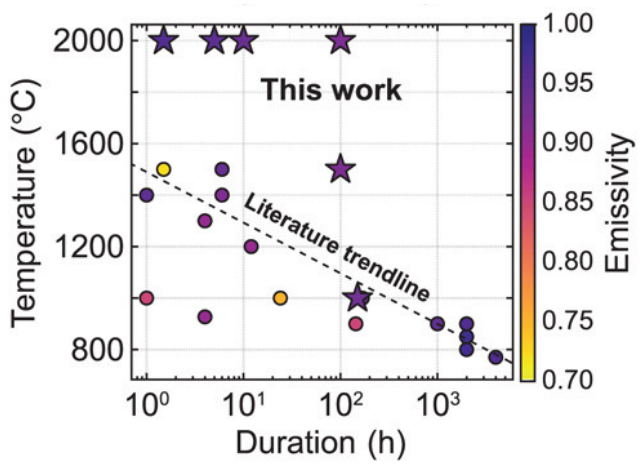

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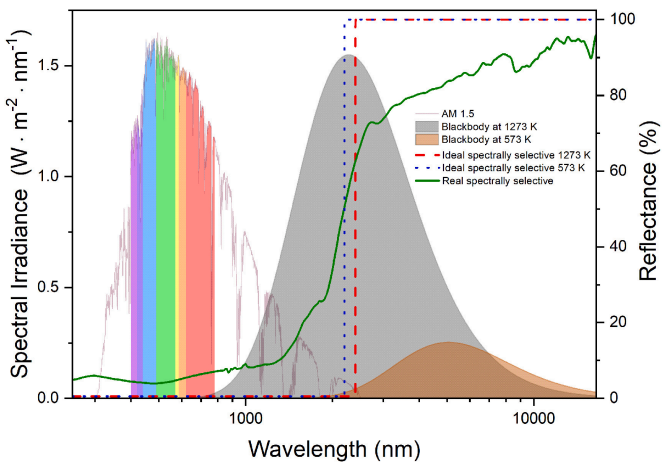

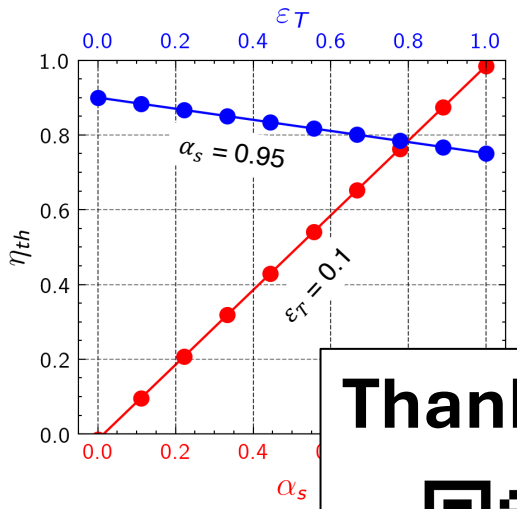

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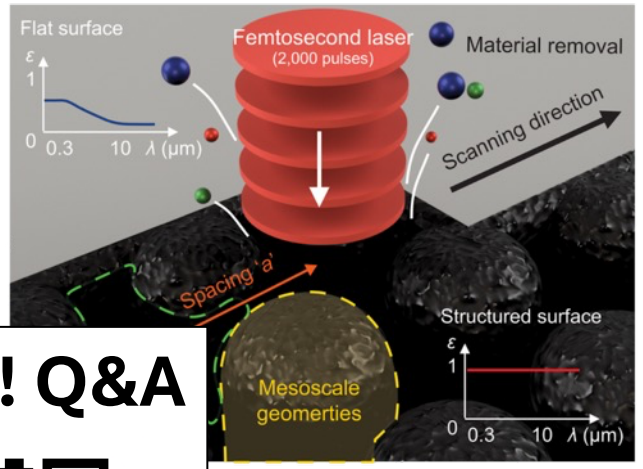
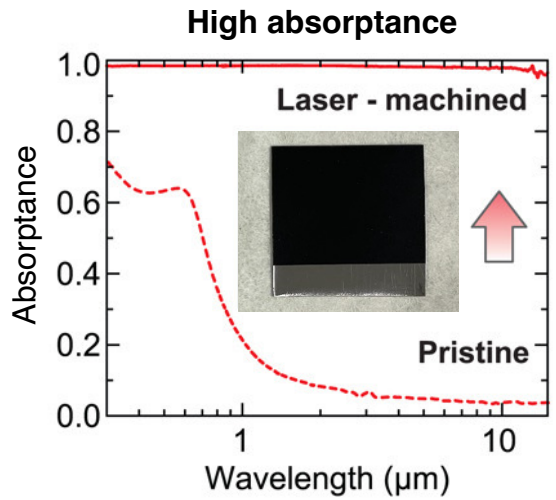
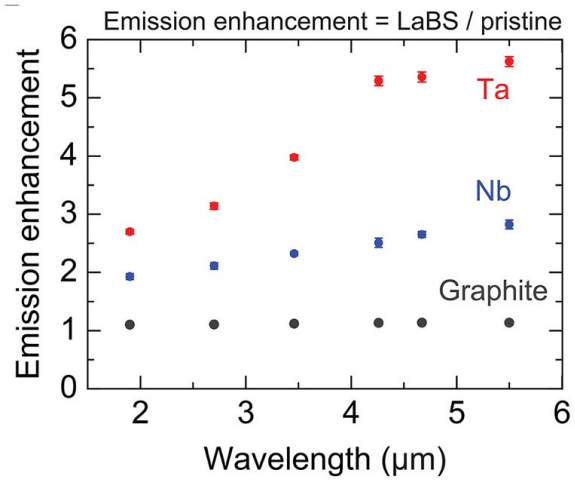
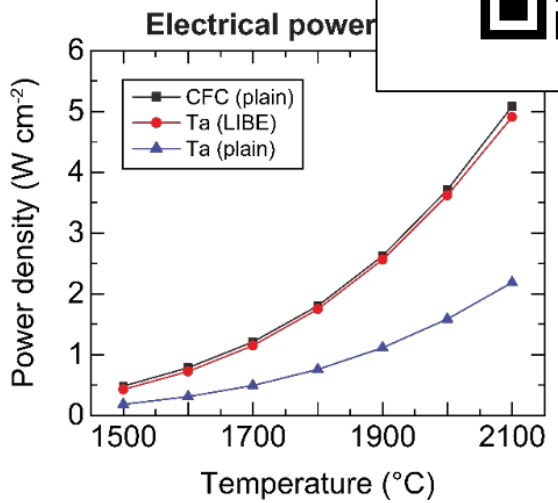




Thanks! Q&A

3. How do these materials perform at high temperatures?





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