

Fabrication and testing of laser-blackened surfaces

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1. Why do we want black surfaces?

2. How can we fabricate black surfaces?

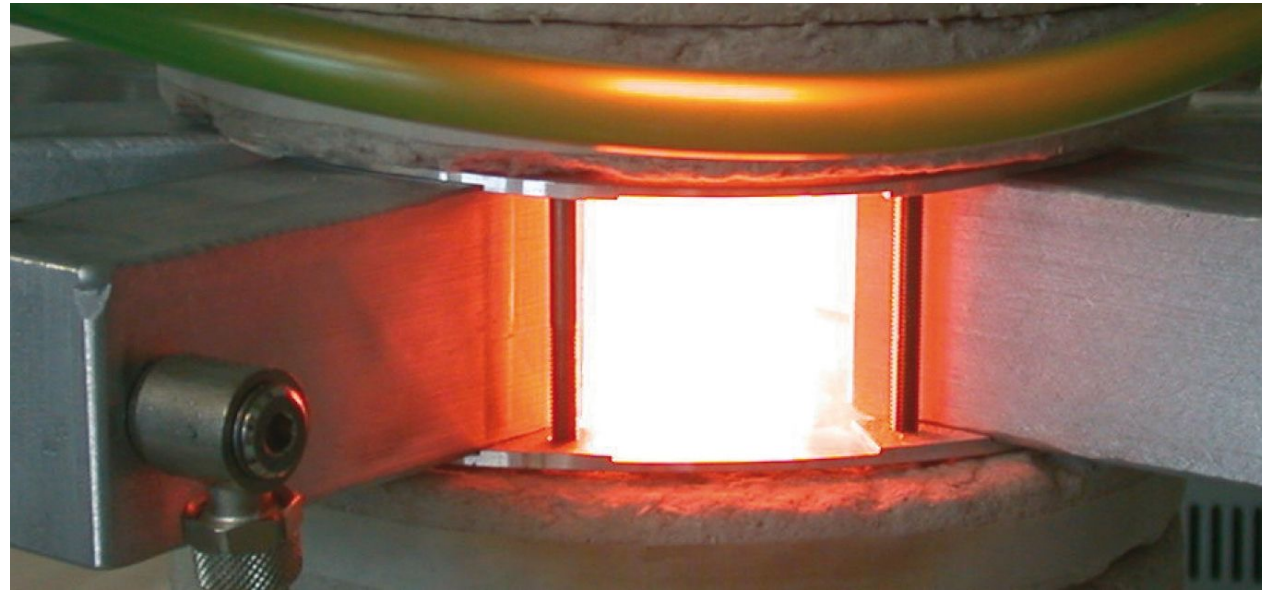
3. How do TPV cells perform with black emitters?

4. How long do the emitters last?

Black surfaces maximize radiative absorption & emission

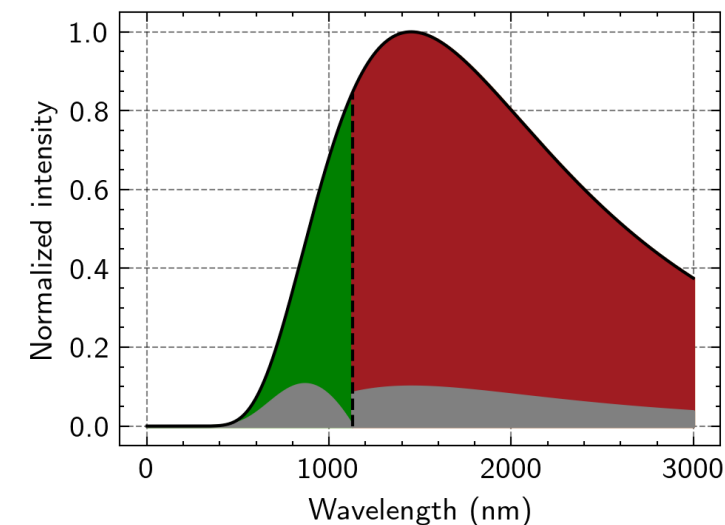
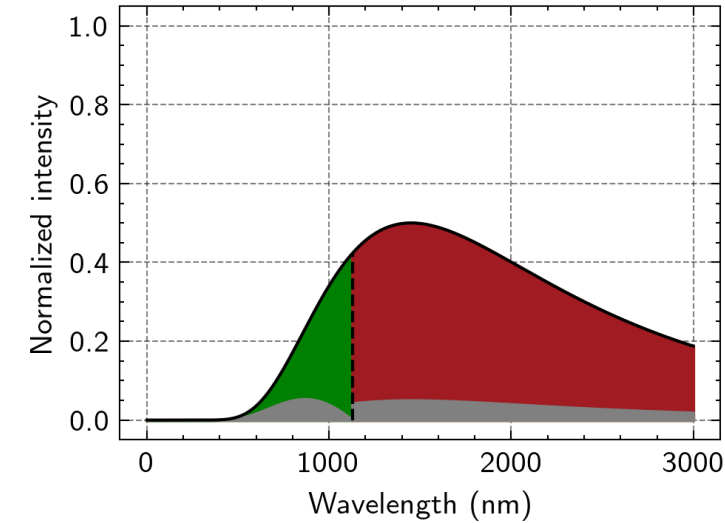
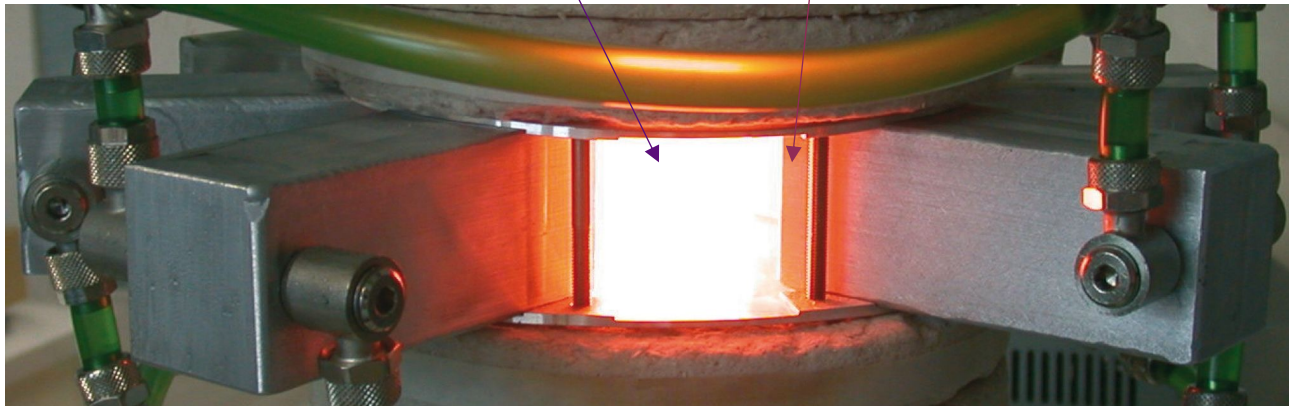
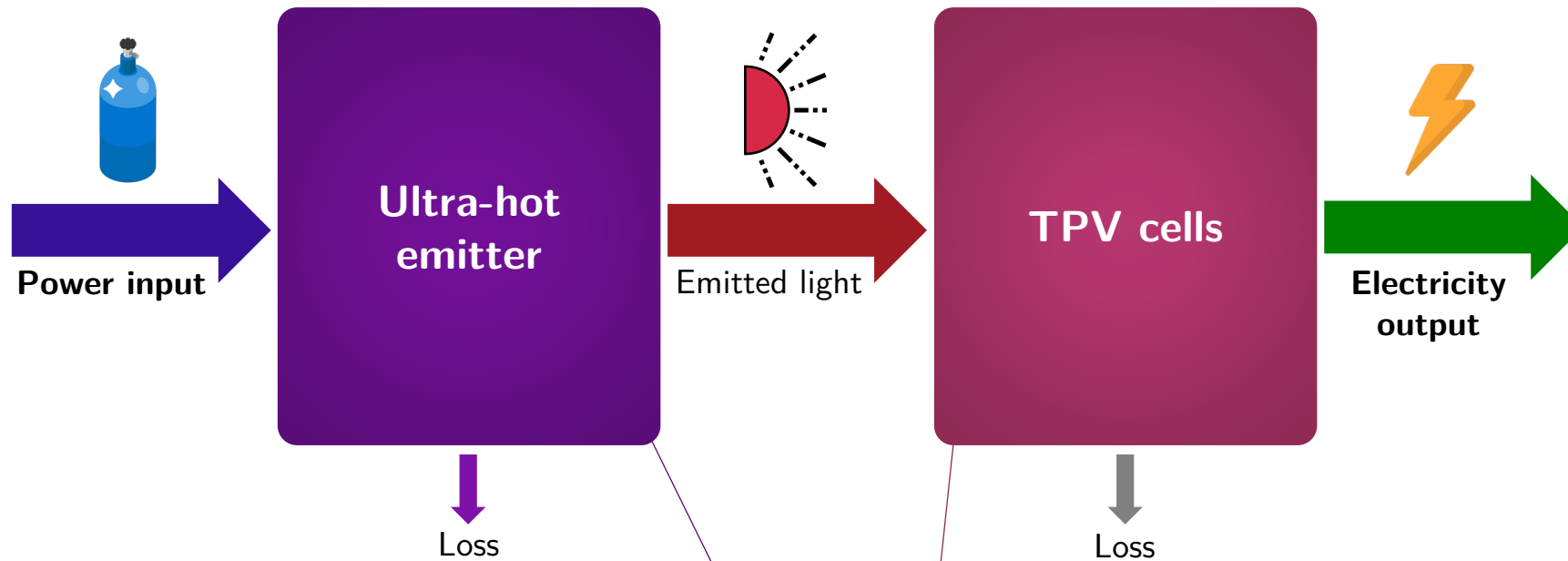


Solar thermal collectors



Thermophotovoltaics

Thermophotovoltaics benefit from higher emission

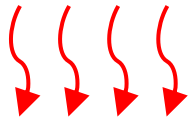


Conventional black emitters have limitations

Carbon based materials

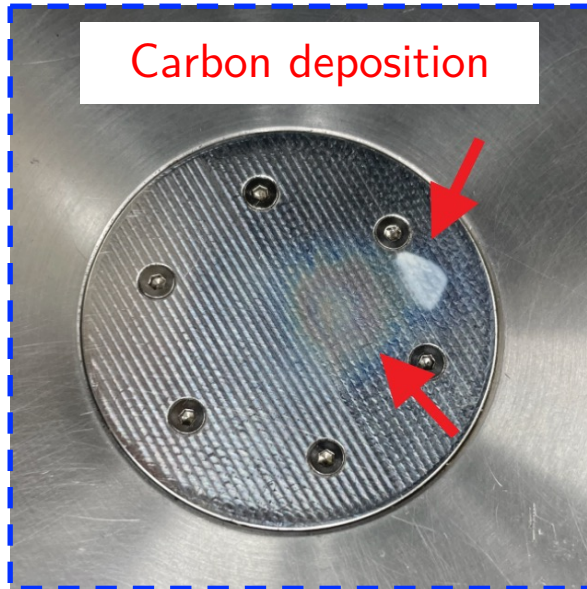
Annealed at 1500°C
(100 hours)

Graphite emitter

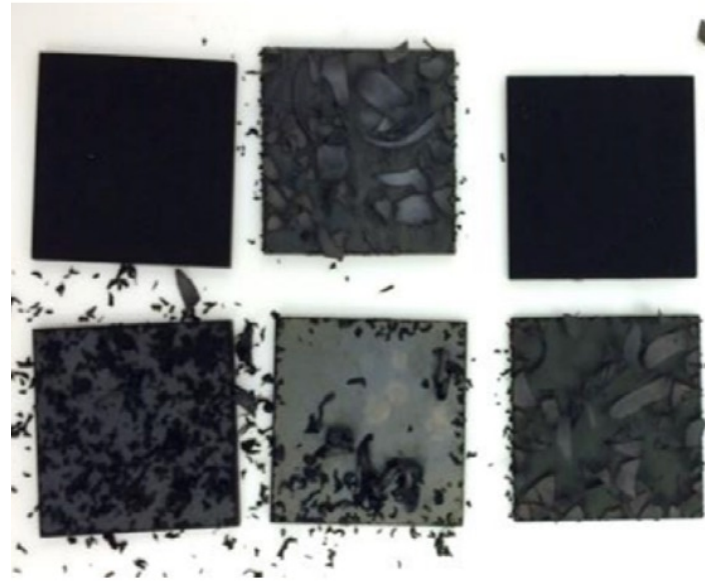


Deposition

Substrate



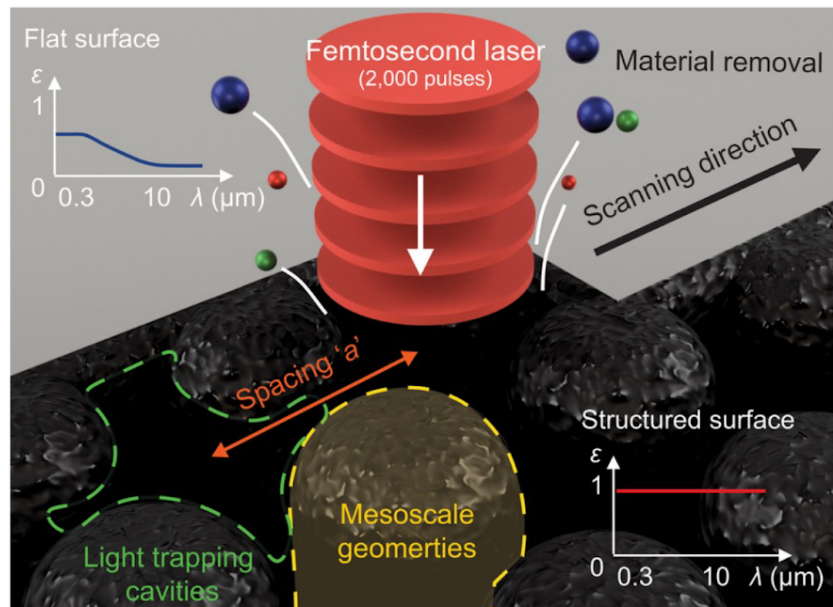
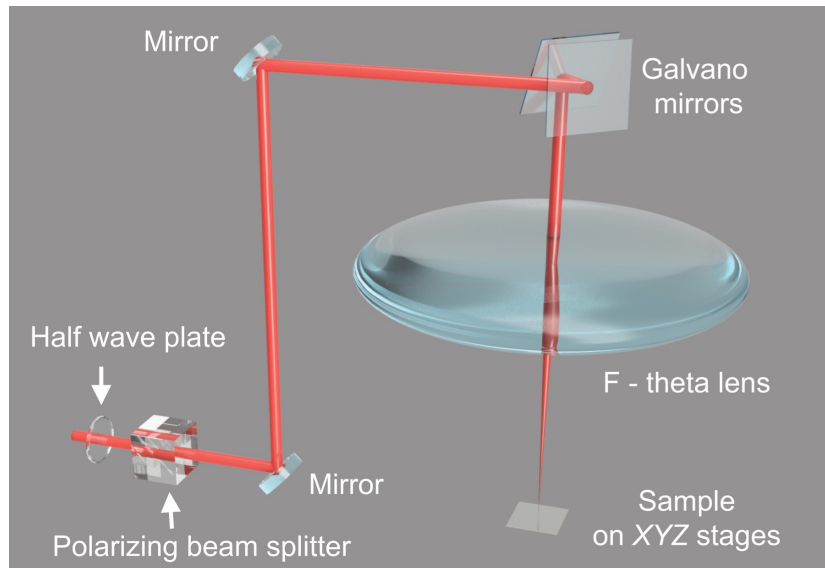
Surface coating



Surface engineering?



Ultrafast fs laser

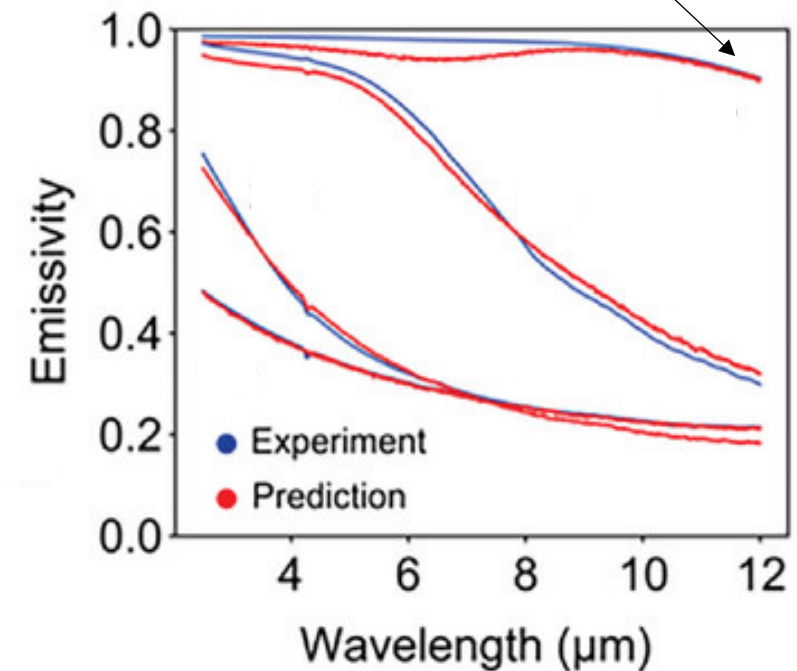
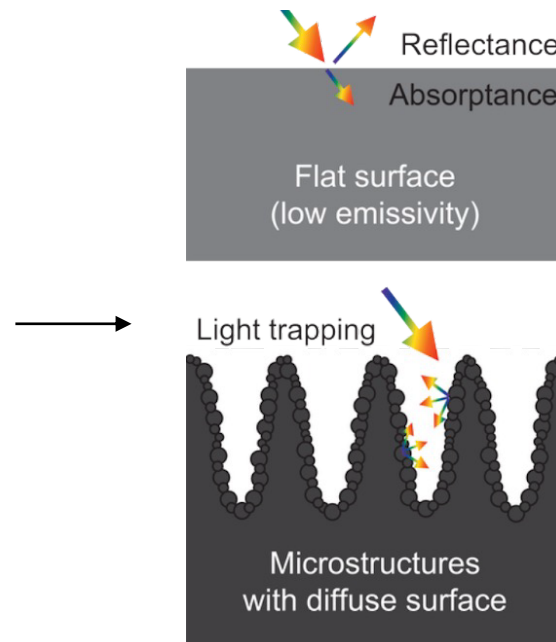


Laser ablation can tune emissivity

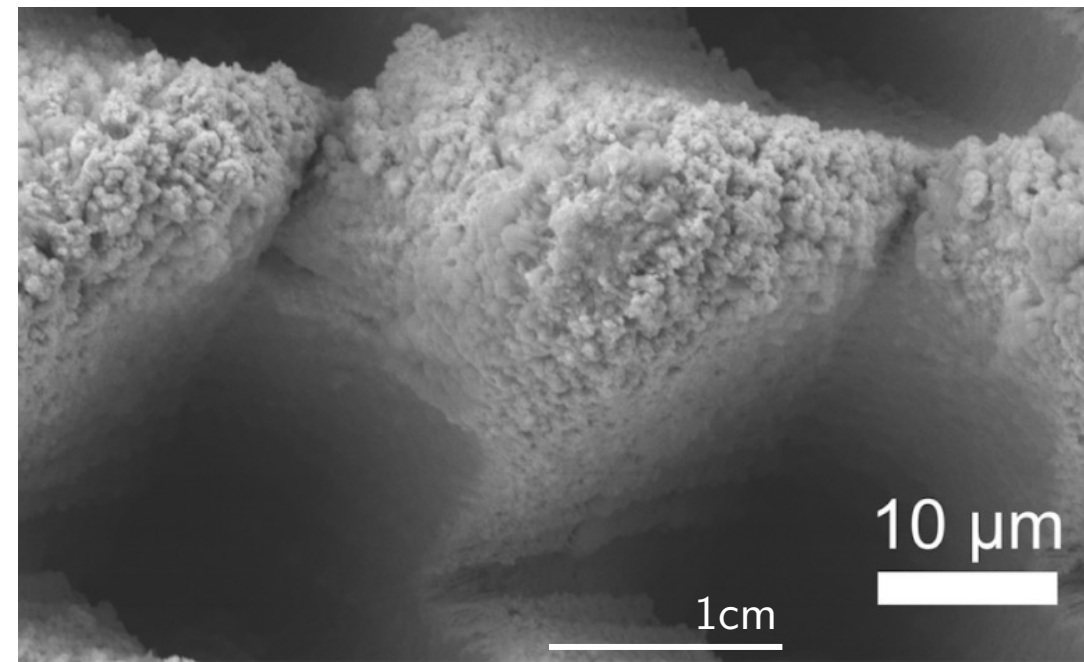
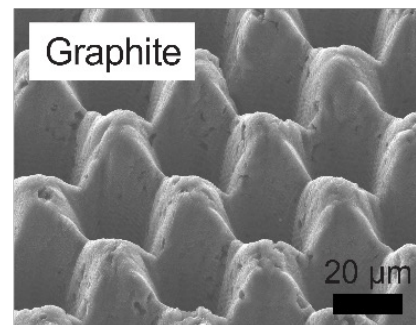
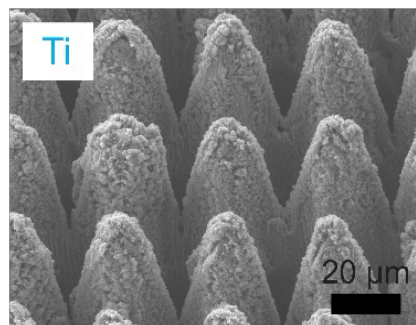
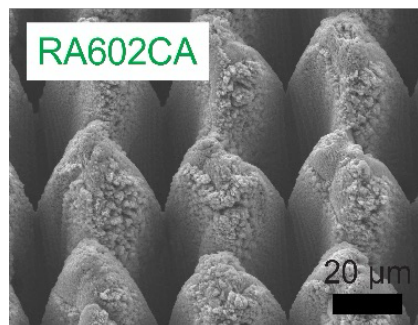
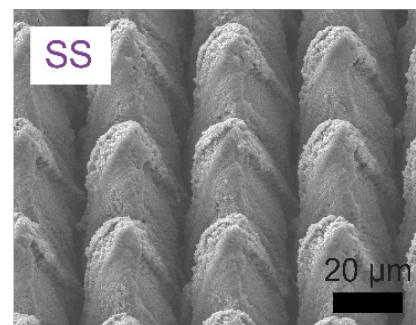
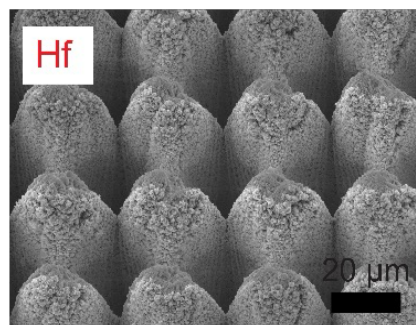
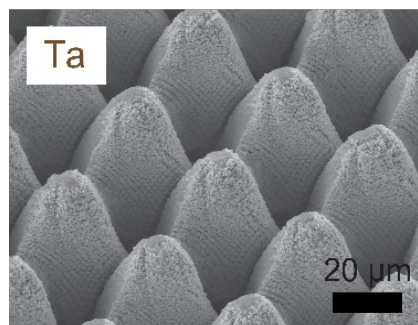
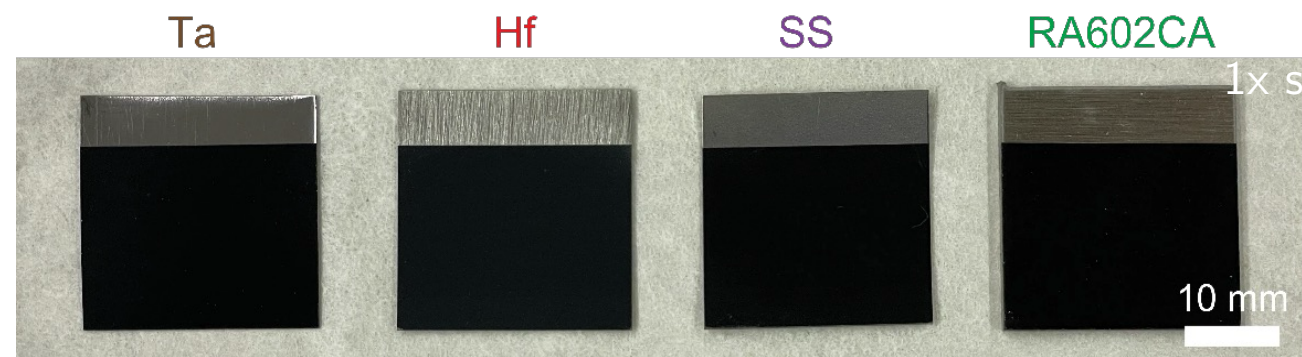
500 fs pulse width

200 kHz rate

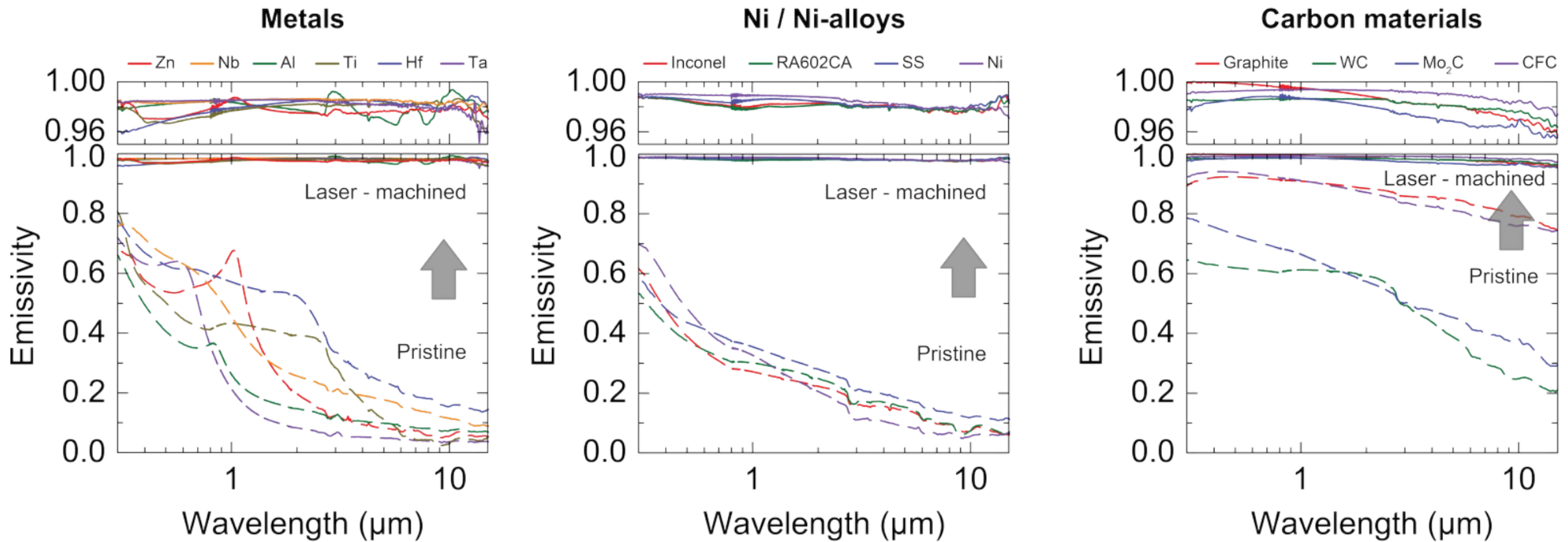
2000 pulses per location

24 μJ energy30 μm spacing

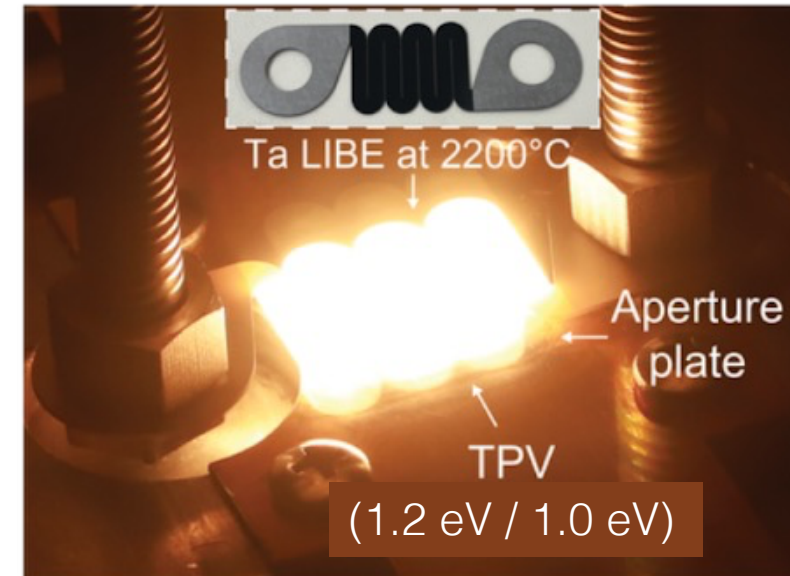
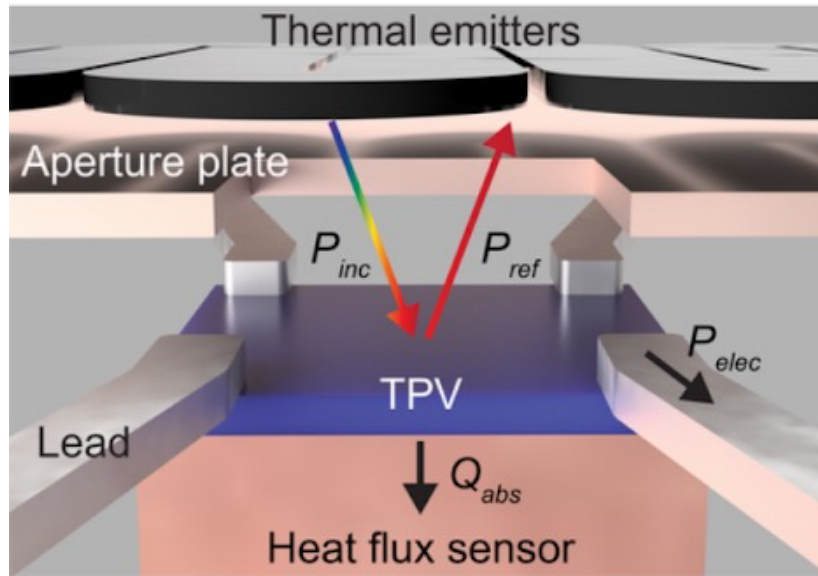
We can make any surface black



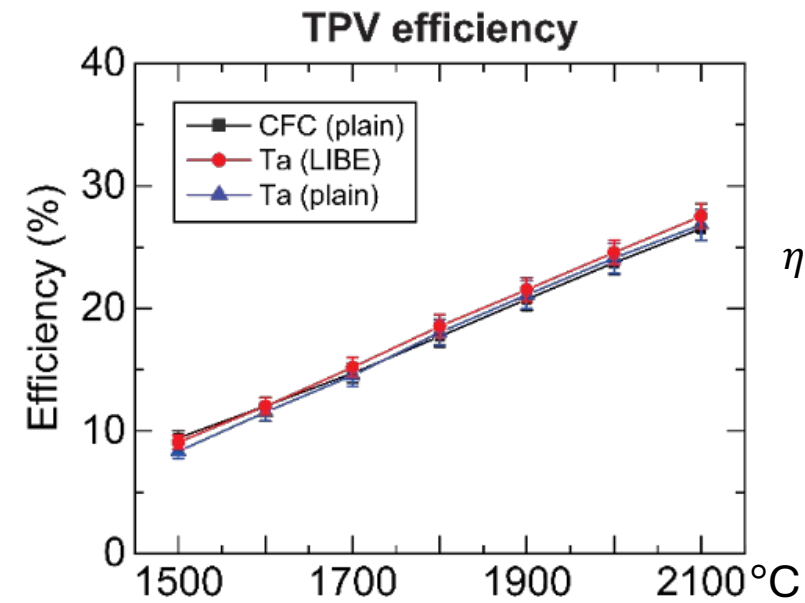
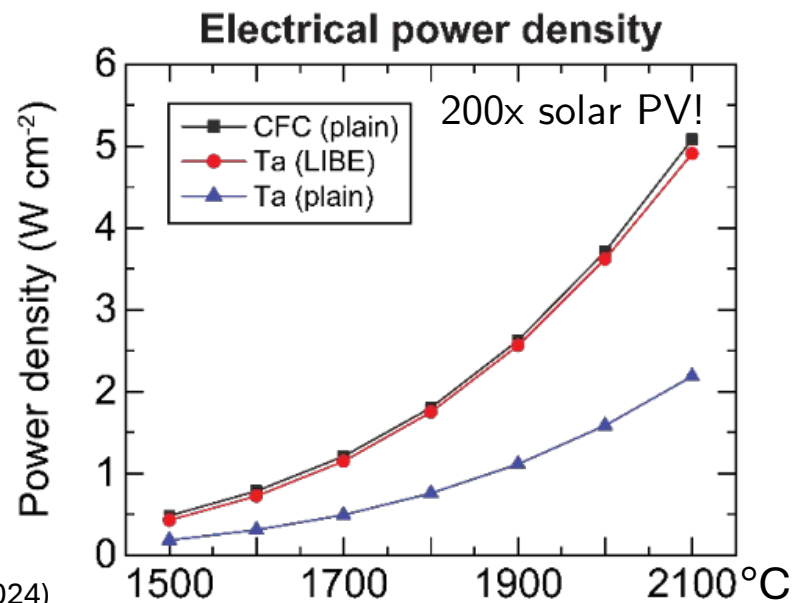
Emissivity before vs. after laser processing



Laser processed emitters and TPV power density



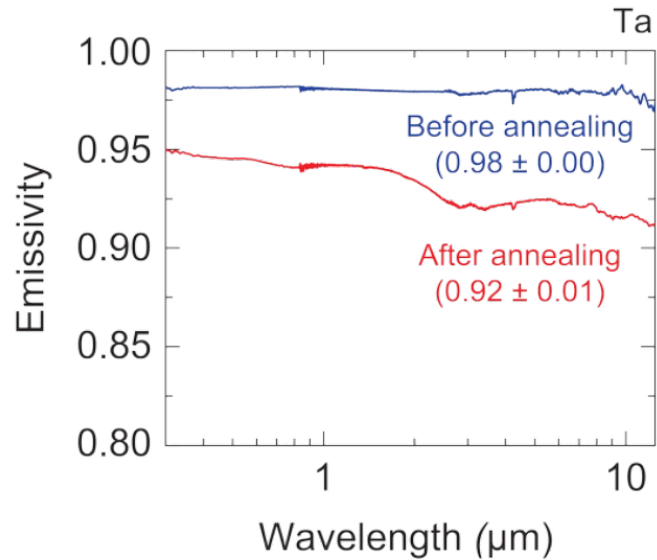
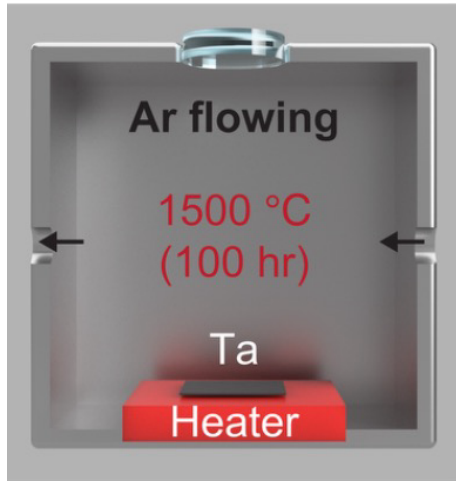
AlGaInAs /
GaInAs
+ Au BSR



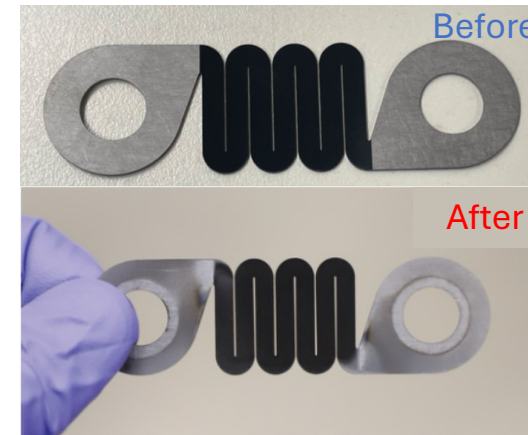
$$\eta_{TPV} = \frac{P_{elec}}{P_{elec} + Q_{abs}}$$

Durability of laser processed emitters

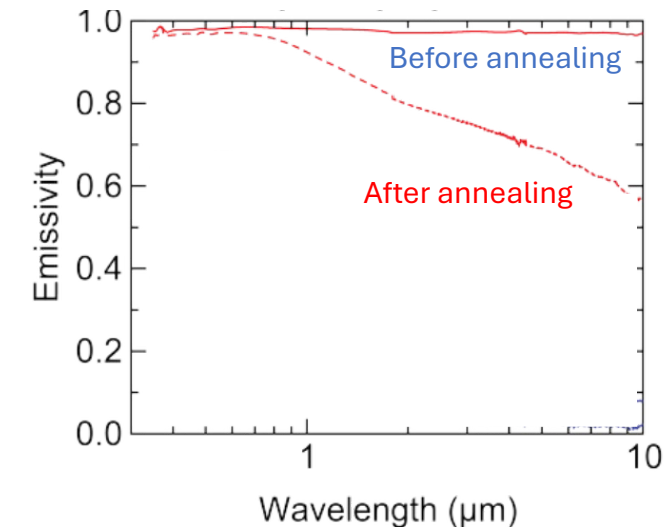
Low-temp, long-duration, oxidizing



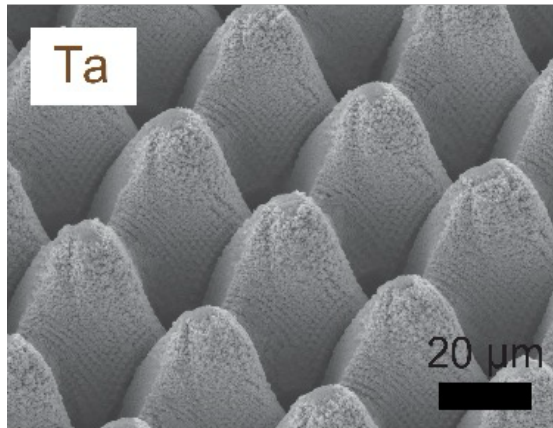
High-temp, short-duration, reducing



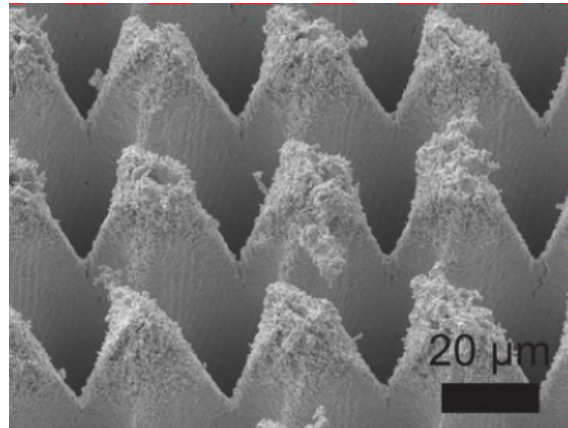
1500-2100C step heating
10 min each



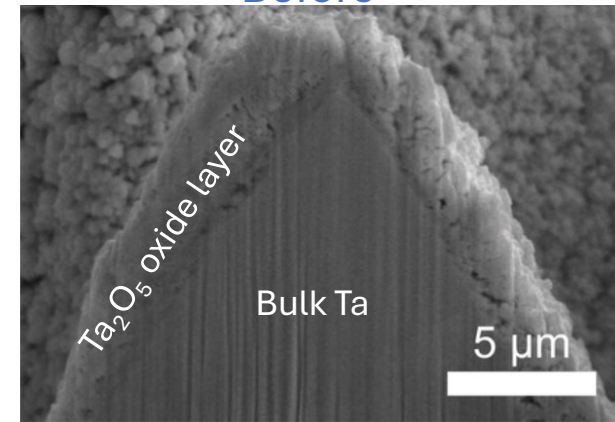
Before



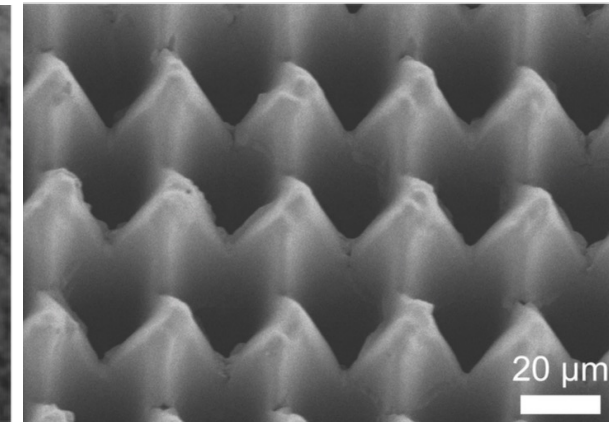
After



Before

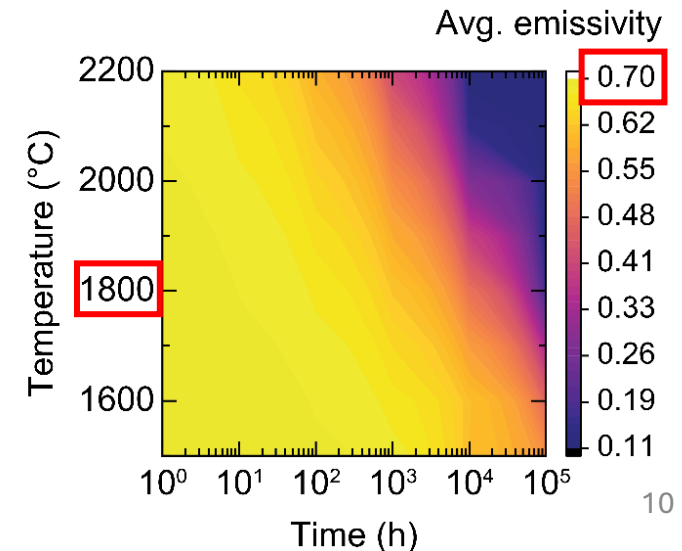
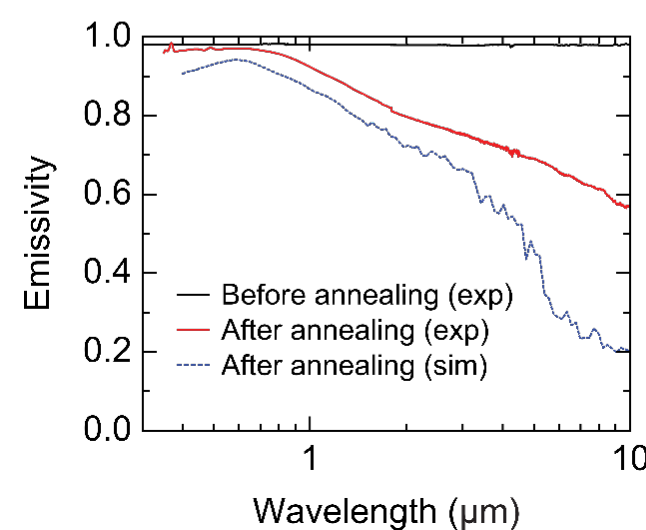
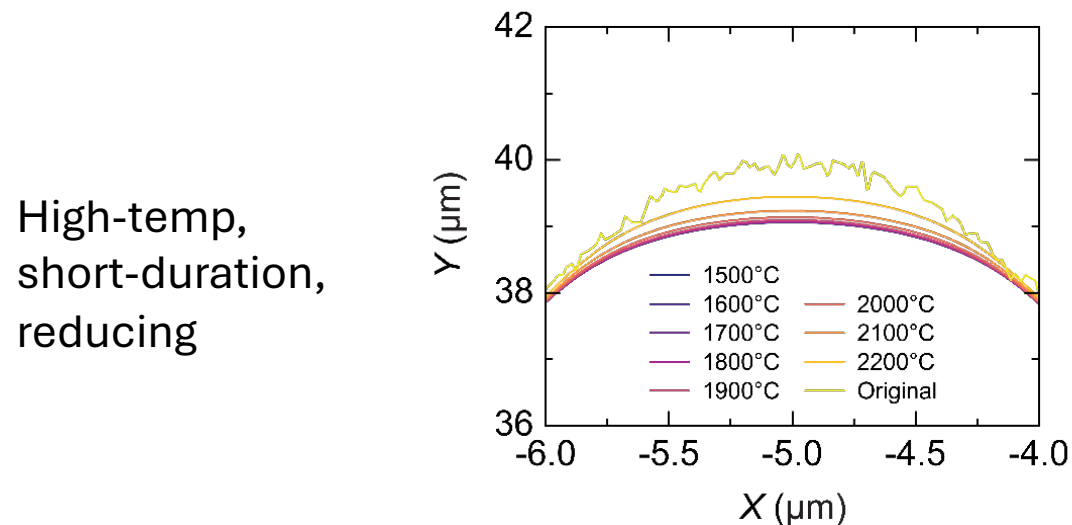
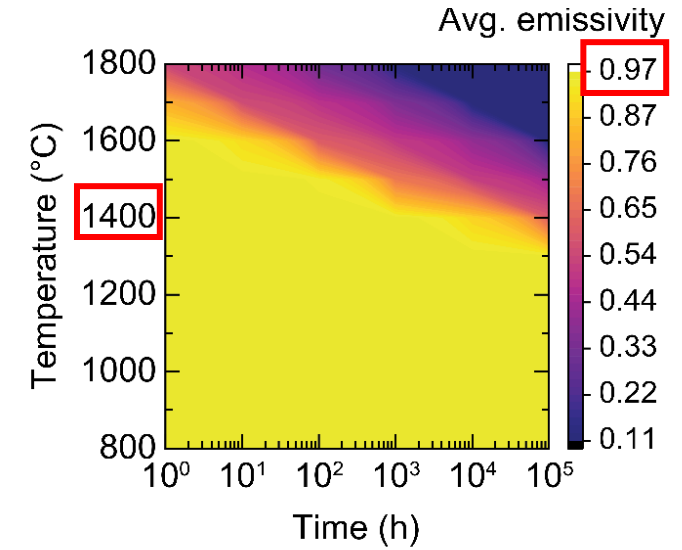
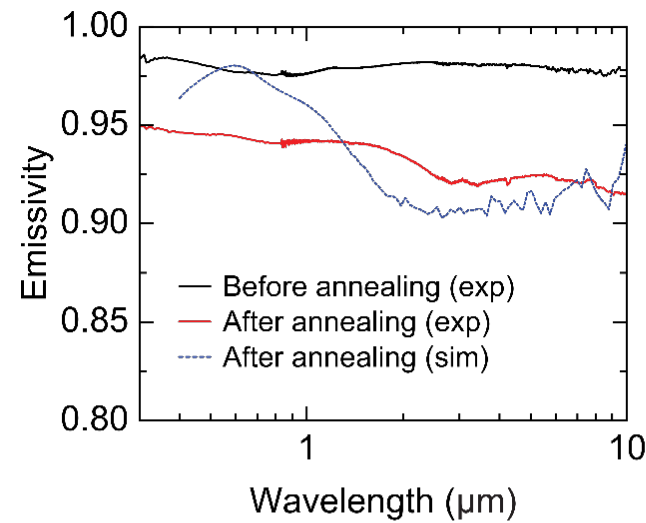
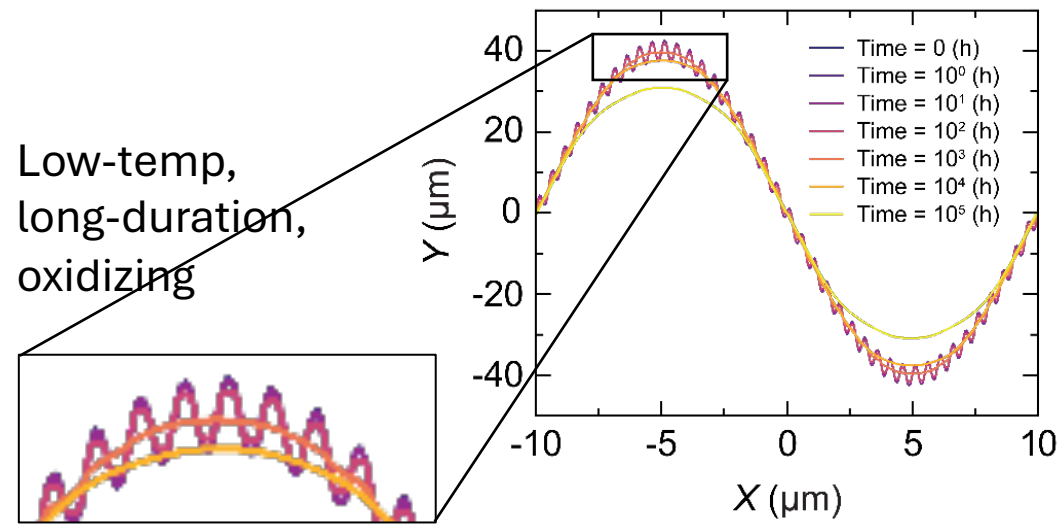


After

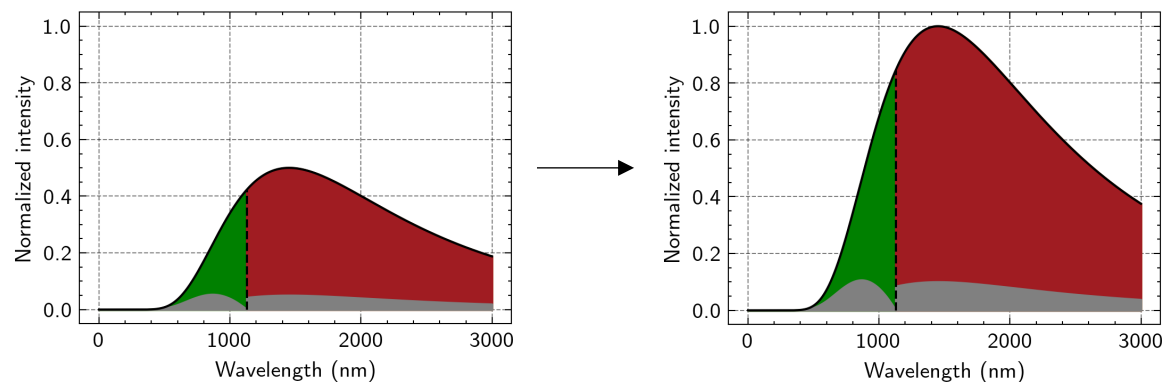


Modeling sintering to extrapolate durability testing

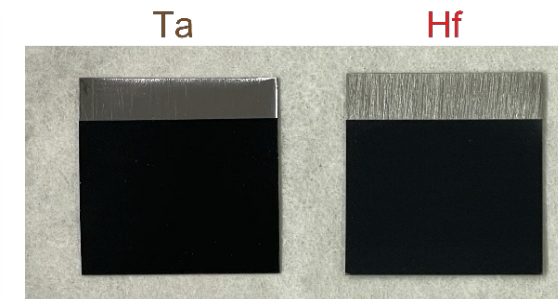
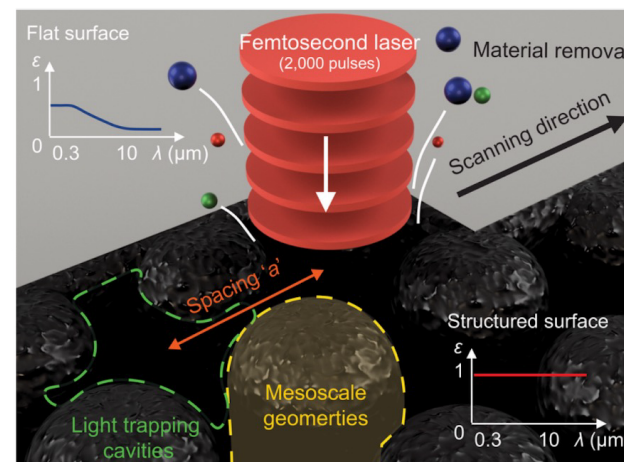
(Including surface diffusion + vapor pressure effects)



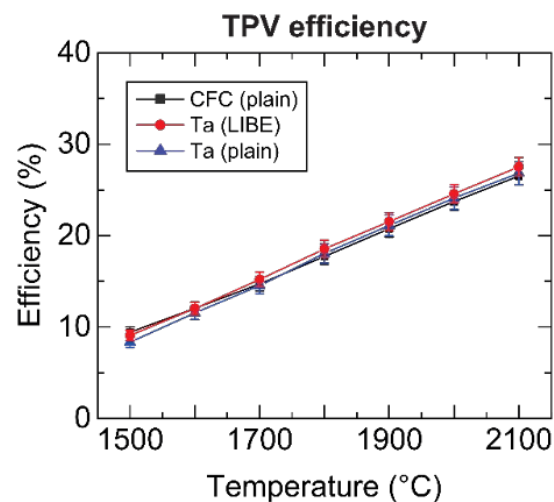
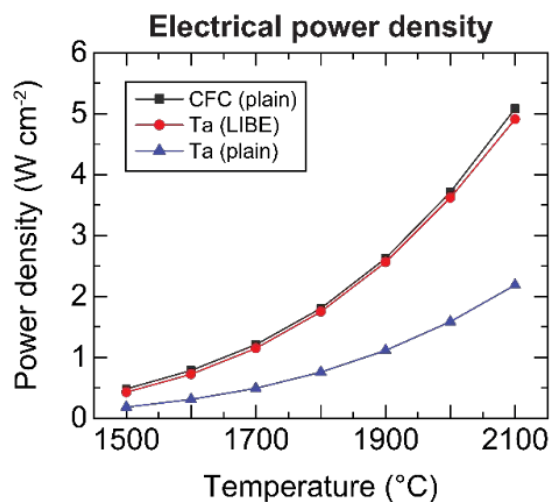
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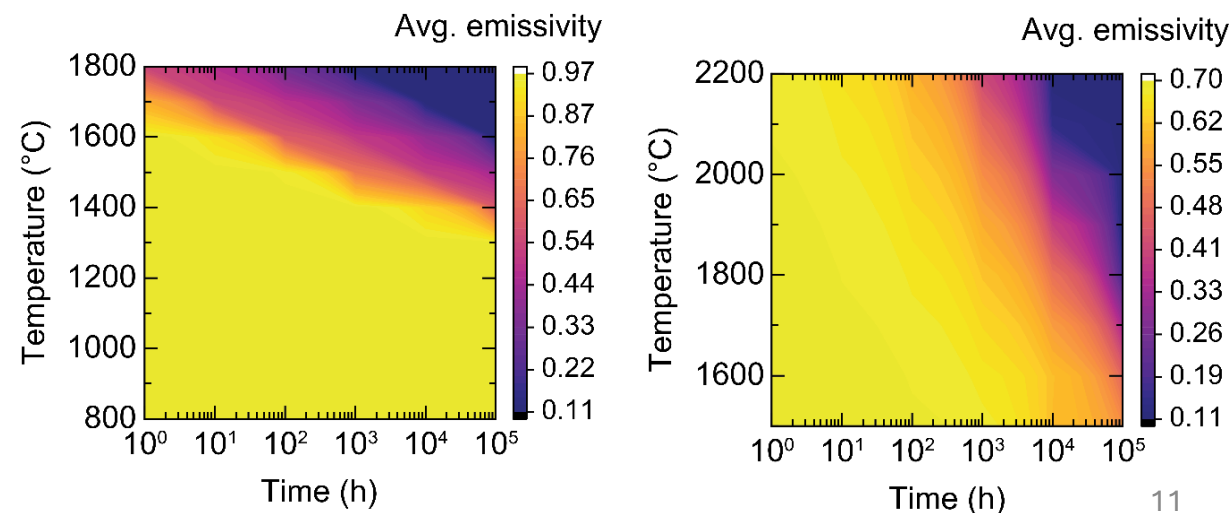
2. How can we create high-emissivity materials?



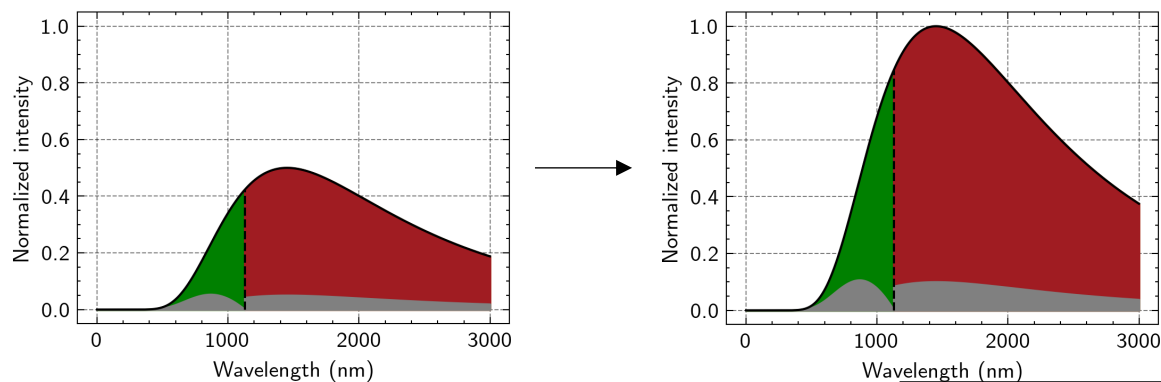
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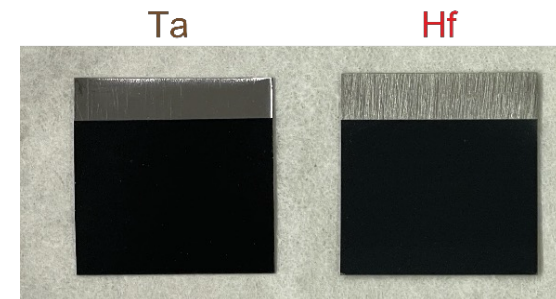
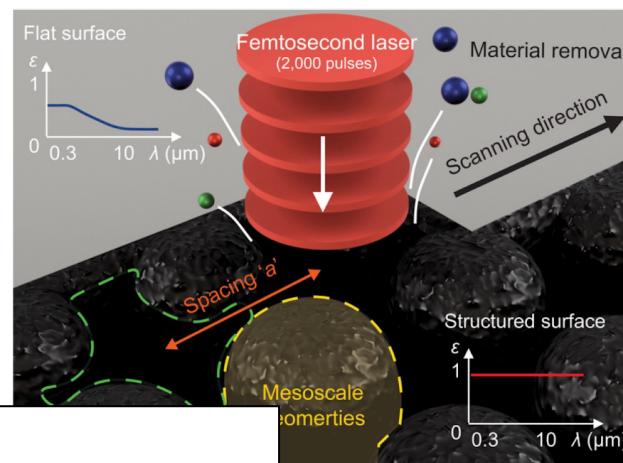
4. How long do the emitters last?



1. Why do we want black surfaces?

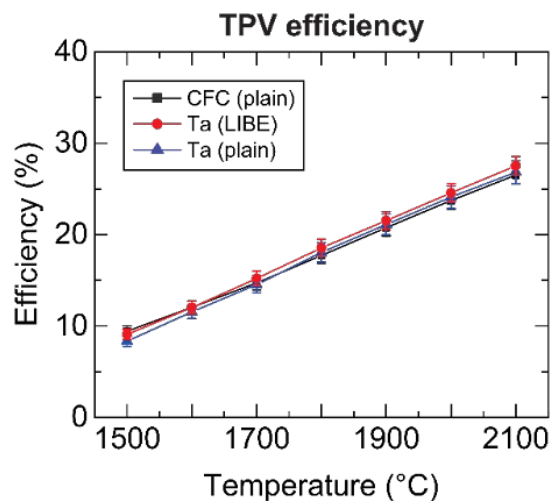
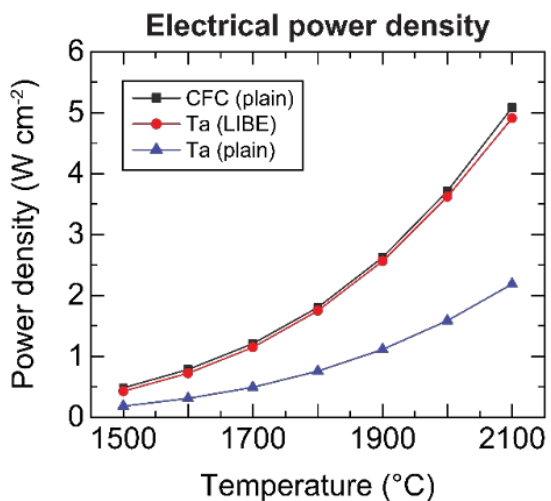


2. How can we create high-emissivity materials?



Questions?

3. How do TPV cells perform with these emitters?



4. How long do the emitters last?

