Additively Manufactured SiC Receiver Design for High Temperature CST

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Heliogen R&D

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Date: Feb. 15, 2024

This presentation is prepared based upon work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under Solar Energy Technology Office (SETO) Award Number DE-E0009804. The views expressed herein do not necessarily represent the views of the U.S. Department of Energy or the United States Government.

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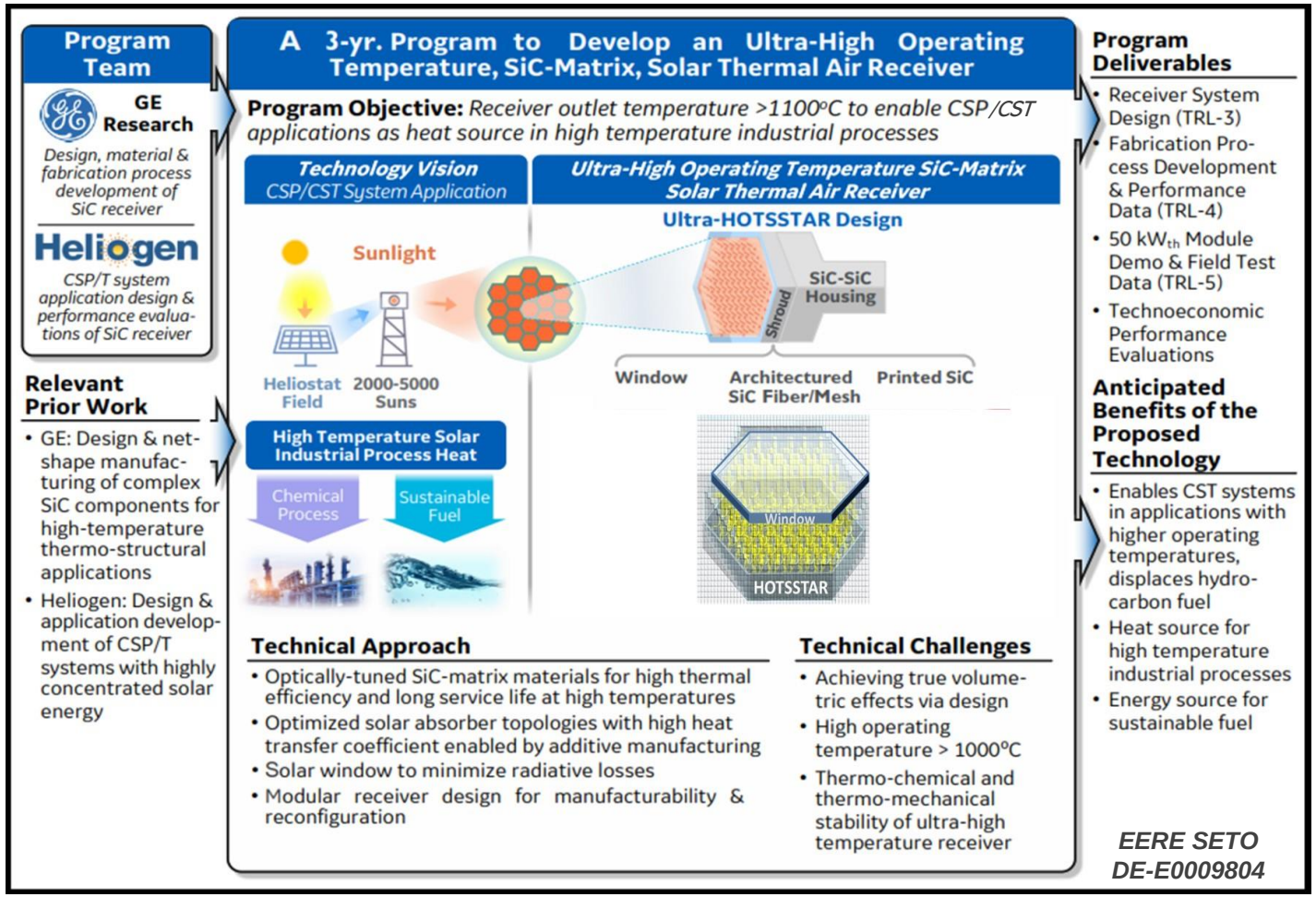
Ultra-HOTSSTAR Program



Develop techno-economically viable Ultra-high temperature SiC air receiver for CST applications

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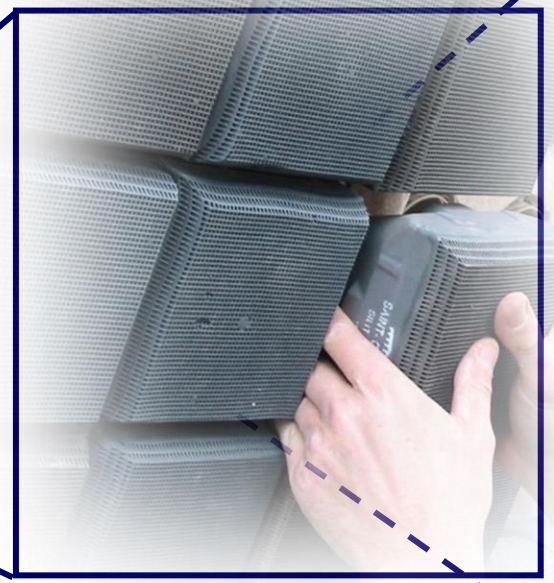
State-of-the-art SiC air receivers

"Gemasolar Thermosolar Plant“ Seville, Spain (picture from NREL report).

Receiver Module



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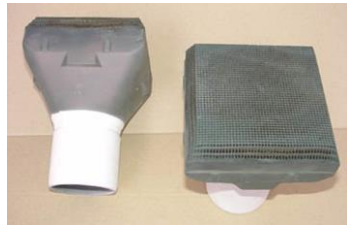
https://stobbe.com/research/solar-energy/solair/

Receiver Elements
Design & Fabrication Methods

Extruded Channels/Honeycomb

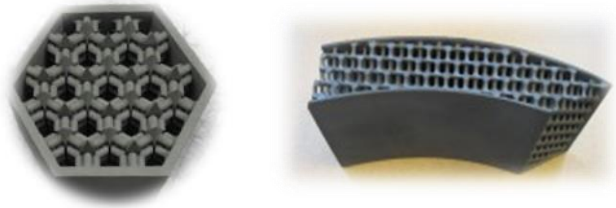


https://stobbe.com/research/solar-energy/solair

Cast Cellular Foam (Reticulated)

MDPI Open Access Article, https://doi.org/10.3390/ma14164687

Additively Manufactured Architectures



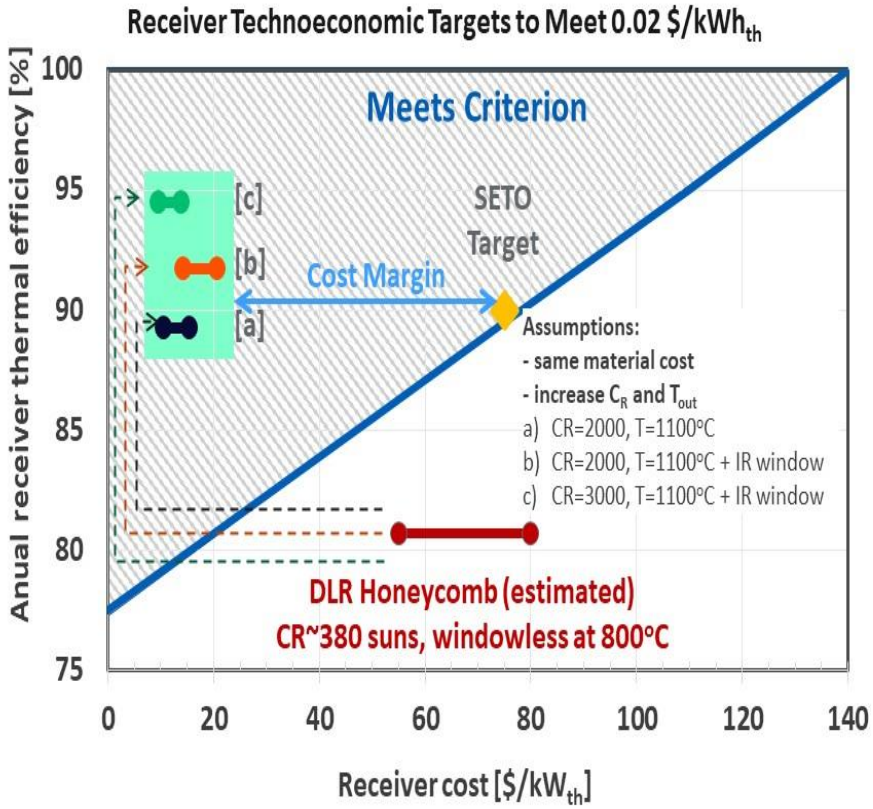
Leading design concept for SiC volumetric air receivers in CSP applications

Receiver design techno-economic & performance objectives

SETO 2030 CSP/CST Goal	150 [$/kW$_{th}$]
SETO 2030 CSR Goal	75 [$/kW$_{th}$]

Concentration ratio, CR	1000	2000	3000
Solar-to-thermal efficiency	0.90	0.90	0.90
Solar power [kW/m^2]	810	1620	2430
Solar receiver cost target [$/m^2]	60,750	121,500	182,250
0.2m x 0.2m CSR unit, cost limit [$]	2,430	4,860	7,290

Receiver system cost objective flow-down



Receiver efficiency vs receiver cost and concentration

High thermal efficiency at high solar concentration enables economically viable high temperature receivers

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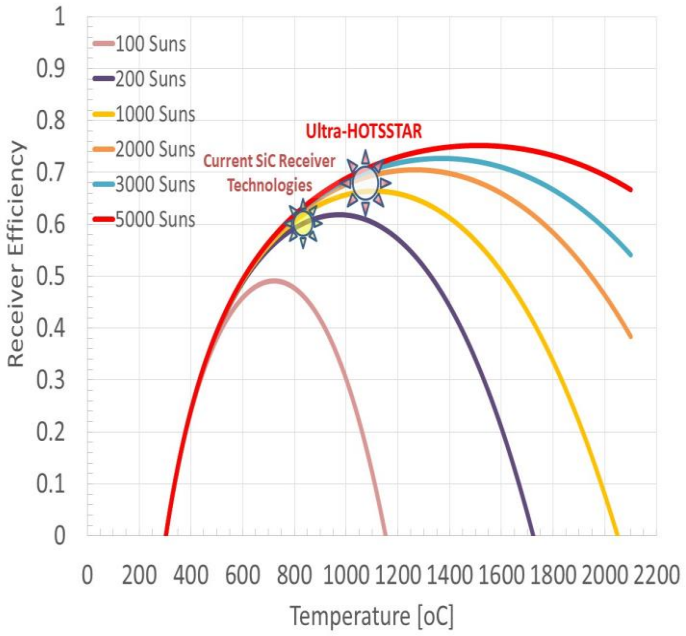
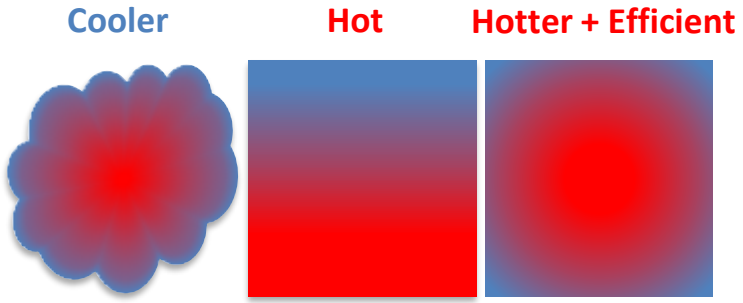
Multi-objective receiver system design strategy

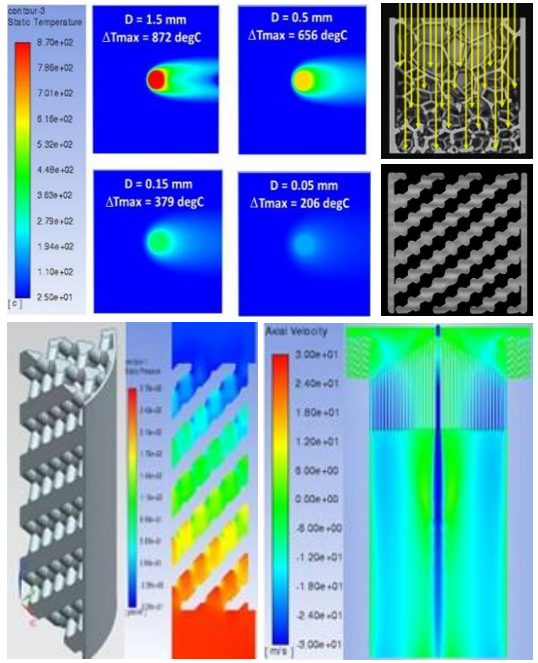
Maximize Concentration



Minimize Spillage of Lower-flux Designs



Optimize Heat Transfer & Efficiencies
Feature Size, Topology and Receiver Architecture



Solar concentration, aiming strategy and receiver architecture to achieve high temperature designs

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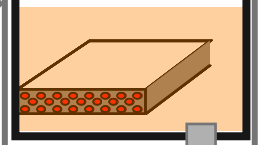
GE Printed SiC and CMC fabrication process flow

Currently exercised in lab scale, TRL-4/-5

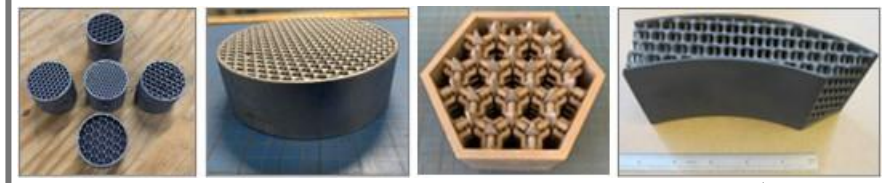
Additive SiC Process

Printed SiC Parts

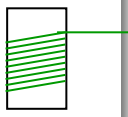
Polymer Impregnation



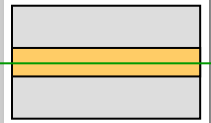
Finished Monolithic SiC Part



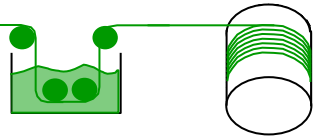
GE SiC CMC Process



SiC fiber

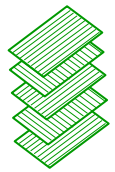


Fiber coating

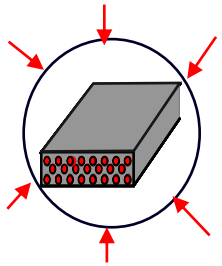


Slurry prepregging

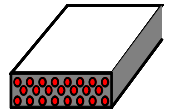
Wet drum winding



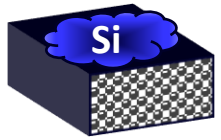
Lay-up preforming



Autoclave Compaction

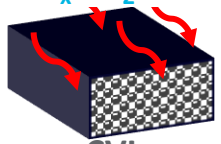


Burn Out / Pyrolysis



Melt-Infiltr.

$SiM_x + H_2 = SiC$



CVI

Machining

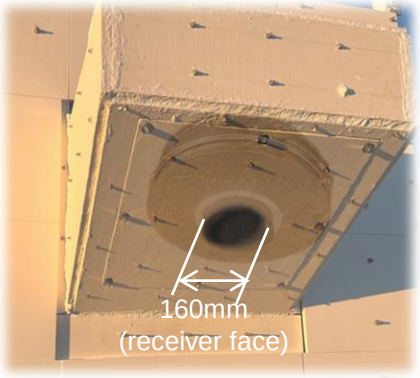
Inspection

Currently in commercial manufacturing use for GE Aerospace turbine engine products, TRL-9/MRL-9

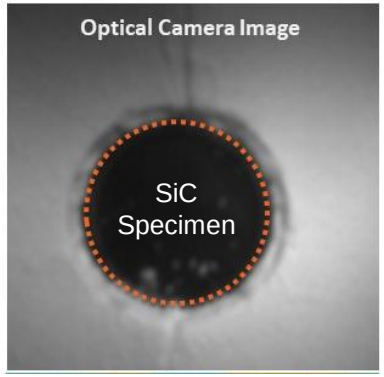
GE SiC CMC process know-how and scalable manufacturing infrastructure applied to printed SiC components

Ultra-HOTSSTAR feature specimen test & evaluation

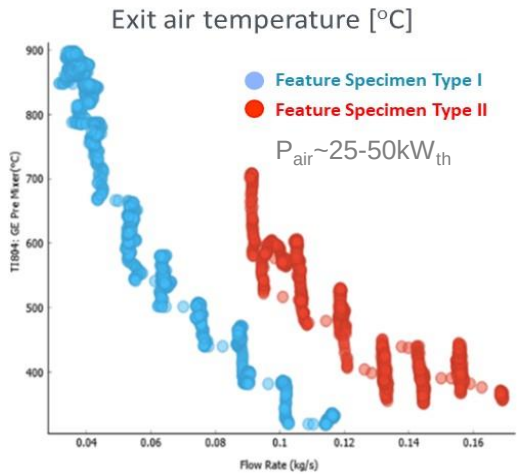
Heliogen Solar Tower

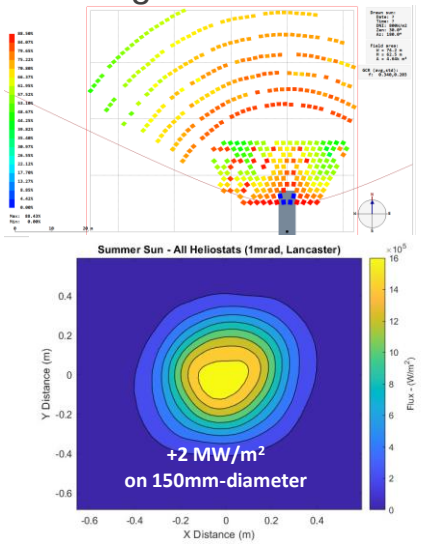


Mounted Printed SiC On-Sun Test

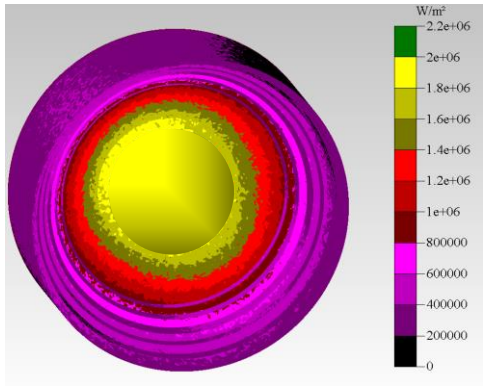


In-situ Visual Observations

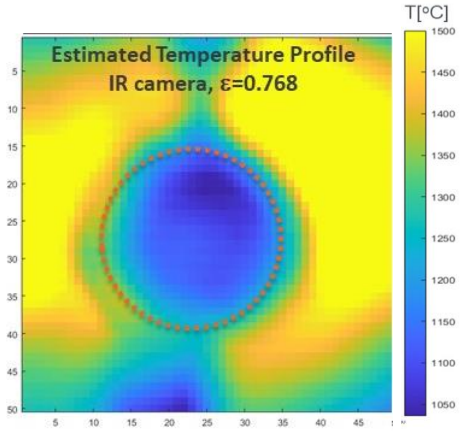




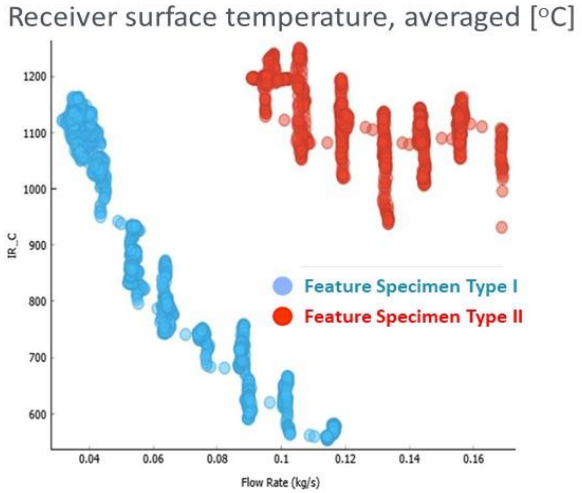
Heliostat Field Mapping



Ray Trace Simulations



In-situ Surface Temperature Profile

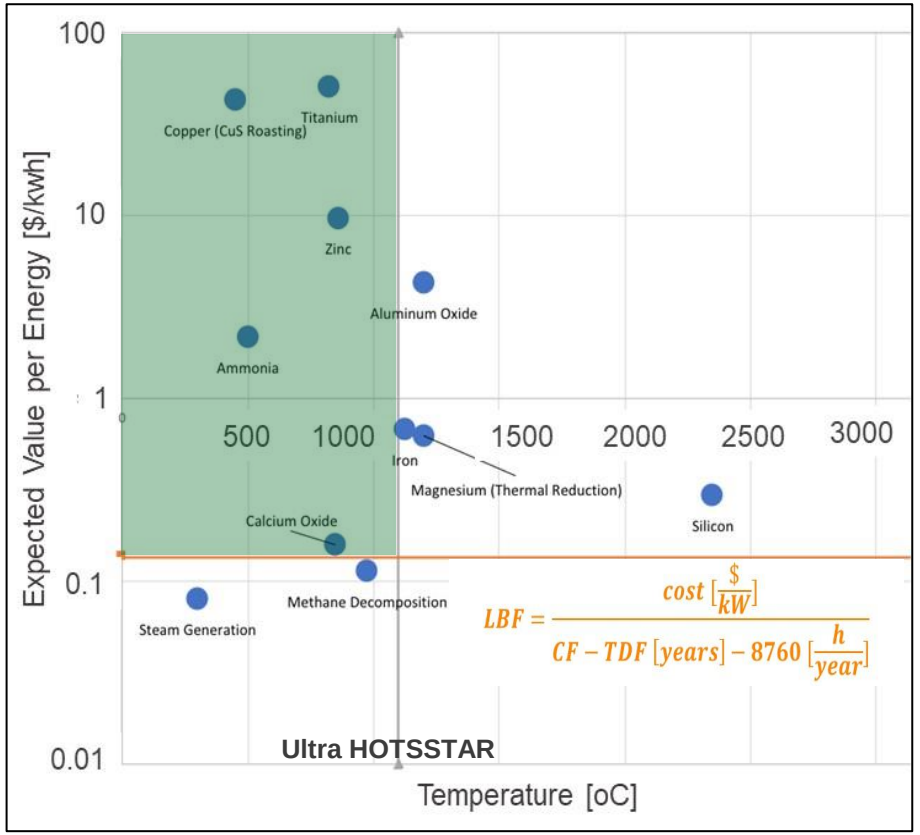


Post-test Performance Analysis

GE Aerospace

Next steps

- Receiver module “alpha design” fabrication and assembly
- On-sun testing of alpha design and optimization toward “beta design”
- Final testing and techno-economic evaluation/survey of potential application space of Ultra-HOTSSTAR



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