Robust Solar Receivers Using MAX Phase Materials

1. Impact
To achieve the Gen3 2030 cost target of $0.05/kWₑ for CSP, advanced receiver materials and designs are needed to collect thermal energy to operate efficient high-temperature (>700 °C) super critical s-CO₂ power cycles.

2. Project Goal
To develop MAX phase based ceramic materials and associated low-cost fabrication methods to demonstrate their feasibility as receiver materials that can operate at conditions where current high-temperature alloys cannot perform.

3. Method(s)
Using combined thermal and stress modeling to develop an optimized receiver design. Leveraging ceramic powder processing, binder jet additive manufacturing, and reactive melt infiltration (RMI) techniques to fabricate the MAX phase (Ti₃SiC₂) material. Performing thermo-physical characterizations on materials and lab-scale prototypes.

4. Outcome(s)
Modeling effort showed the feasibility of the MAX phase material receivers with long-term reliability for Gen3 application. Binder jet printed and infiltrated samples were fabricated with bulk densities >95% of theoretical values. However, surface cracking was observed post infiltration. Thermo-physical properties of the bulk Ti₃SiC₂ are comparable to literature values.

5. Conclusion/Risks
Feasibility of MAX phase materials for the Gen3 receiver application has been evaluated. Next steps are to mitigate the surface cracking by control of RMI process, demonstrate fabrication of prototype receiver tubes, and perform key characterizations.

6. Team
Argonne National Laboratory