

SolarPACES Task II Technology Innovation

Ivan Ermanoski, Paul Gauché

Sandia National Laboratories

**Many thanks to the researchers who kindly provided
the material for this Task II update.**



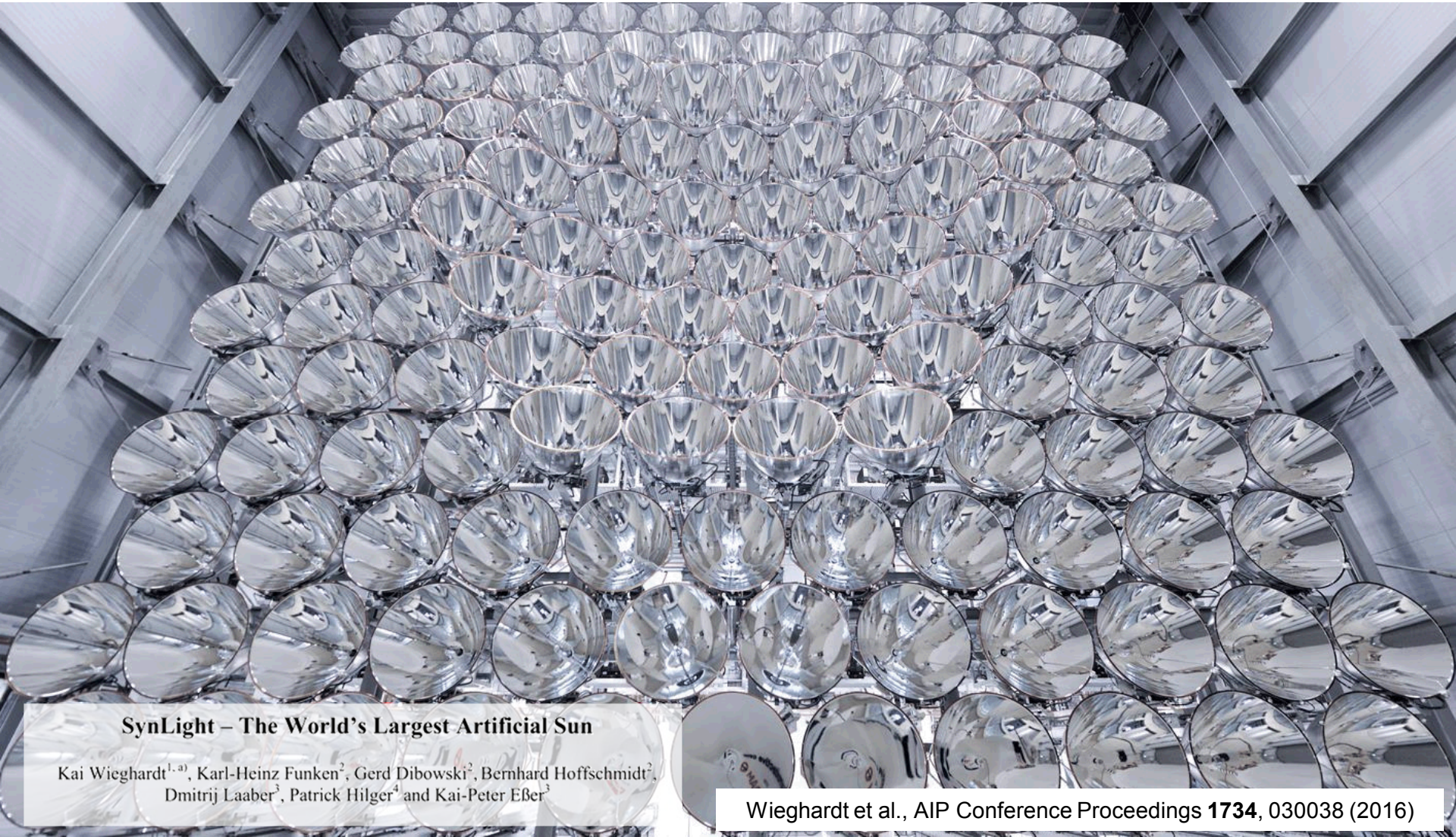


About Technology Innovation

- Novel high-temperature solar reactor materials and components
- Advanced redox active materials
- Advanced heat recovery systems for solar thermochemical processes
- Advanced optics for high solar flux intensities and high temperatures.

High Solar Flux: Synlight at DLR Jülich

149 Lamps, 380 kW, 10 000 Suns



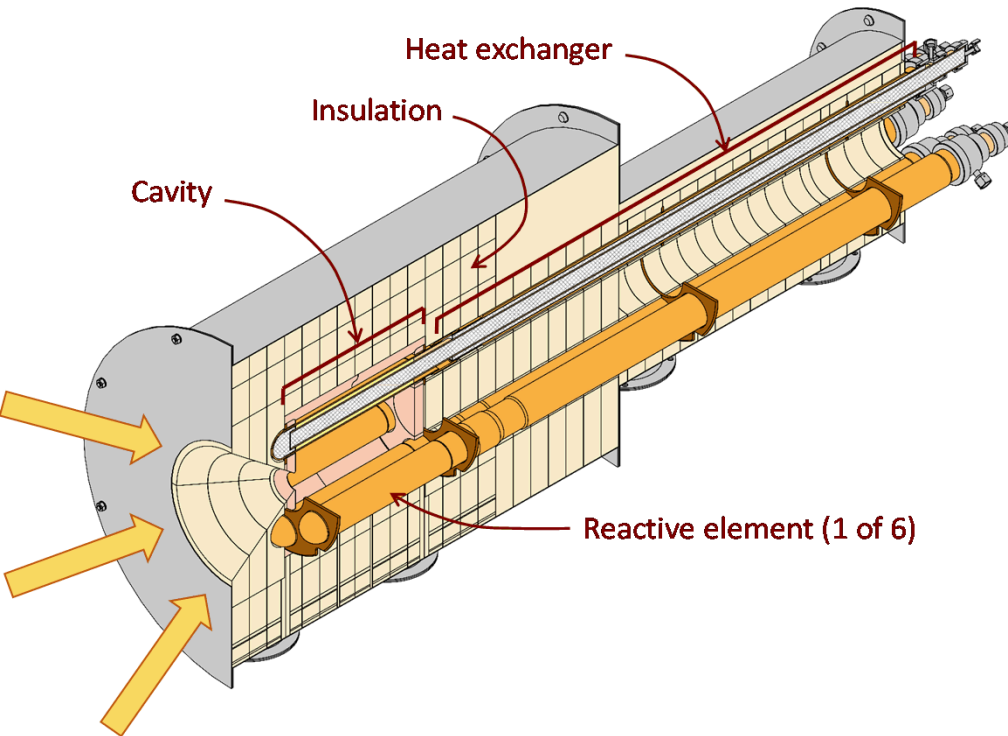
SynLight – The World's Largest Artificial Sun

Kai Wieghardt^{1,*}, Karl-Heinz Funken², Gerd Dibowski², Bernhard Hoffschmidt²,
Dmitrij Laaber³, Patrick Hilger⁴ and Kai-Peter Eßer³

Wieghardt et al., AIP Conference Proceedings **1734**, 030038 (2016)

Advanced Heat Recovery: UMN

- Continuous Co-production of separate streams of syngas and hydrogen
- Demonstrated 90% effective heat recovery of gas-phase sensible heat

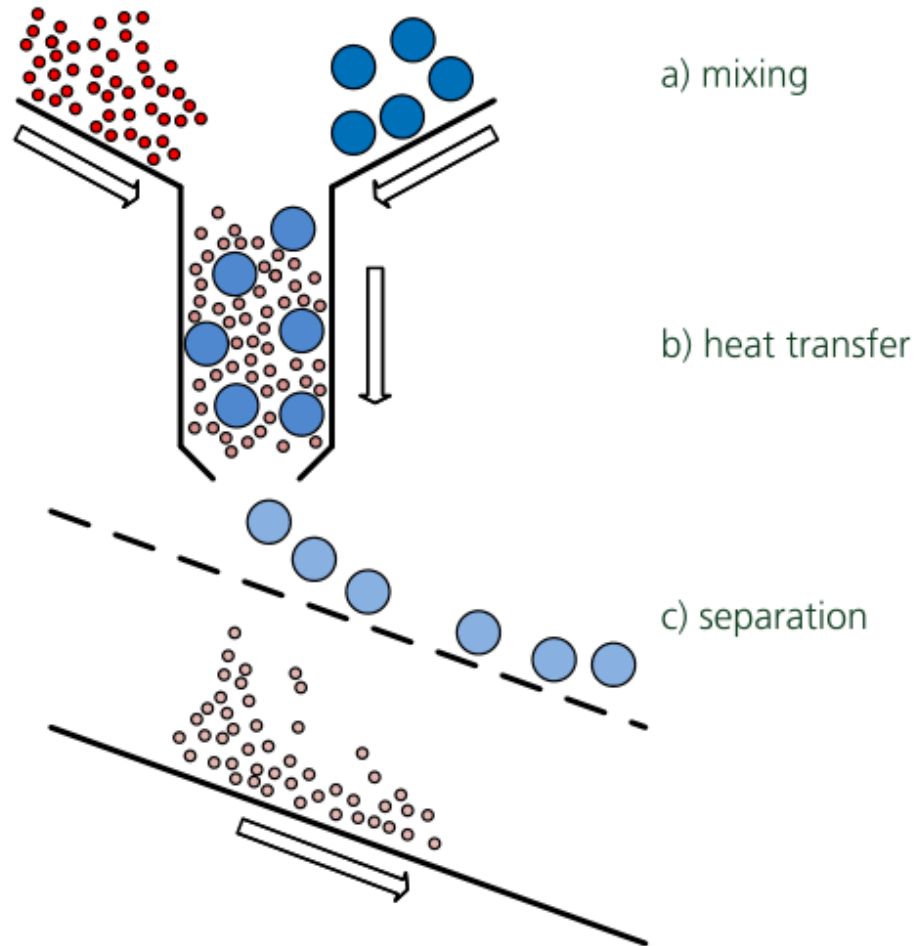


Prototype Reactor

- Mechanically robust with 6 tubular fixed beds, each integrated with counterflow heat exchanger
- porous fiber ceria particles developed with industry
- Demonstrated for >9000 cycles in solar simulator
- Integrated gas phase heat recovery
 - **93-95% sensible heat recovery from reactant and product gases in an integrated ceramic HX**
- Process under development is based on partial oxidation of methane coupled with water splitting
 - **Efficiency approaching 50% based on measured reaction rates, conversion and selectivity**
 - **Demonstrated on-sun for 7 hours with 1 of 6 tubular reactive elements, achieving 7% efficiency**

Advanced Heat Recovery: DLR

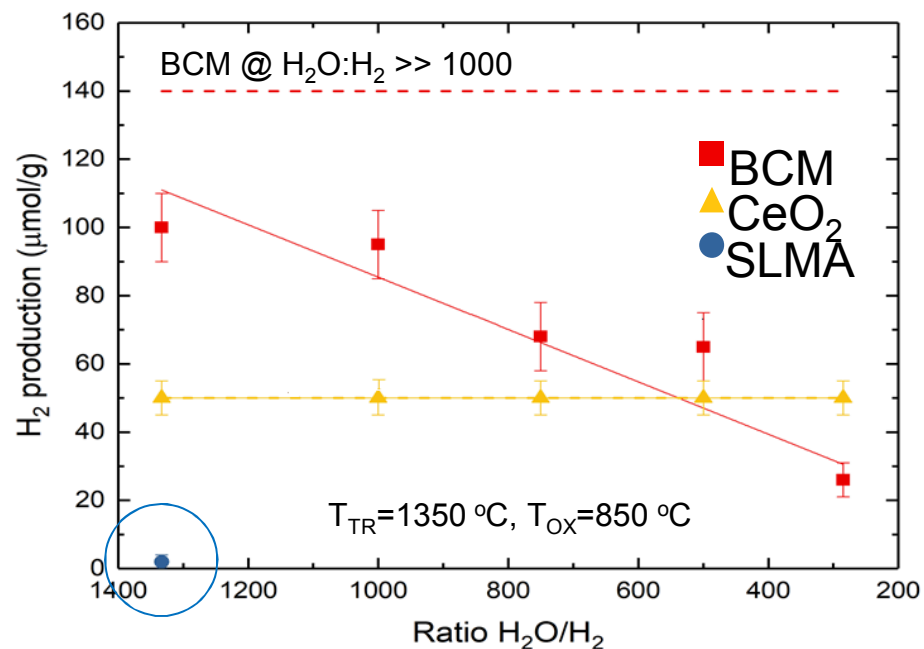
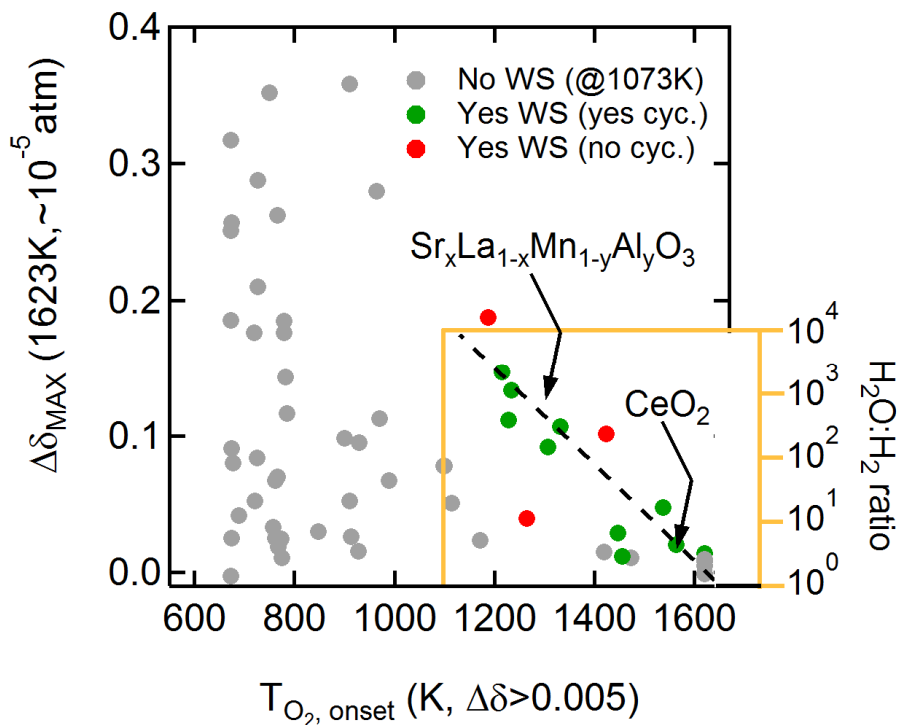
Heat recovery using a solid heat transfer medium



Advanced Redox Materials: Sandia-H₂

Tradeoffs between $\Delta\delta$, T_{TR} , and $H_2O:H_2$ is necessary to challenge CeO_2

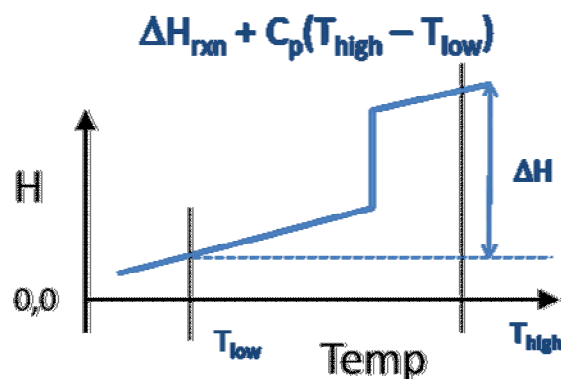
ABM outperforms SLMA at more commercially relevant $H_2O:H_2$ ratios



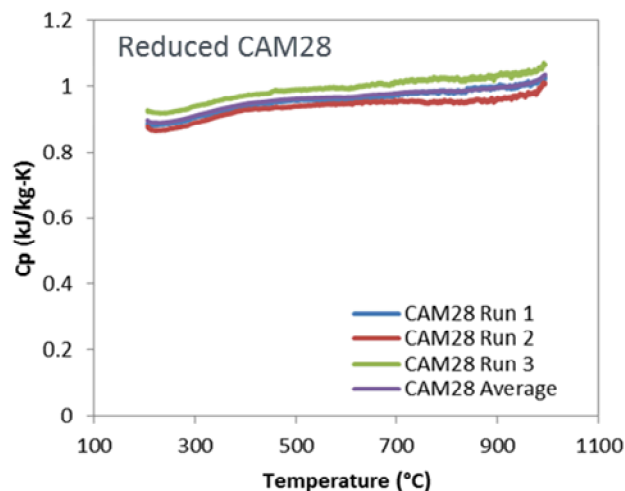
Advanced Materials: Sandia TC Storage

$$\Delta H_{\text{tot}} = \Delta H_{\text{rxn}} + C_p \Delta T$$

Chemical + Sensible Energy Storage



Measured heat capacity as a function of temperature



Candidate material	Mol weight (g/mol)	$T_{\text{red Onset}}$ (°C)	Max δ	ΔH_{rxn} (kJ/kg) (at δ_{max})	C_p (kJ/kg-K)	ΔH_{tot} (kJ/kg)
LSCM3791	209.5	343	0.461	242	*0.595	837
CTM28	141.6	901	0.293	393	*0.881	1274
CAM28	135.8	759	0.322	371	*0.910	1281

*Estimated Values: $C_p = 3R \cdot N$ (J/mol-K) = 15R, $T_{\text{high}} = 1200$ °C, $T_{\text{low}} = 200$ °C