# Einfluss von Mineralstäuben auf keramische Solarabsorber

Martin Schmücker
Deutsches Zentrum für Luft- und Raumfahrt
Institut für Werkstoff-Forschung

51147 Köln

Deutsches Zentrum für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

15. Kölner Sonnenkolloquium

Honeycomb SiC absorber (new)

Honeycomb SiC absorber (used, few 10 h)

# Outline

- Model dust
- Accelerated dust deposition on SiC absorber components
- Temperature dependent dust adhesion
- Estimation of dust deposition under real conditions
- Melting of dust particles and SiC corrosion
- Influence on light absorbance and efficiency
- Conclusions

# Inorganic dust compositions

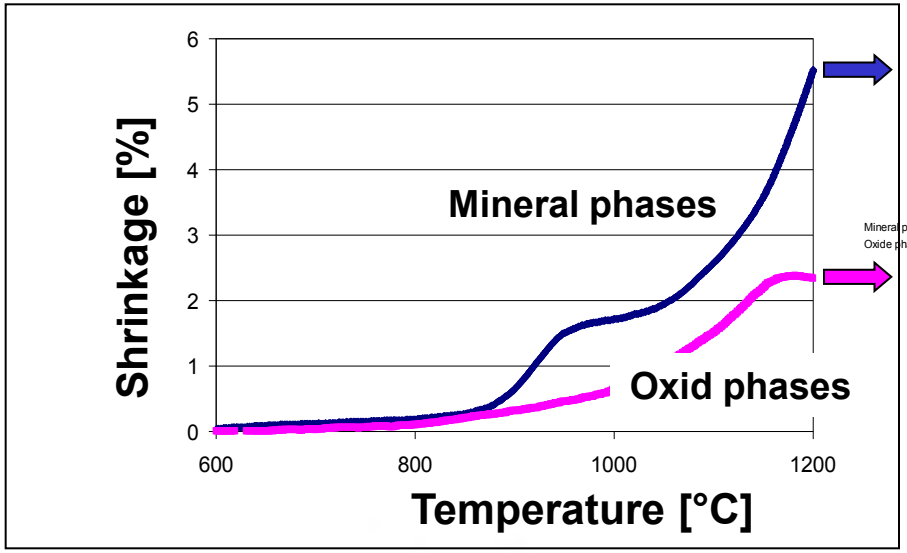
| Elements | Litho-sphere | Silica-rich *"Arizona road dust"* | Lime-rich (= *desert dust close to Cairo)* |
|---|---|---|---|
| $SiO_2$ | 61,5 | 72 | 39 |
| $Al_2O_3$ | 15,1 | 15 | 12 |
| $Fe_2O_3$/FeO | 2,36/3,52 | 4 | 7 |
| $Na_2O$ | 3,2 | 3 | 1 |
| CaO | 5,5 | 4 | 33 |
| MgO | 3,7 | 1 | 6 |
| $TiO_2$ | 0,60 | 1 | 0 |
| $K_2O$ | 2,40 | | 2 |

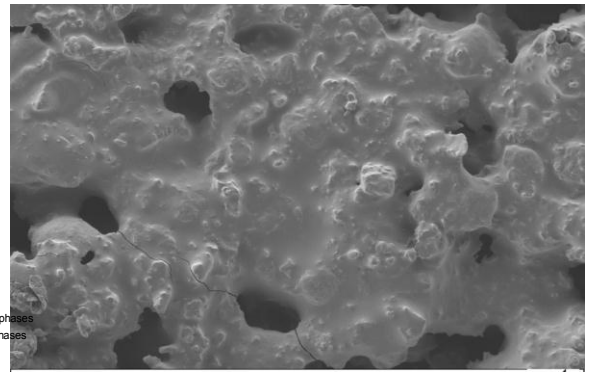
**Commercial available powder mixtures**

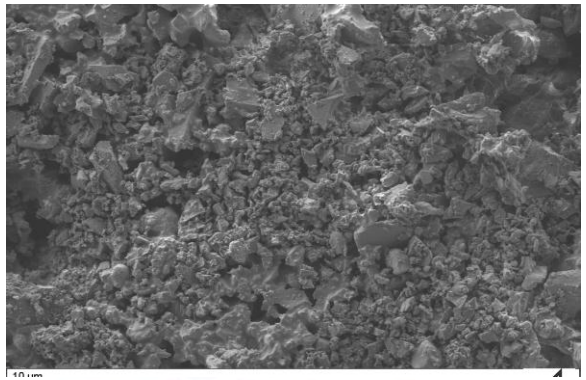

…Both methods, IR spectroscopy and XRD analysis, show that all investigated samples contain **quartz**, **feldspars** and **clay minerals** in different compositions. In addition, the samples from Cairo and Morocco contain significant amounts of **calcite, dolomite** and gypsum…

**From: Optical properties and mineralogical composition of different Saharan mineral dust samples: a laboratory study**
**C. Linke, O. Mohler, A. Veres, A´ . Mohacsi, Z. Bozoki, G. Szabo, and M. Schnaiter**

# Sintering of model oxide dust and mineral dust



Mineral constituents


Quartz Dolomite Calcite Clay minerals

# Outline

- Motivation
- Model dust
- **Accelerated dust deposition on SiC absorber components**
- Temperature dependent dust adhesion
- Estimation of dust deposition under real conditions
- Melting of dust particles and SiC corrosion
- Influence on light absorbance and efficiency
- Conclusions

# Test rig for accelerated deposition of mineral dust on SiC honeycomb structures

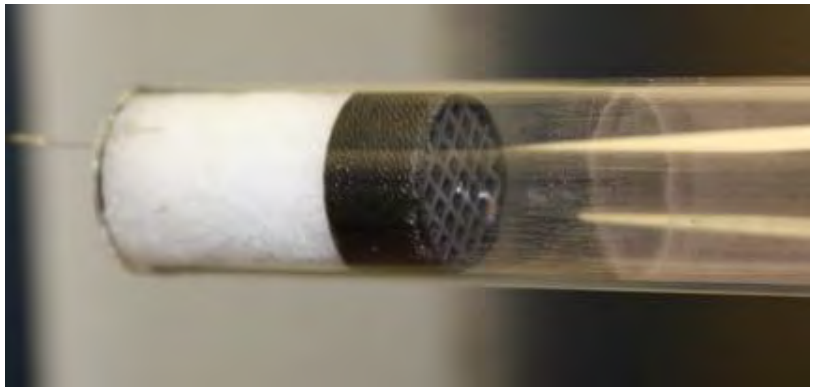

turbulent
fluidised bed

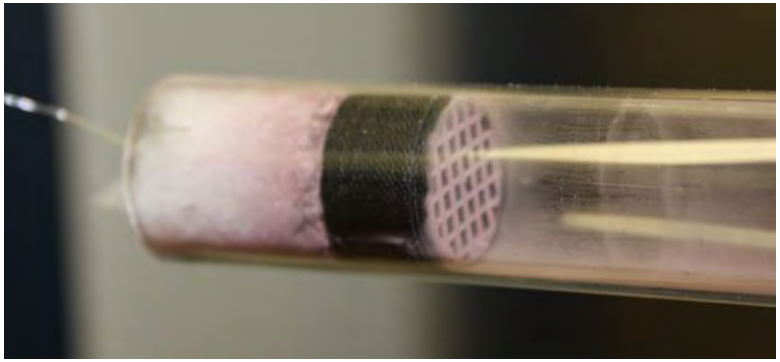
- **Particle transport by air flow**
- **Air flow corresponds to realistic conditions**
- **Cylindrical specimen within tube furnace**

# Outline

- Motivation
- Model dust
- Accelerated dust deposition on SiC absorber components
- **Temperature dependent dust adhesion**
- Estimation of dust deposition under real conditions
- Melting of dust particles and SiC corrosion
- Influence on light absorbance and efficiency
- Conclusions

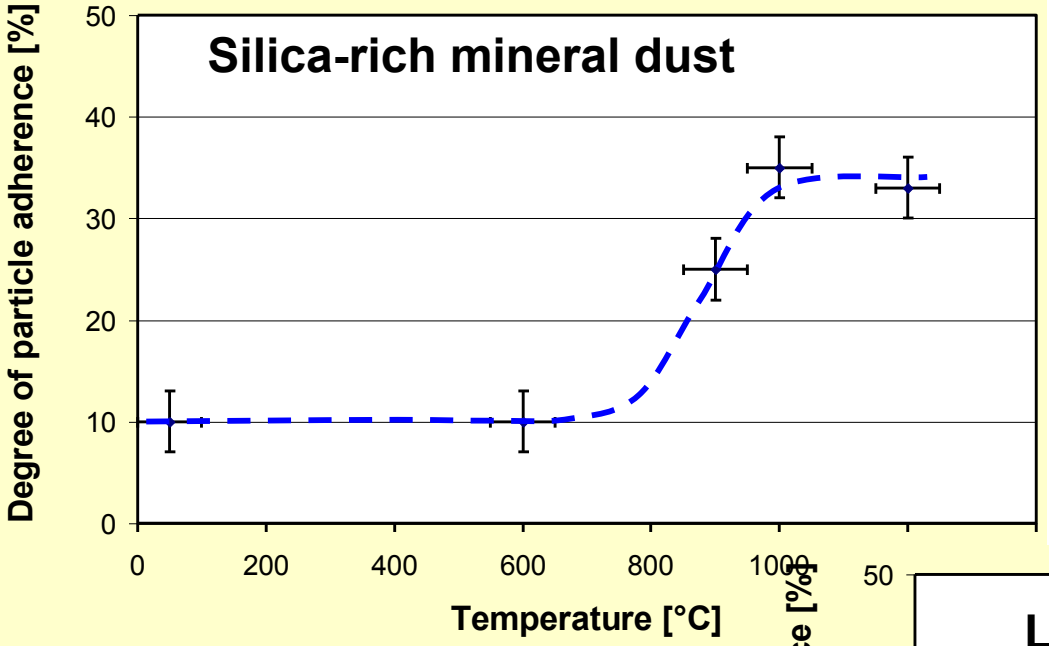
# Temperature dependent dust adhesion

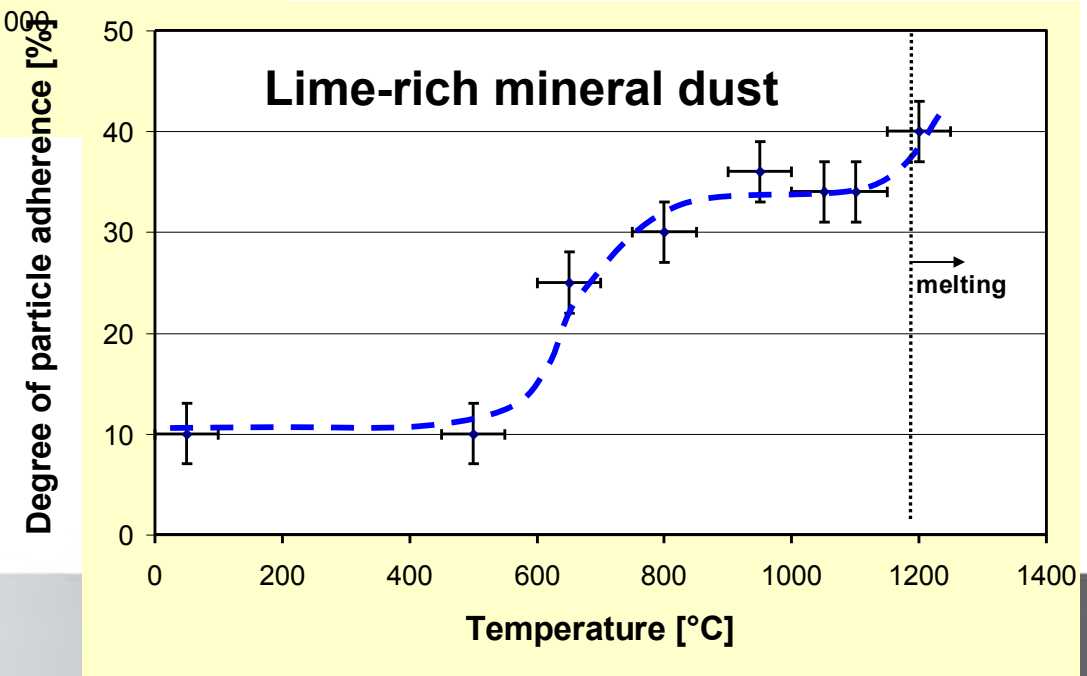




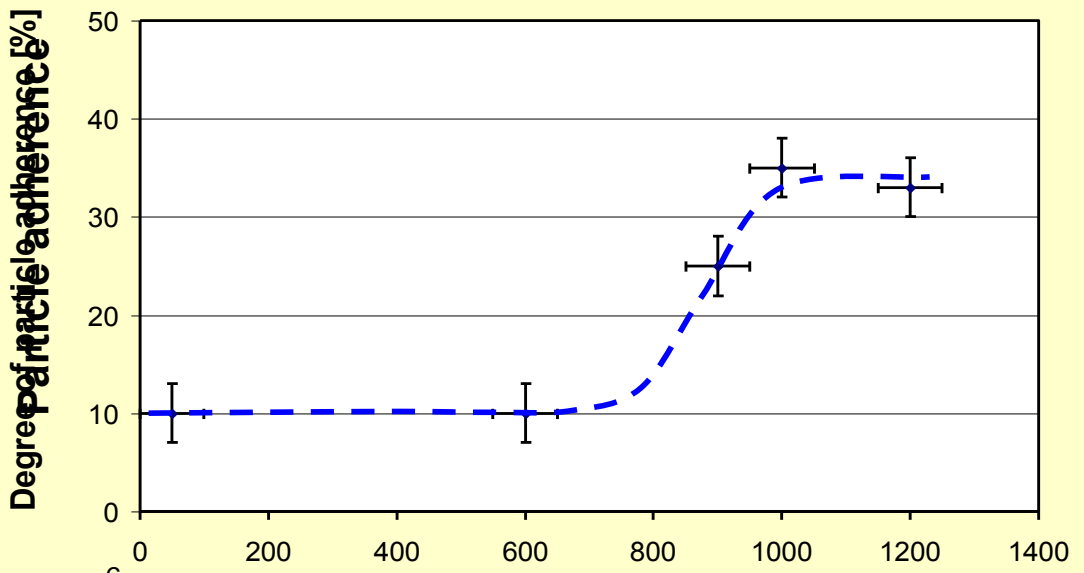
Degree of particle adhesion must be known to estimate dust deposition for extrapolated service time

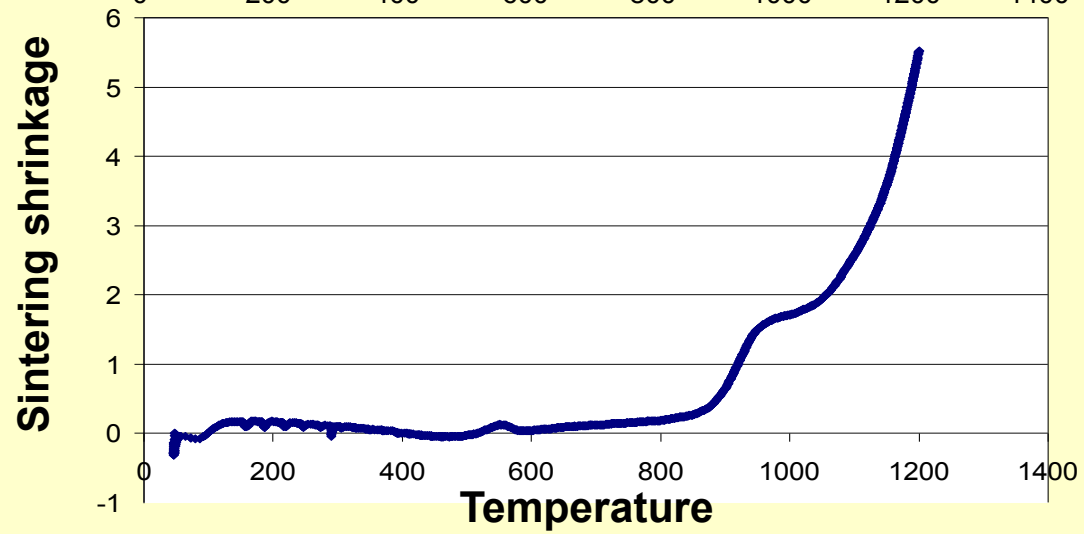
# Temperature dependent dust adhesion



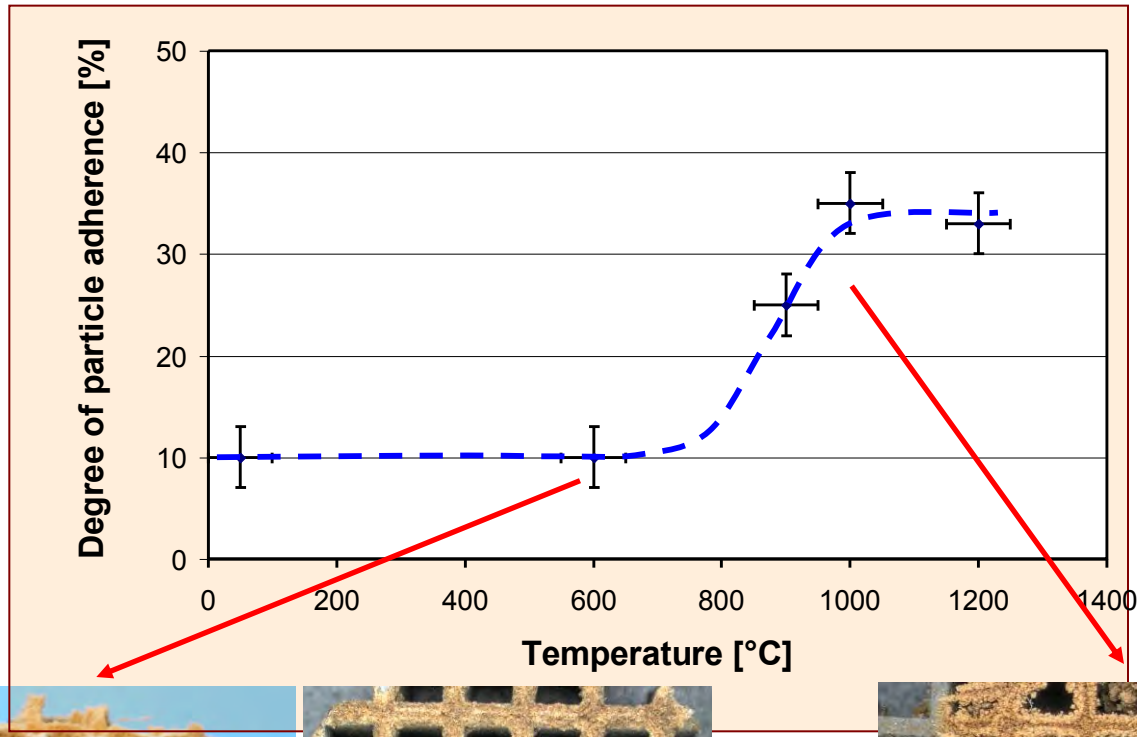



# Particle adherence and sintering activity

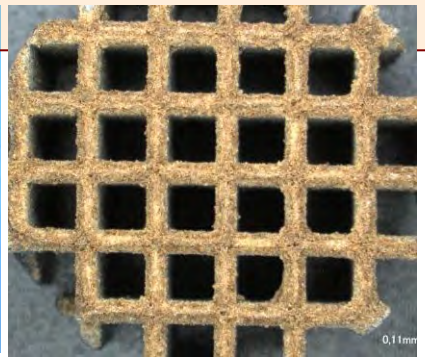


# Particle adherence and channel choking




Mineral dust can be removed easily by suitable brushes as long as no melt formation occured



**T < ≈750 °C:**
**Deposition only on cell connecting bars**

**T > ≈750 °C:**
**Choking of channels**

# Outline

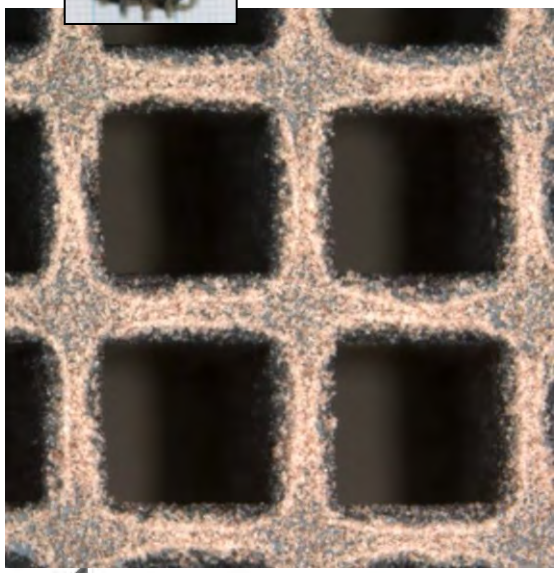
- Motivation
- Model dust
- Accelerated dust deposition on SiC absorber components
- Temperature dependent dust adhesion
- **Estimation of dust deposition under real conditions**
- Melting of dust particles and SiC corrosion
- Influence on light absorbance and efficiency
- Conclusions

# Estimation of dust deposition under real conditions

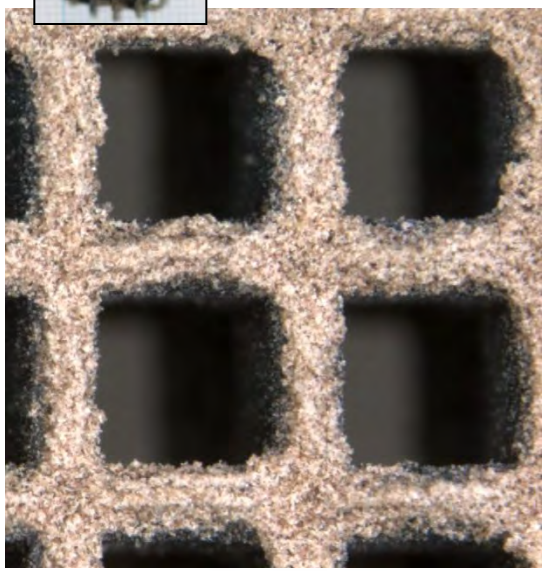
15 l air / s, 47 x 47 channels
→ 25 l / channel · h

1 $m^3$ air: ca. 100 µg mineral dust (literature review)
Degree of adherence: 25%

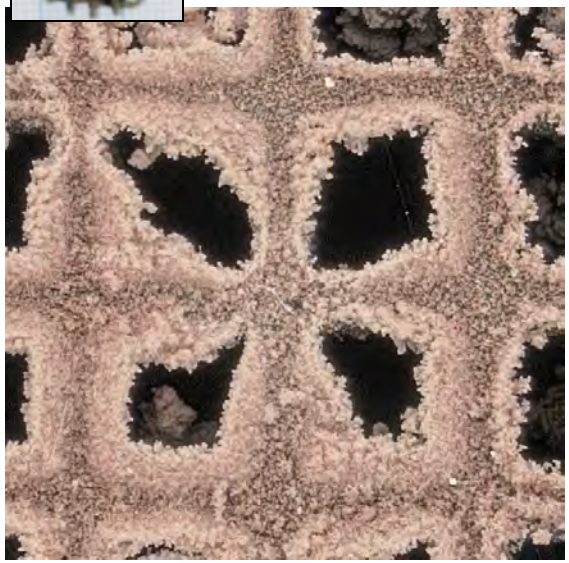
**4mg** ≈250h



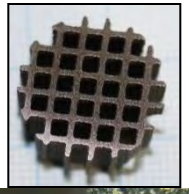
**22mg** ≈1400h



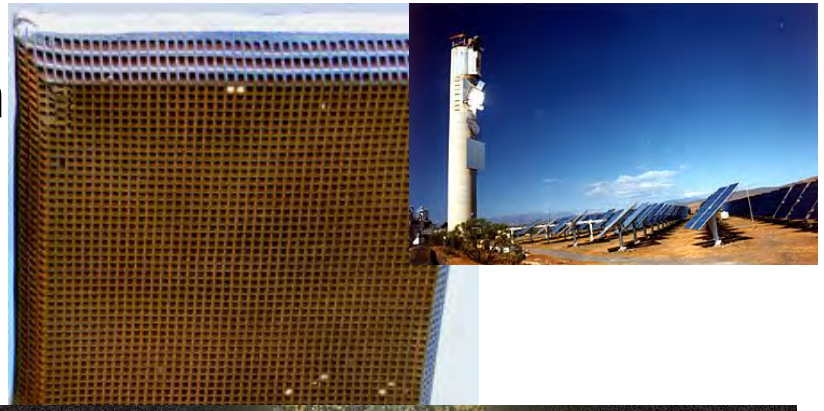
**43mg** ≈2700h



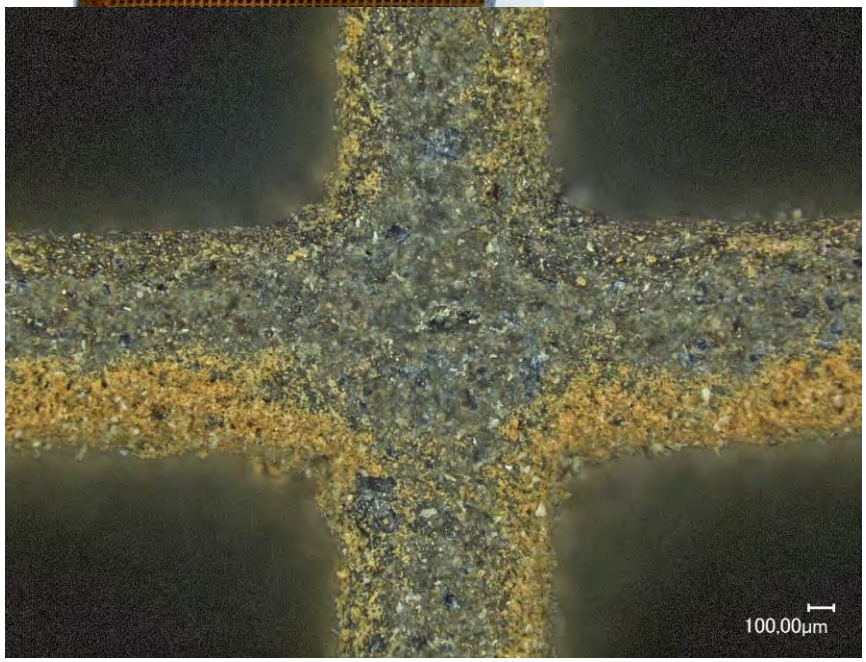
# Estimation of dust deposition under real conditions, Validation



0.4mg




≈25 h
(estimated for real conditions)



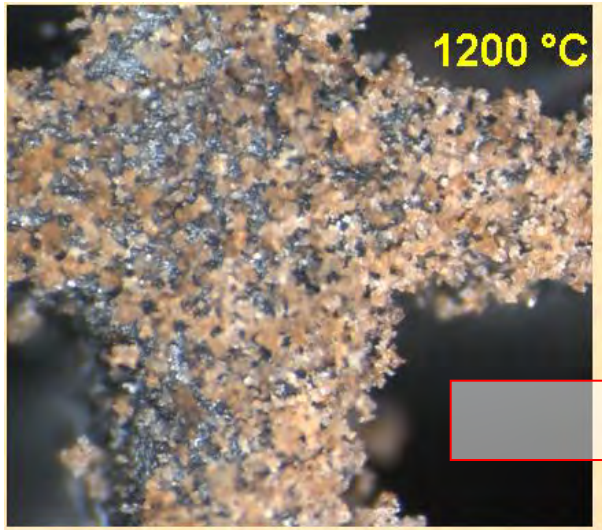

in service, few 10 h


Solid state mineral dust deposition:
Relatively poor particle cohesion.
➡ Dust particles can be removed easily.

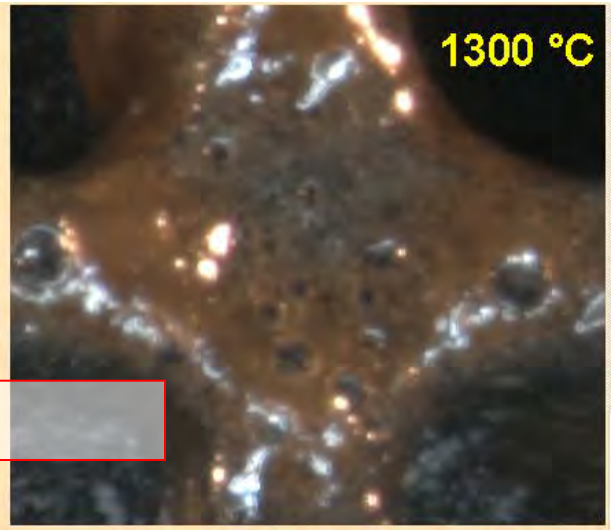
# Outline

- Motivation
- Model dust
- Accelerated dust deposition on SiC absorber components
- Temperature dependent dust adhesion
- Estimation of dust deposition under real conditions
- **Melting of dust particles and SiC corrosion**
- Influence on light absorbance and efficiency
- Conclusions

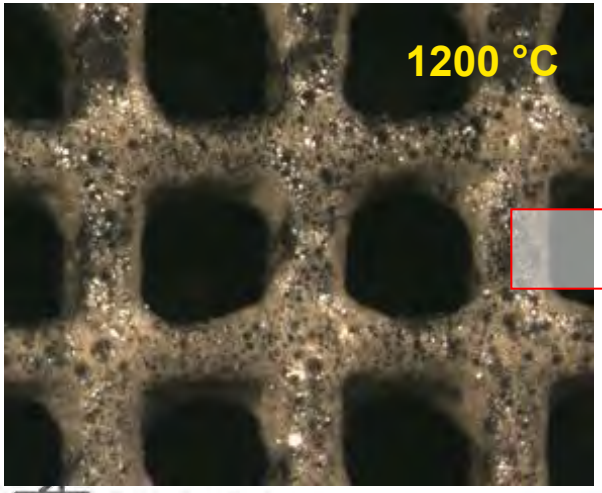
# Melting of dust particles and SiC corrosion





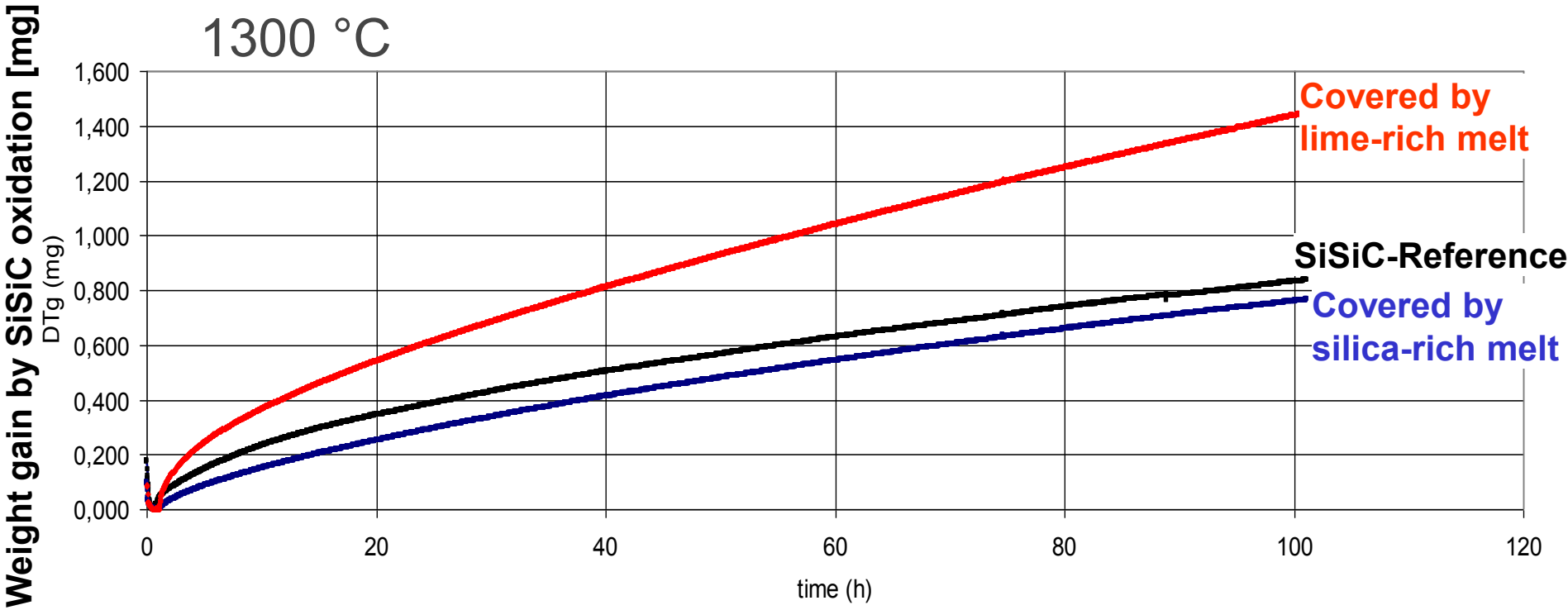



Silica-rich

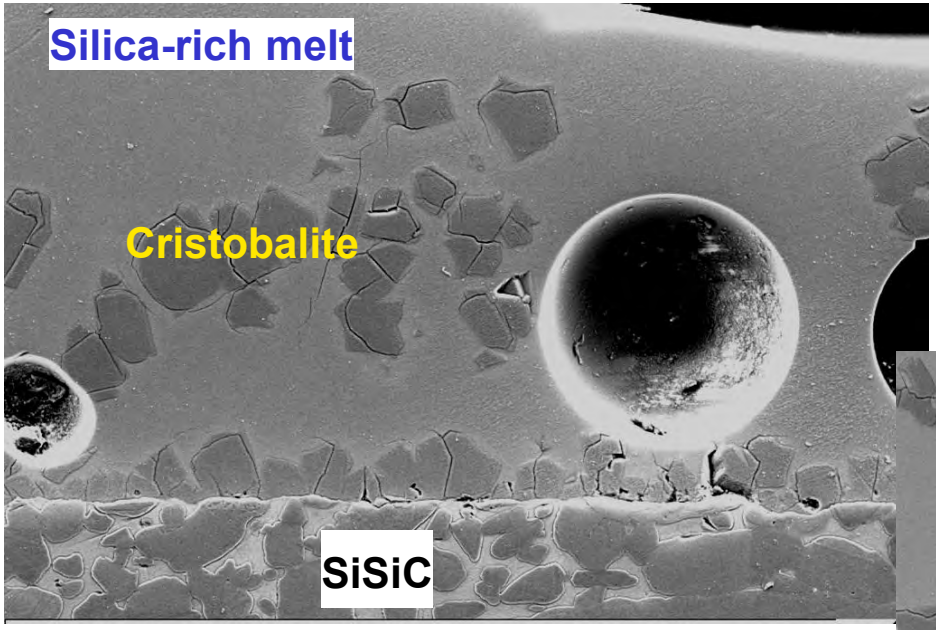



Lime-rich

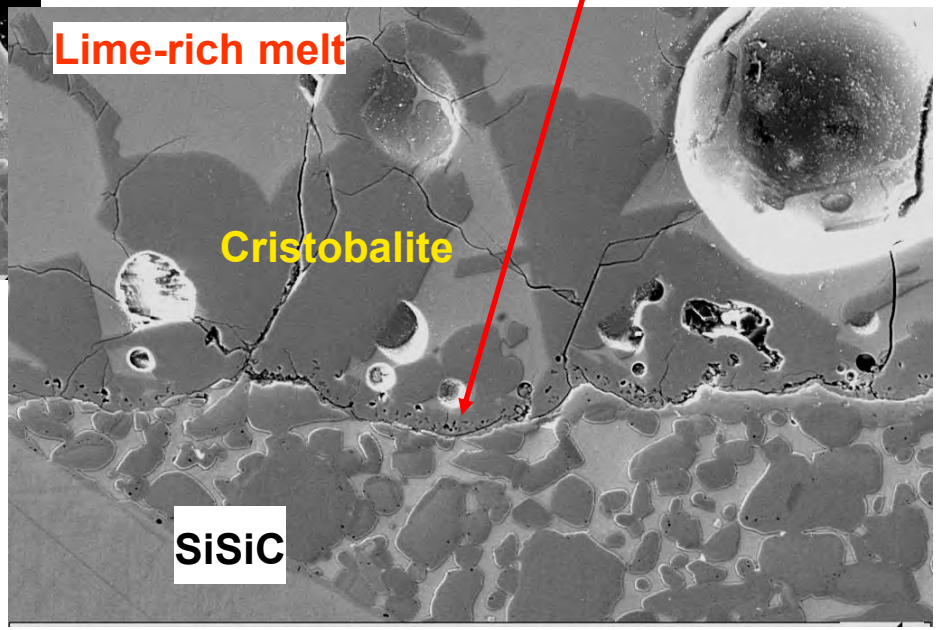
# Melting of dust particles and SiC corrosion



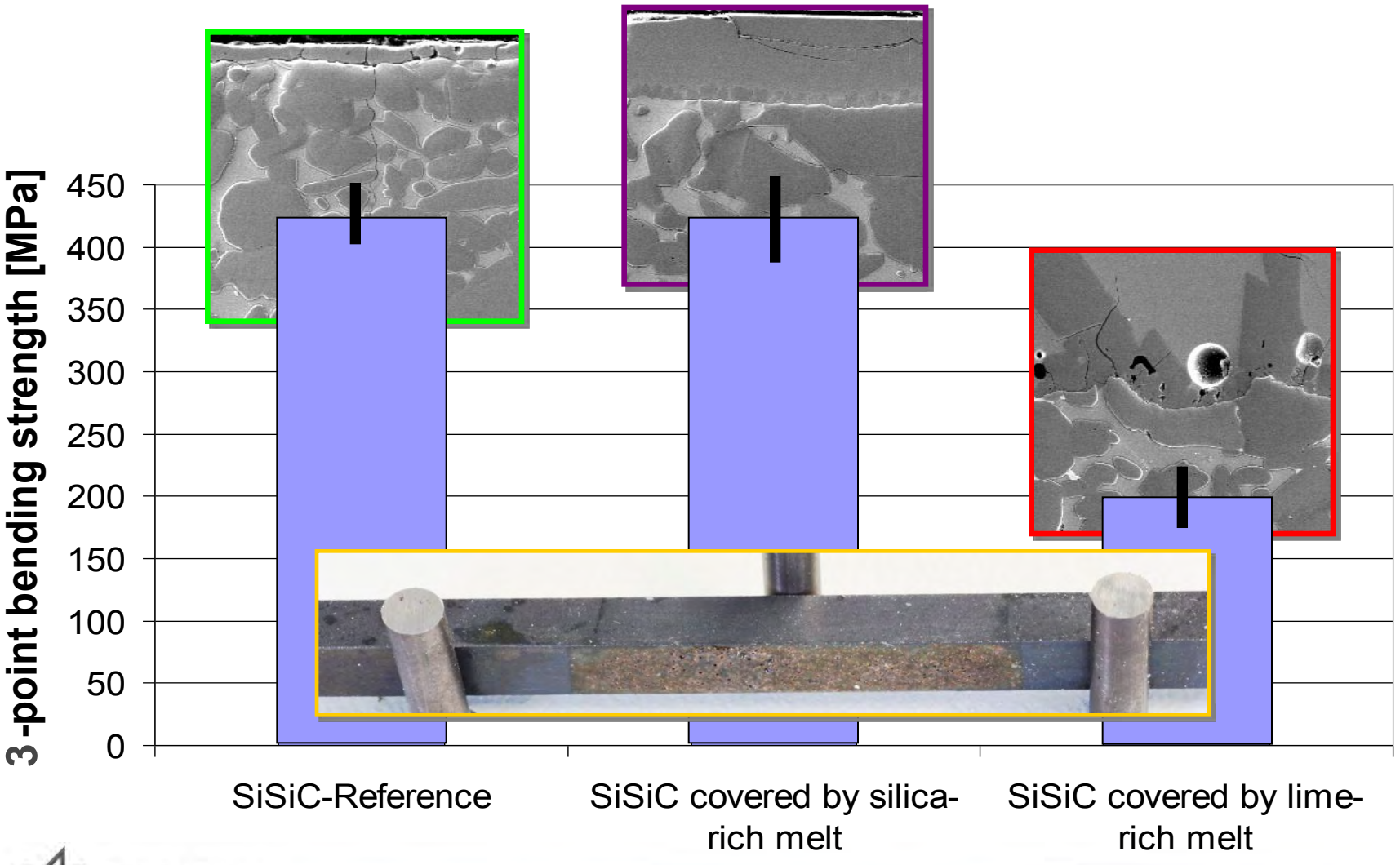
# Melting of dust particles and SiC corrosion



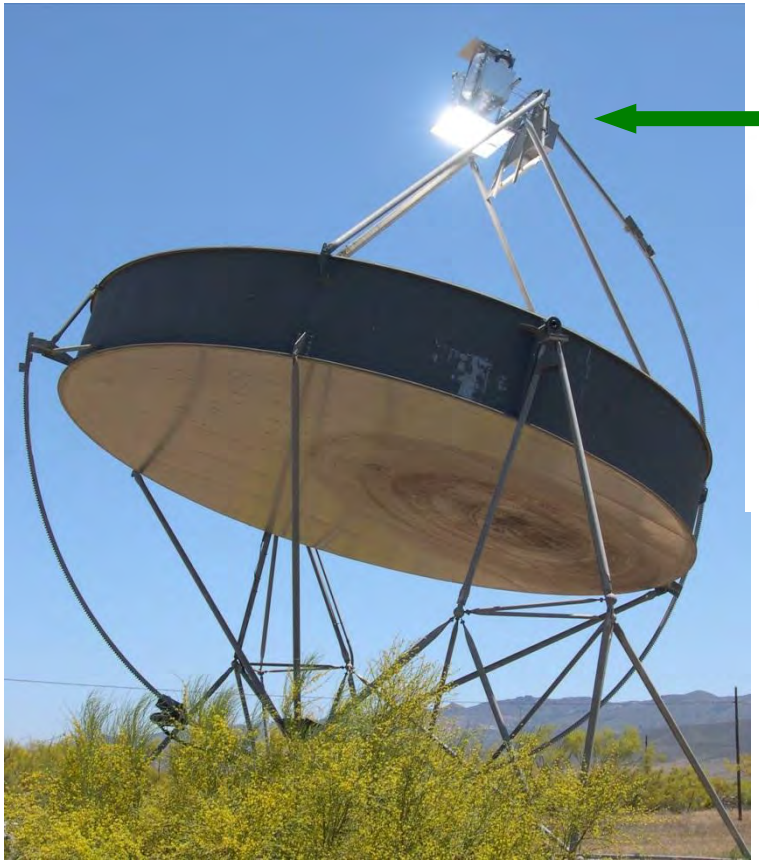

*Corrosive attack!*

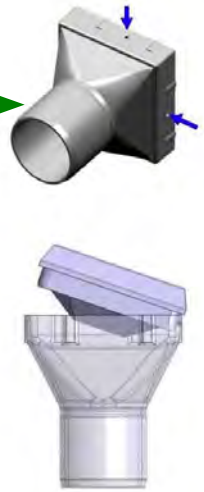


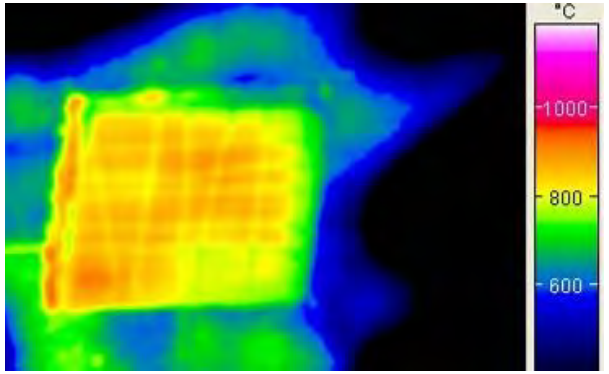
# Influence of mineral dust melts on SiSiC strength

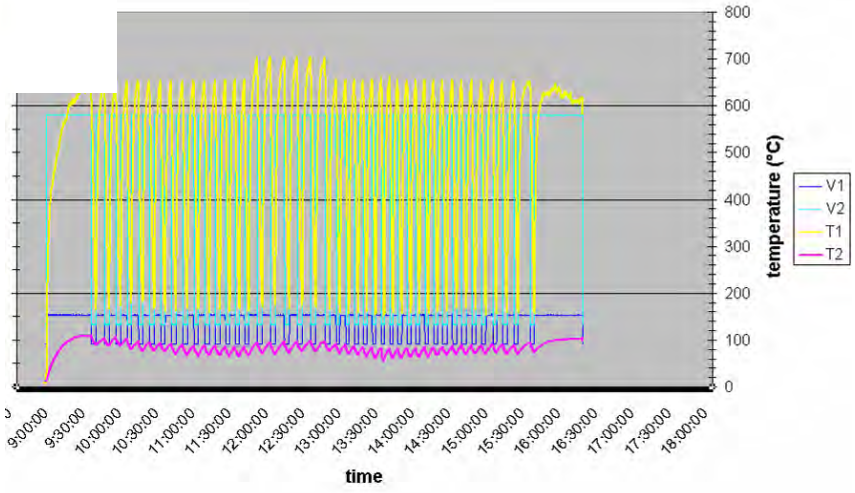


# Thermal shock testing of absorber units by solar dish facilities





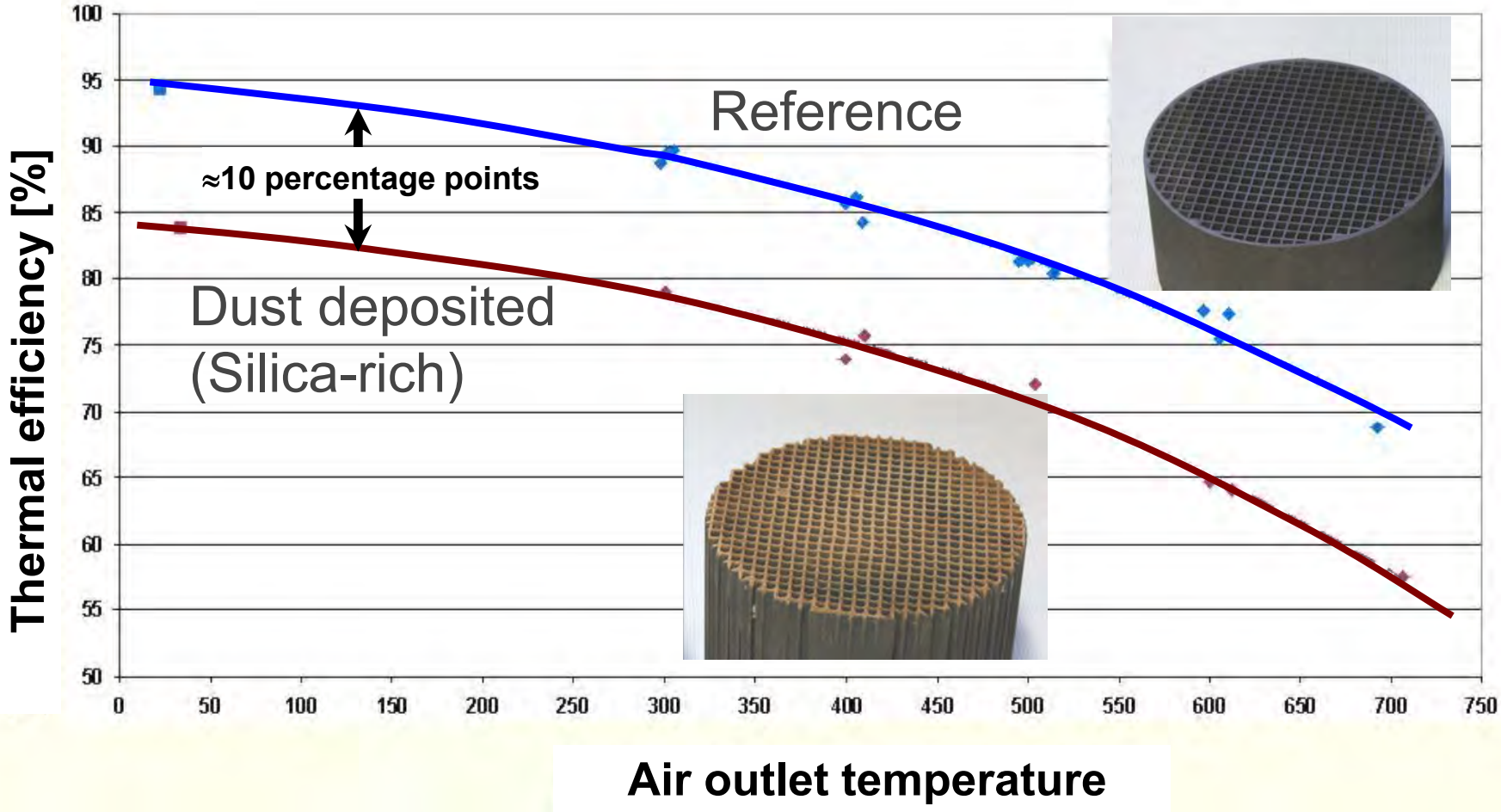


# Outline

- Motivation
- Model dust
- Accelerated dust deposition on SiC absorber components
- Temperature dependent dust adhesion
- Estimation of dust deposition under real conditions
- Melting of dust particles and SiC corrosion
- **Influence on light absorbance and efficiency**
- Conclusions

# Influence on light absorbance and efficiency



# Outline

- Motivation
- Model dust
- Accelerated dust deposition on SiC absorber components
- Temperature dependent dust adhesion
- Estimation of dust deposition under real conditions
- Melting of dust particles and SiC corrosion
- Influence on light absorbance and efficiency
- **Conclusions**

# Conclusion

- Significant deposition of mineral dust can be expected during service
- Reduction of efficiency due to lower radiation absorbance
- Choking of channels may occur at high service temperatures
- Adhesion (sintering) between dust particles and SiC is poor as long T <1200 °C (silica-rich dust) or 1150 °C (lime-rich dust), respectively

$\rightarrow$ dust deposition can be removed by suitable brushes

- If molten, mineral coatings have high adherence on SiC structures
- Lime-rich mineral melts cause corrosive attack on SiSiC structures