A Novel Approach for Non-Destructive Testing of the Adhesion of Thermal Barrier Coatings

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Structure

- **Motivation**
  - increase of the efficiency of gas turbines
  - non-destructive testing of thermal barrier coatings (TBCs)

- **Non-contact characterization**
  - infrared-optical properties
  - structural properties
  - adhesive properties

- **Conclusions and outlook**
  - characterization of coating and layers
  - structural analysis

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Motivation

Improvement of the energy efficiency of gas turbines using TBCs.

Non-destructive determination of adhesion or delamination of layer systems.

Relevant quantities:

- temperature
- heat transfer by thermal radiation (infrared-optical properties)
- structure (morphological properties)

Delamination

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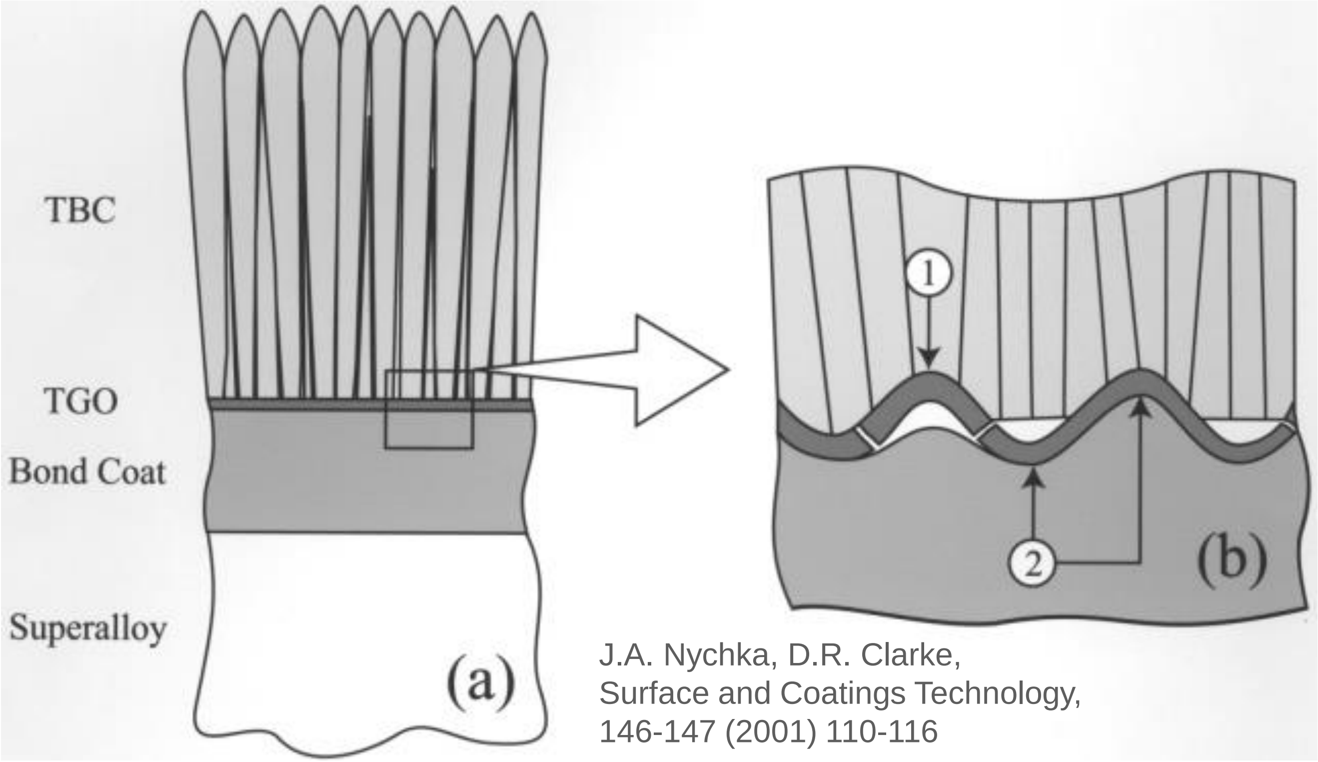
TBC on substrate: structural changes due to delamination

partial delamination caused by thermally grown oxide (TGO)



J.A. Nychka, D.R. Clarke,
Surface and Coatings Technology,
146-147 (2001) 110-116

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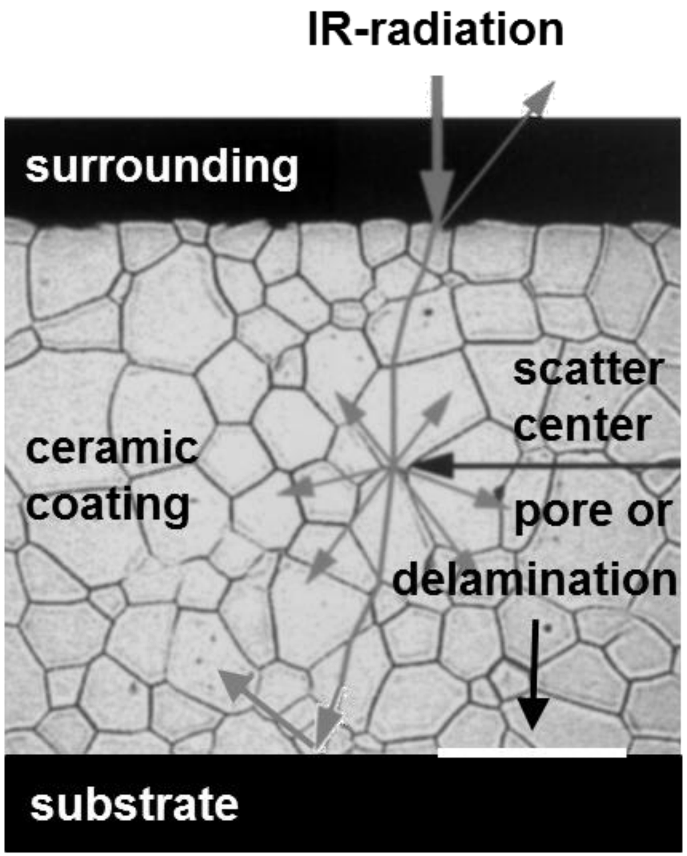
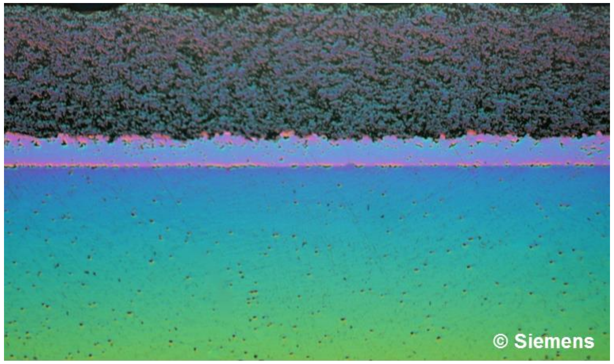
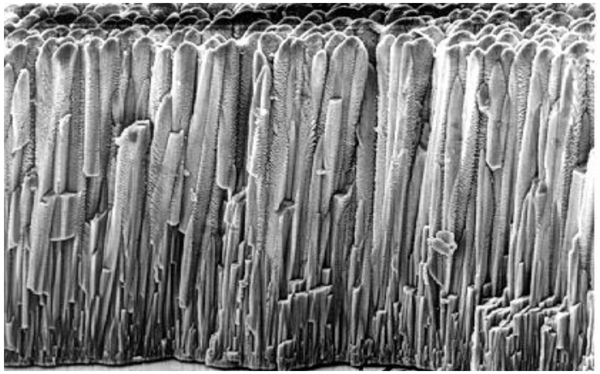
Radiative Transfer

Transfer of thermal radiation through TBCs





PS-PVD-coating



EB-PVD-coating

Radiative Transfer

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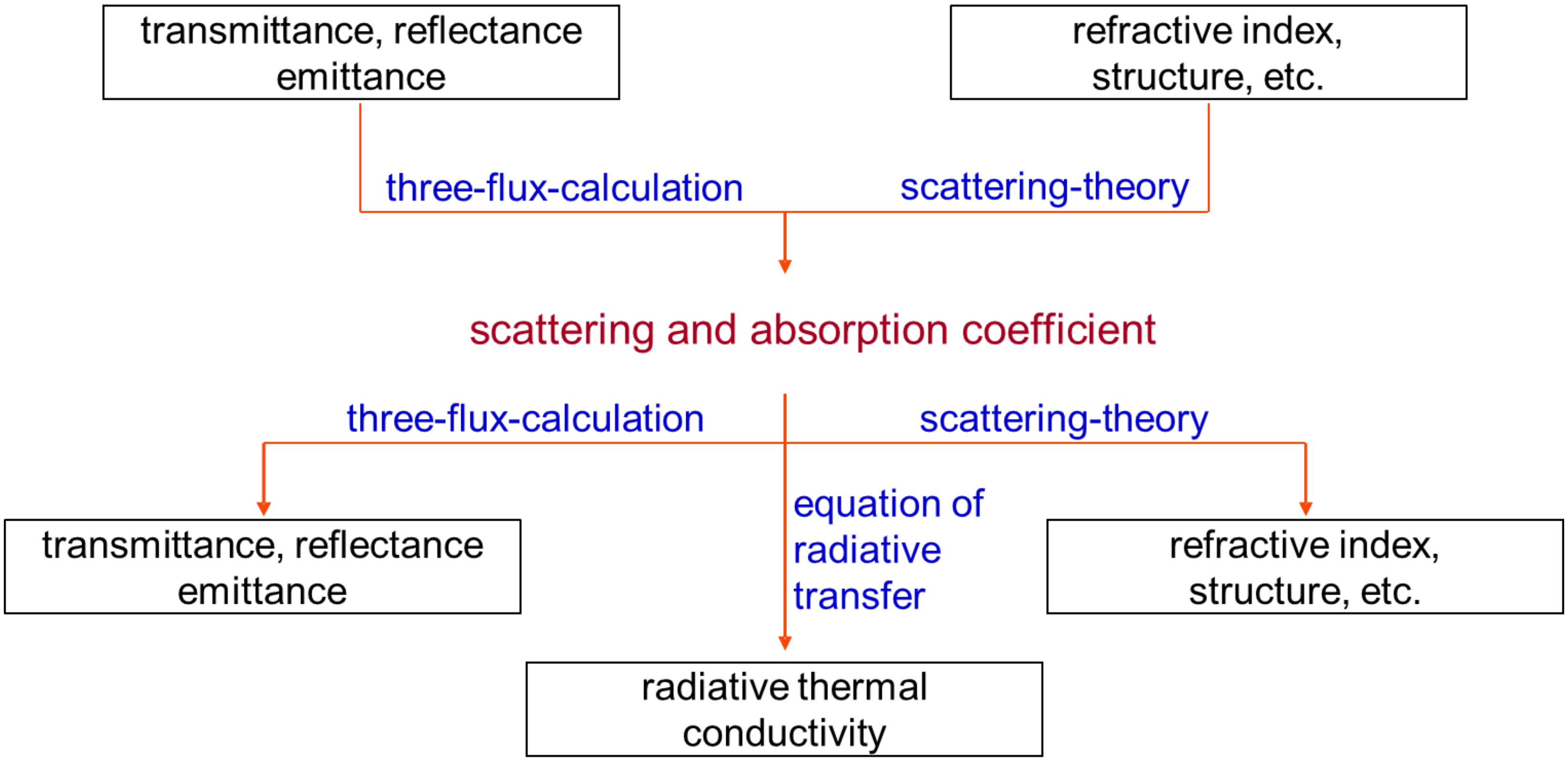
Infrared-optical characterization and modelling of radiative transfer



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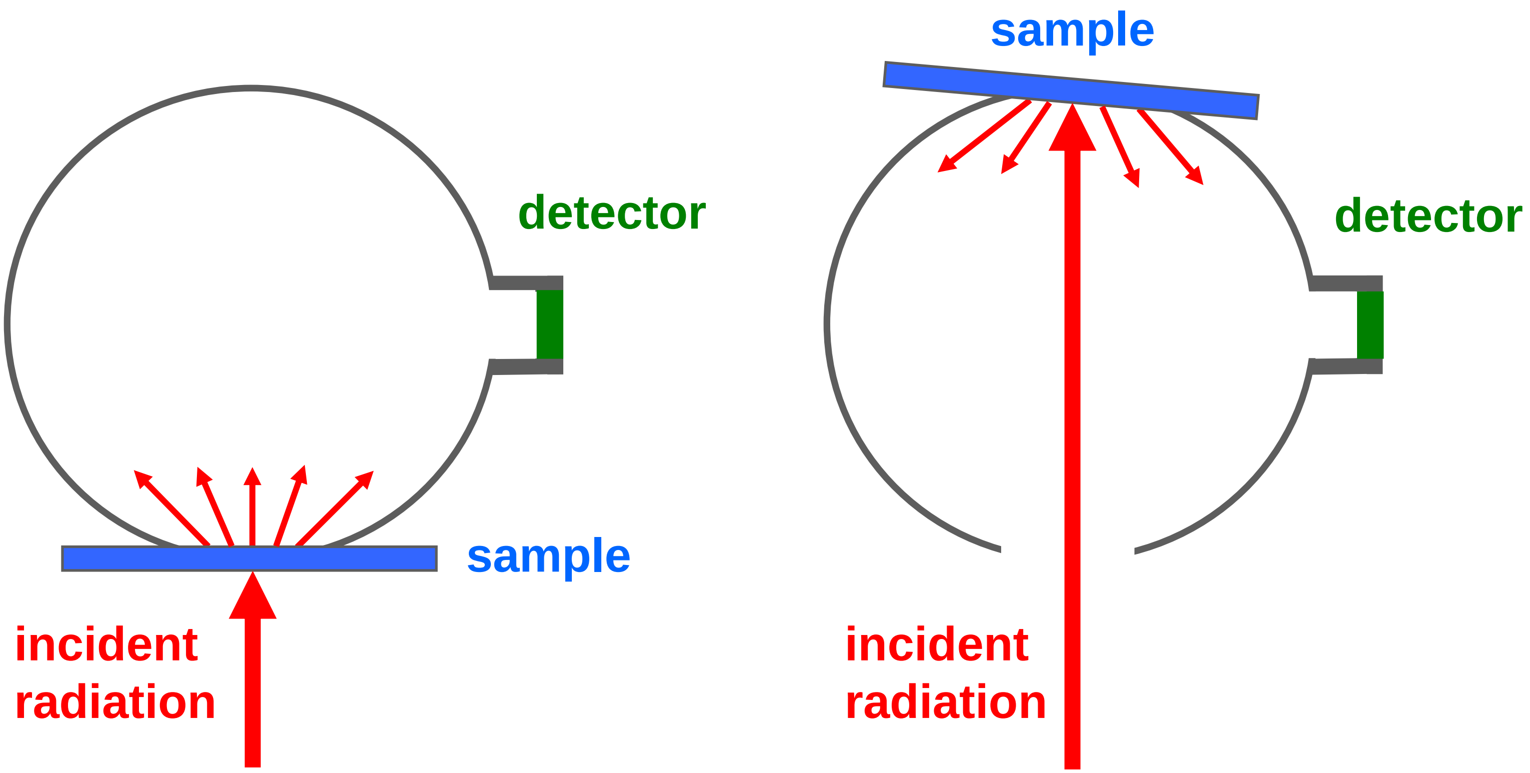
Integrating Sphere

Setup for measurement of transmittance and reflectance at ambient temperature



Blackbody Boundary Conditions (BBC)

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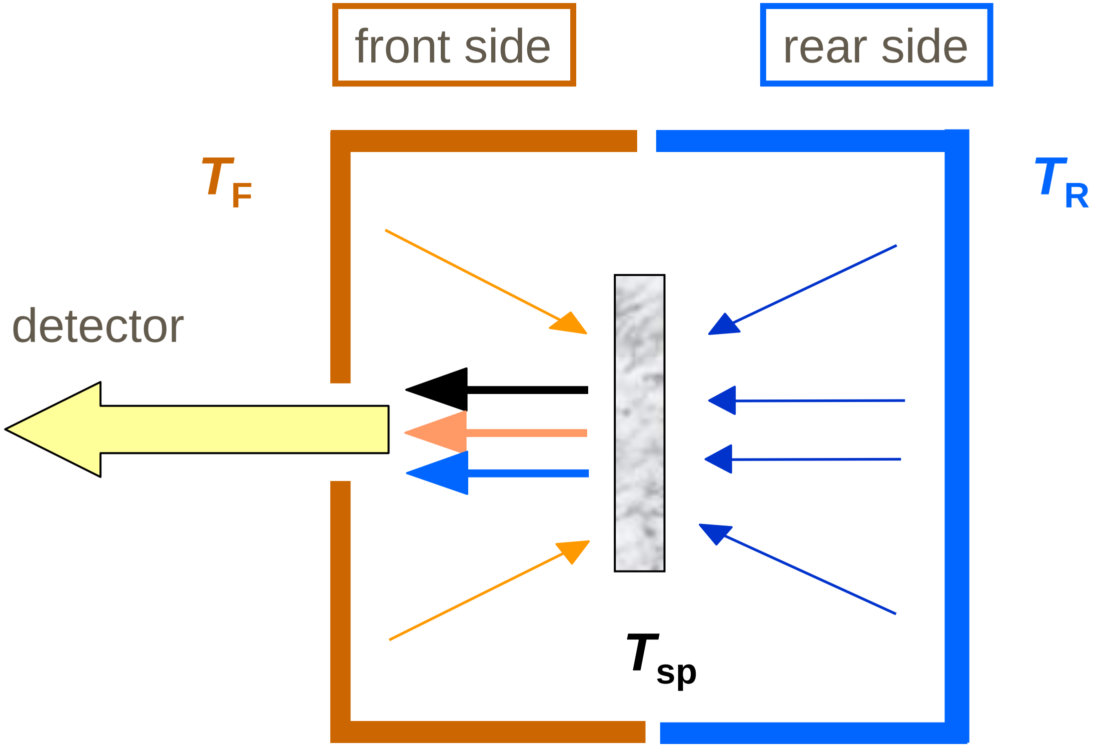
Apparatus for measurement of transmittance and emittance at high temperatures



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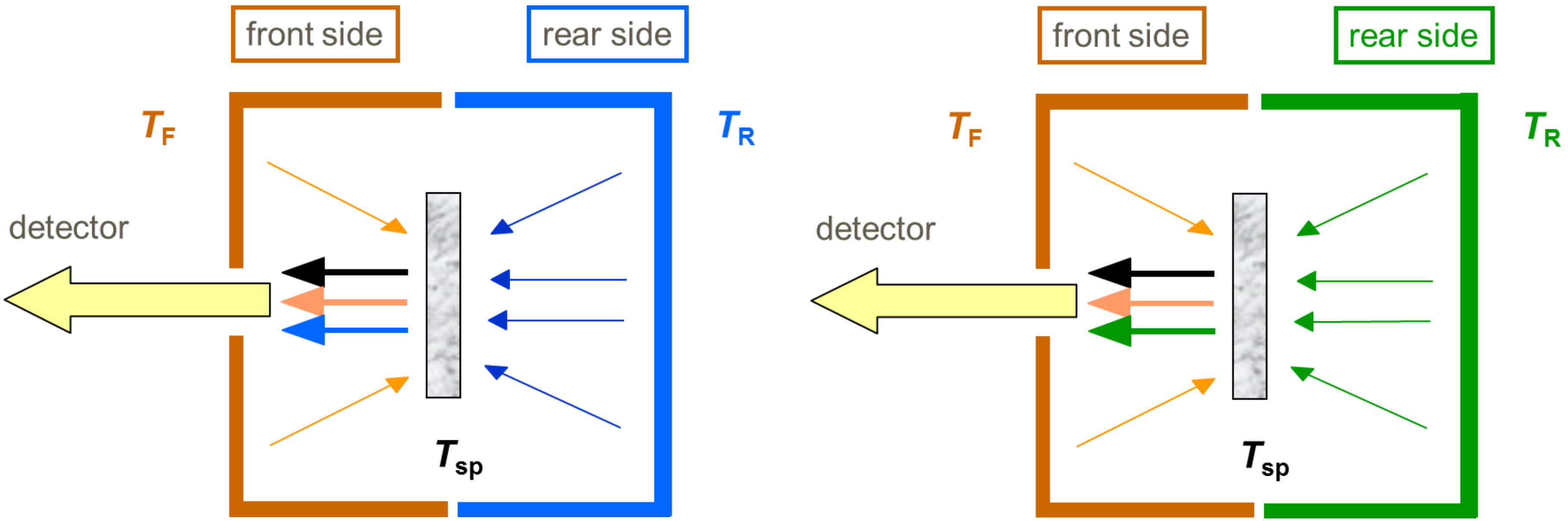

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Structural Analysis

Characterization of alumina (Al_2O_3) with a porosity of 2 %

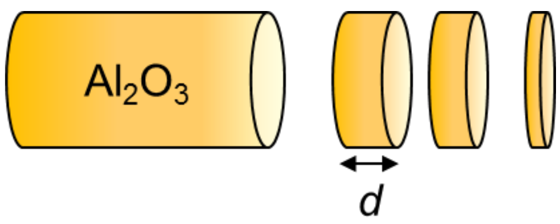
transmittance, reflectance emittance

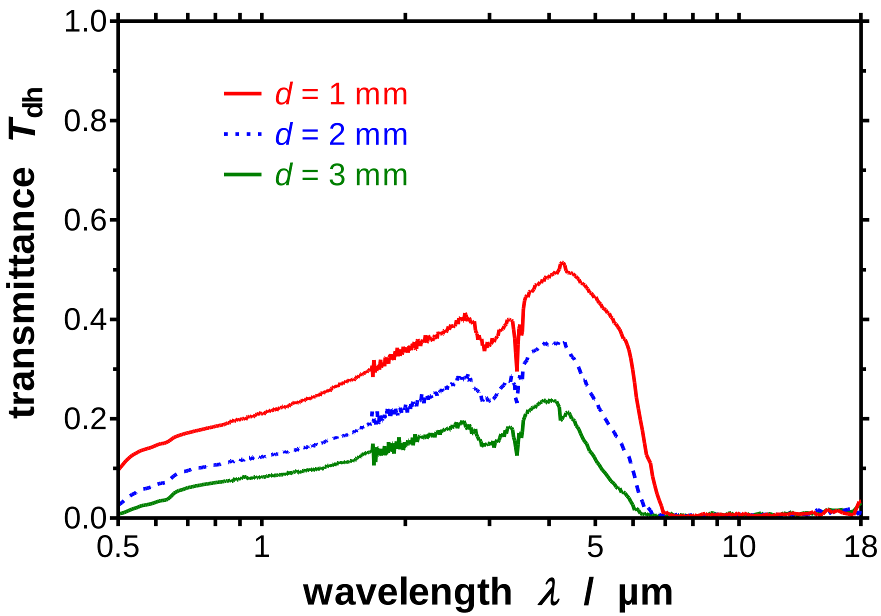
refractive index, structure, etc.

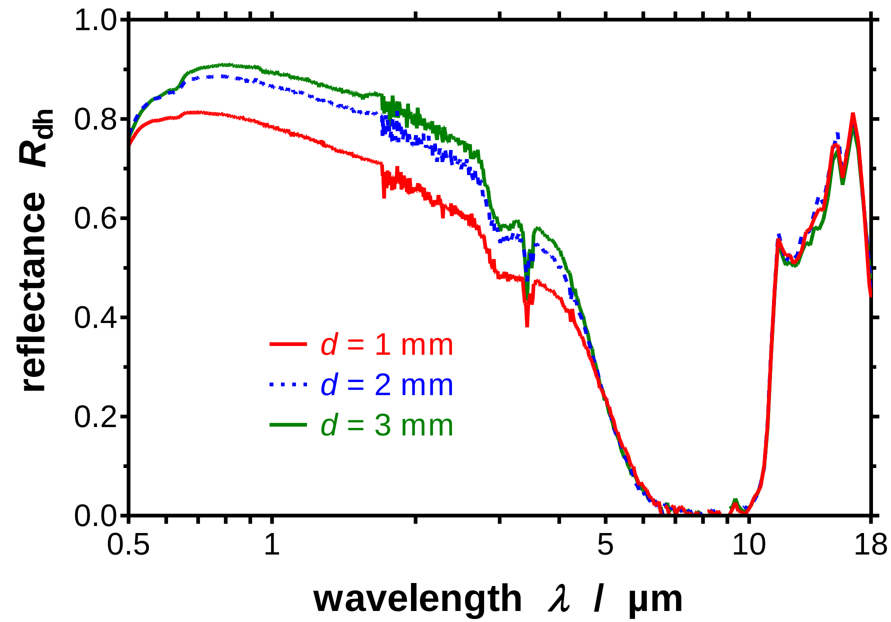
three-flux-calculation

scattering-theory

scattering and absorption coefficient







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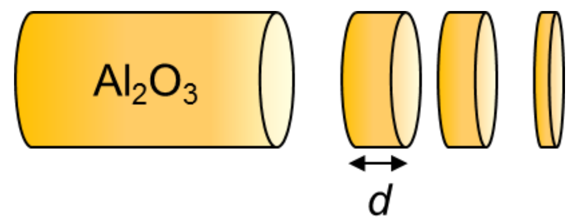

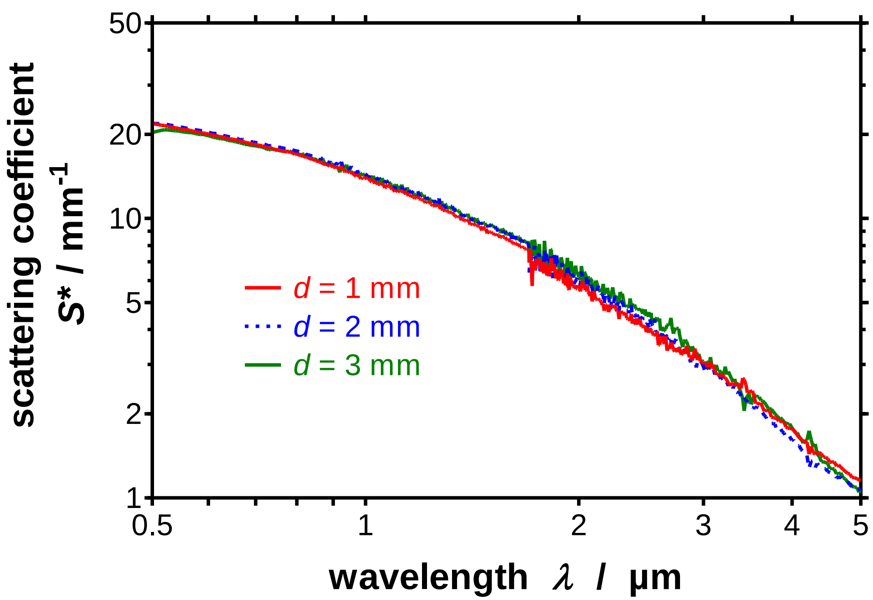

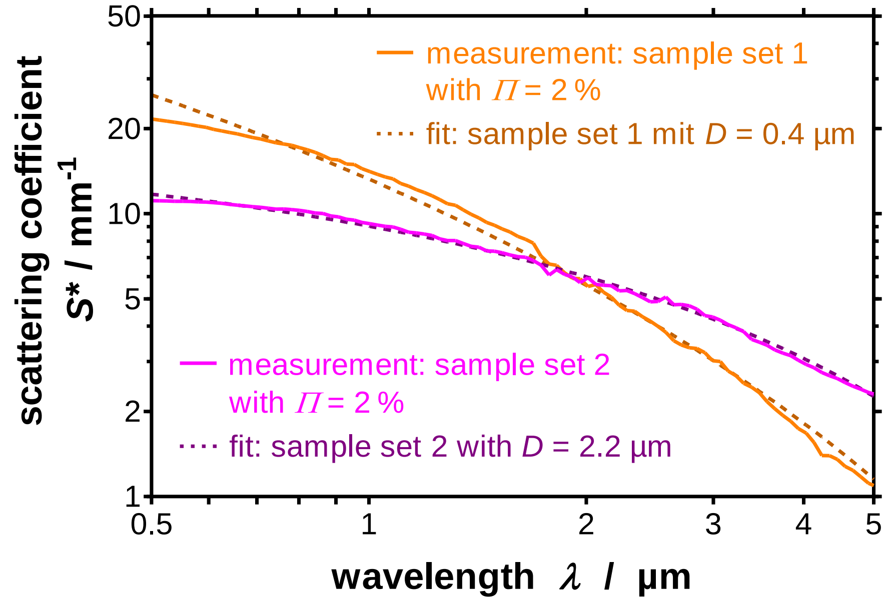

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Characterization of Radiative Transfer

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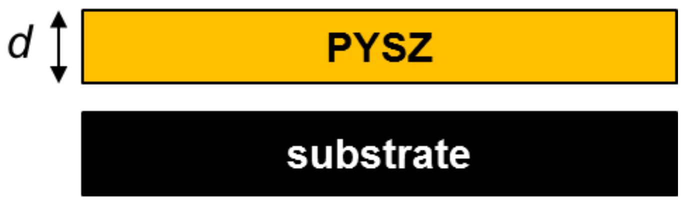
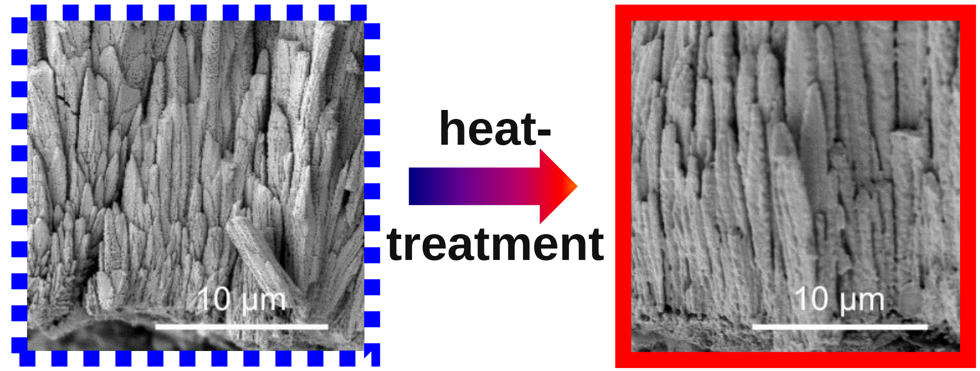
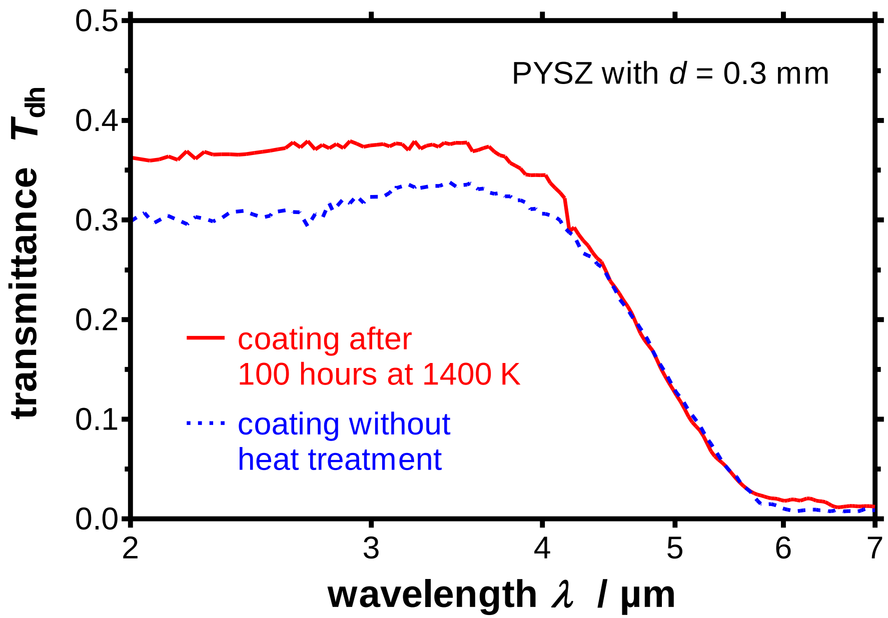
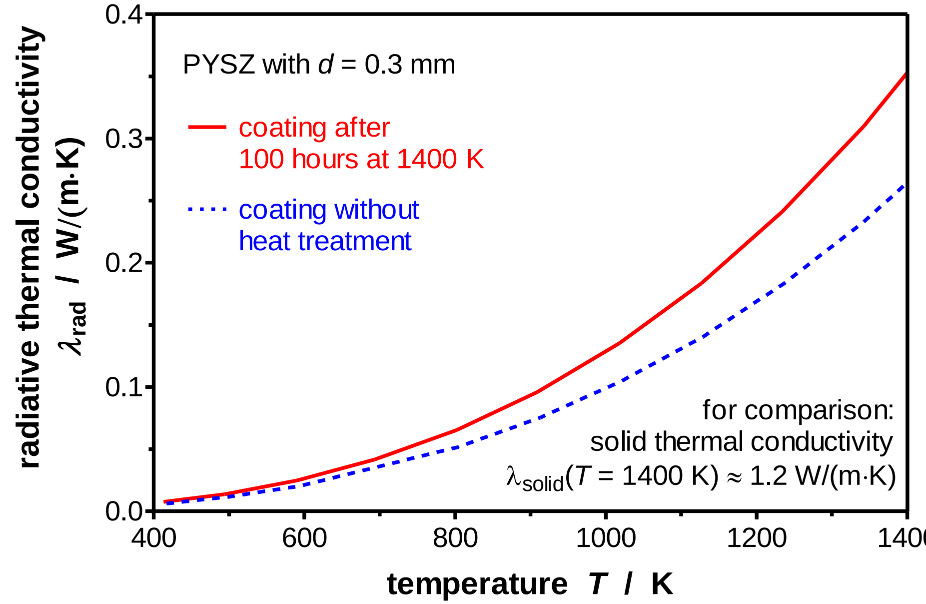
Freestanding TBC: partially yttria stabilized zirconia (PYSZ)









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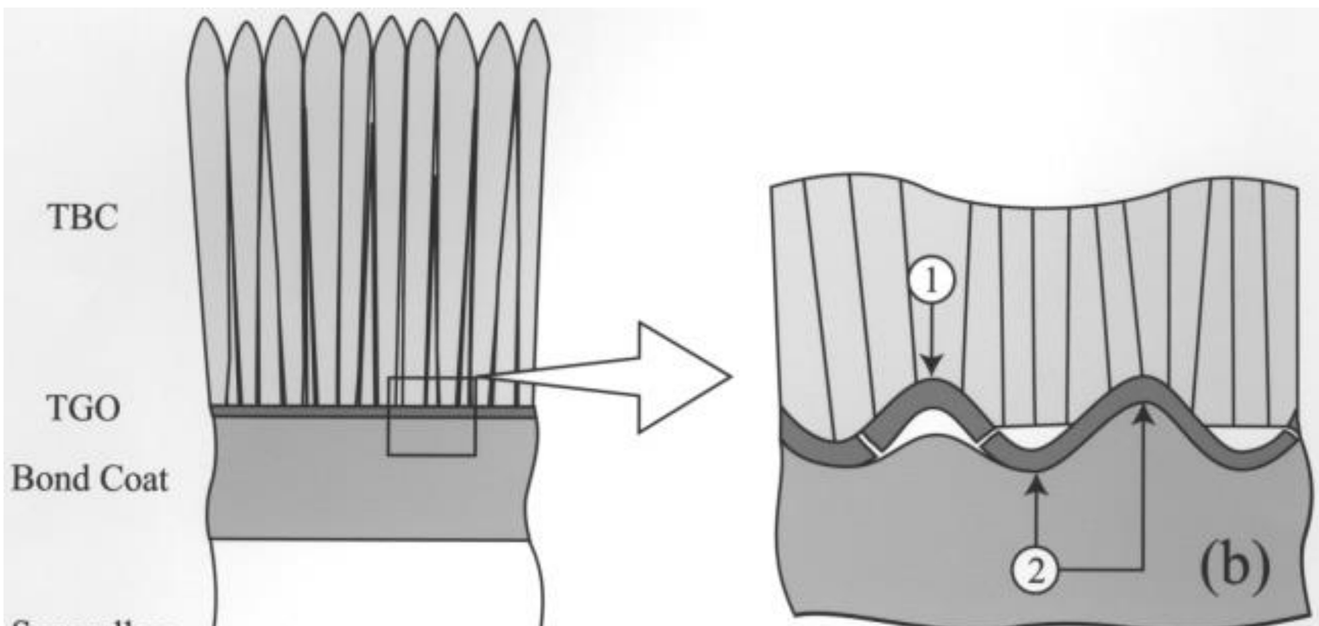
Delamination of TBC

Partial delamination:

- change of the morphology
- change of the radiative transfer
- change of the temperature gradient



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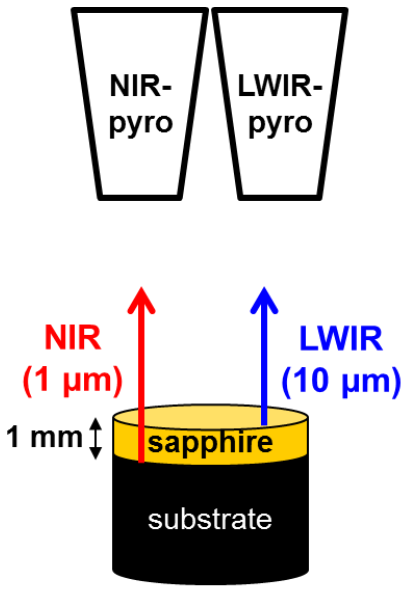
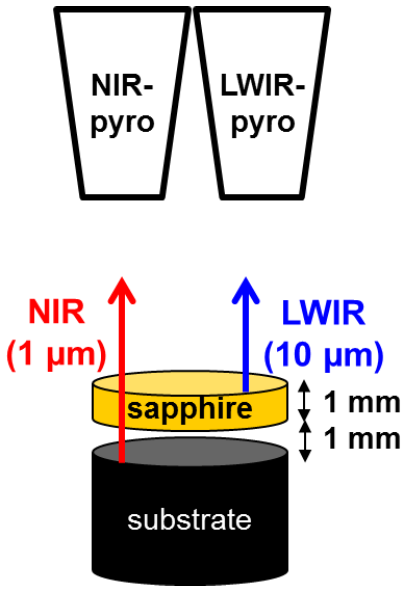
Determination of Temperature Gradient

Change of the temperature gradient due to delamination:

sapphire on a substrate: without gap and with gap



without gap



with gap

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Determination of Temperature Gradient

Change of the temperature gradient due to delamination:

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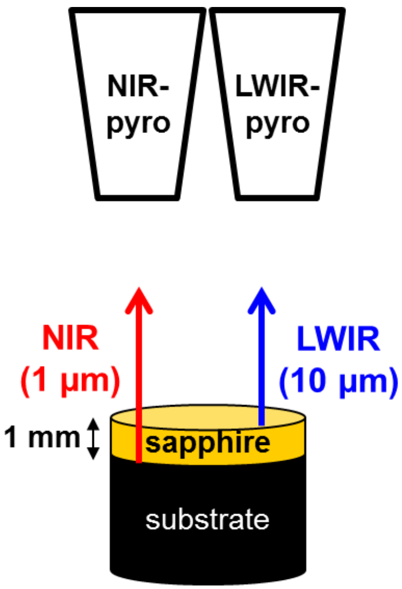
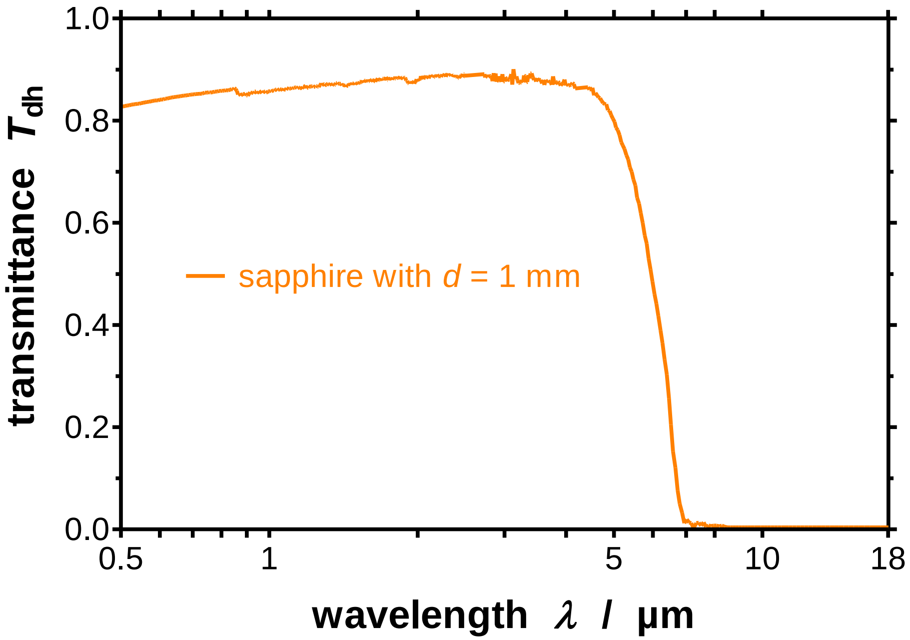
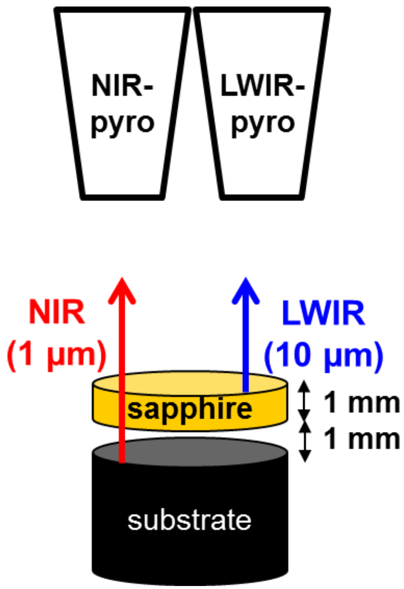


without gap





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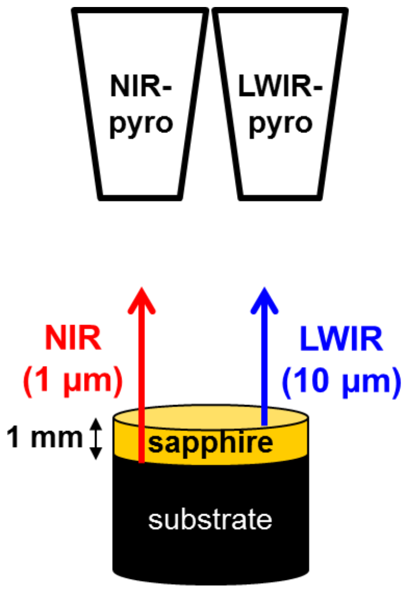
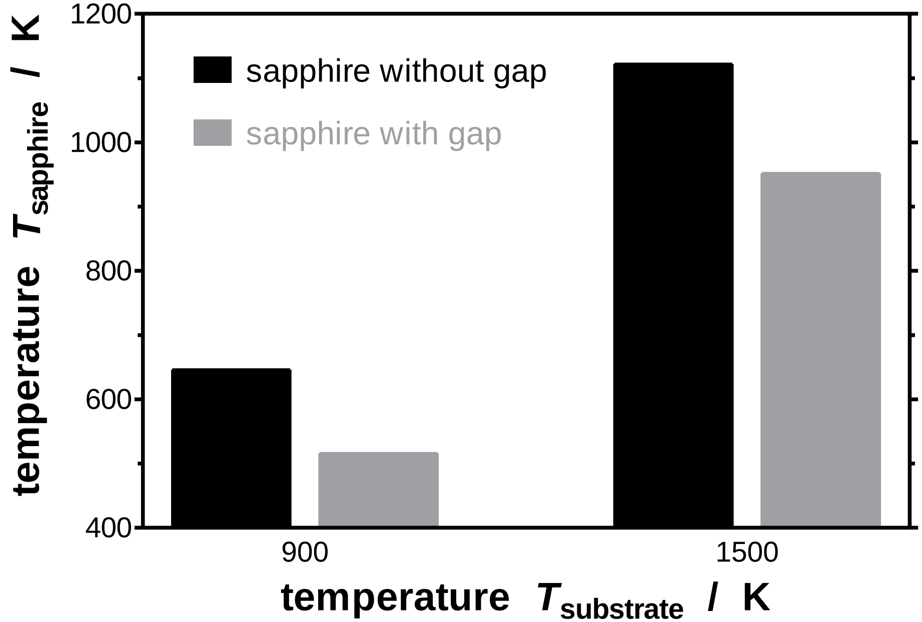
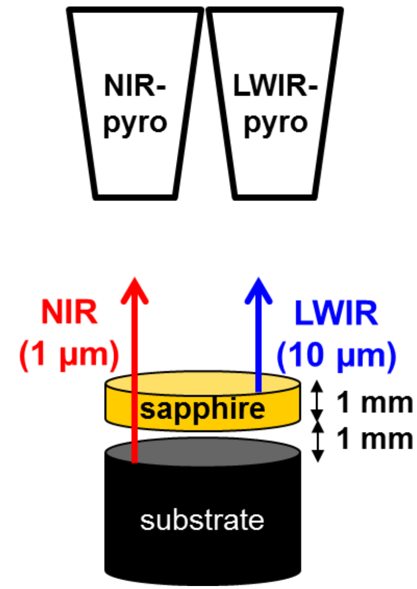


without gap





with gap

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Conclusions and Outlook

Characterization of free-standing layer

- infrared-optical characterization at high temperatures
- determination of structure and morphology
- modelling of the radiative transfer and radiative thermal conductivity

Analysis of coatings and layer systems

- non-destructive testing at high temperatures
- possibility of detecting delamination of TBCs

Outlook

- correlations need to be further investigated and thoroughly quantified
- further work will be done on testing adhesion of TBCs

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Thank you!

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