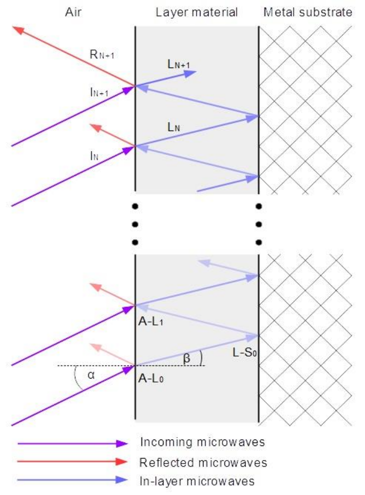
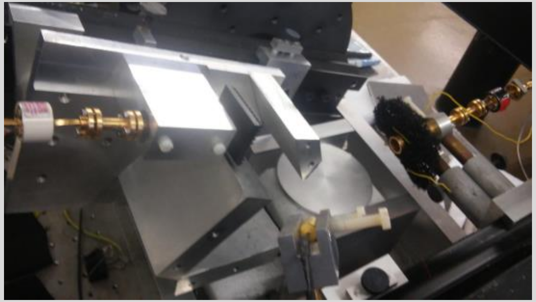
University of Stuttgart
Institute of Interfacial Process Engineering and Plasma Technology





Simulation and reflectivity measurements of the ITER first plasma beam dump material

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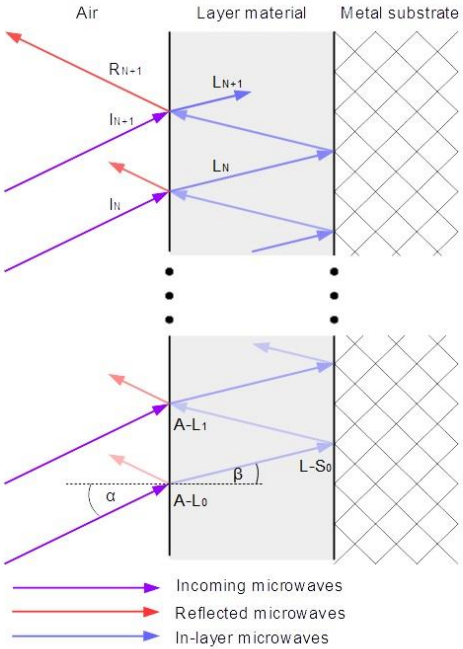
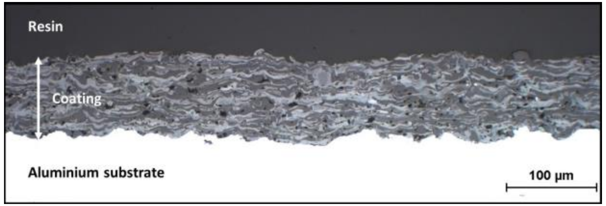
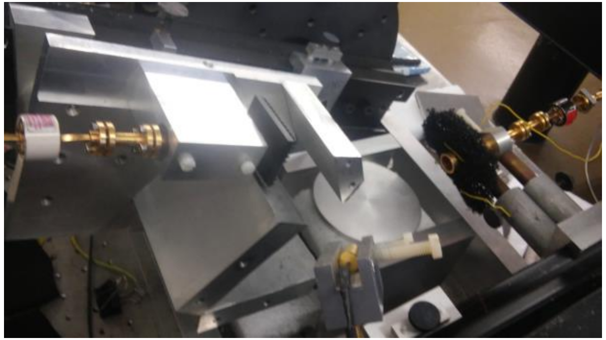
Content

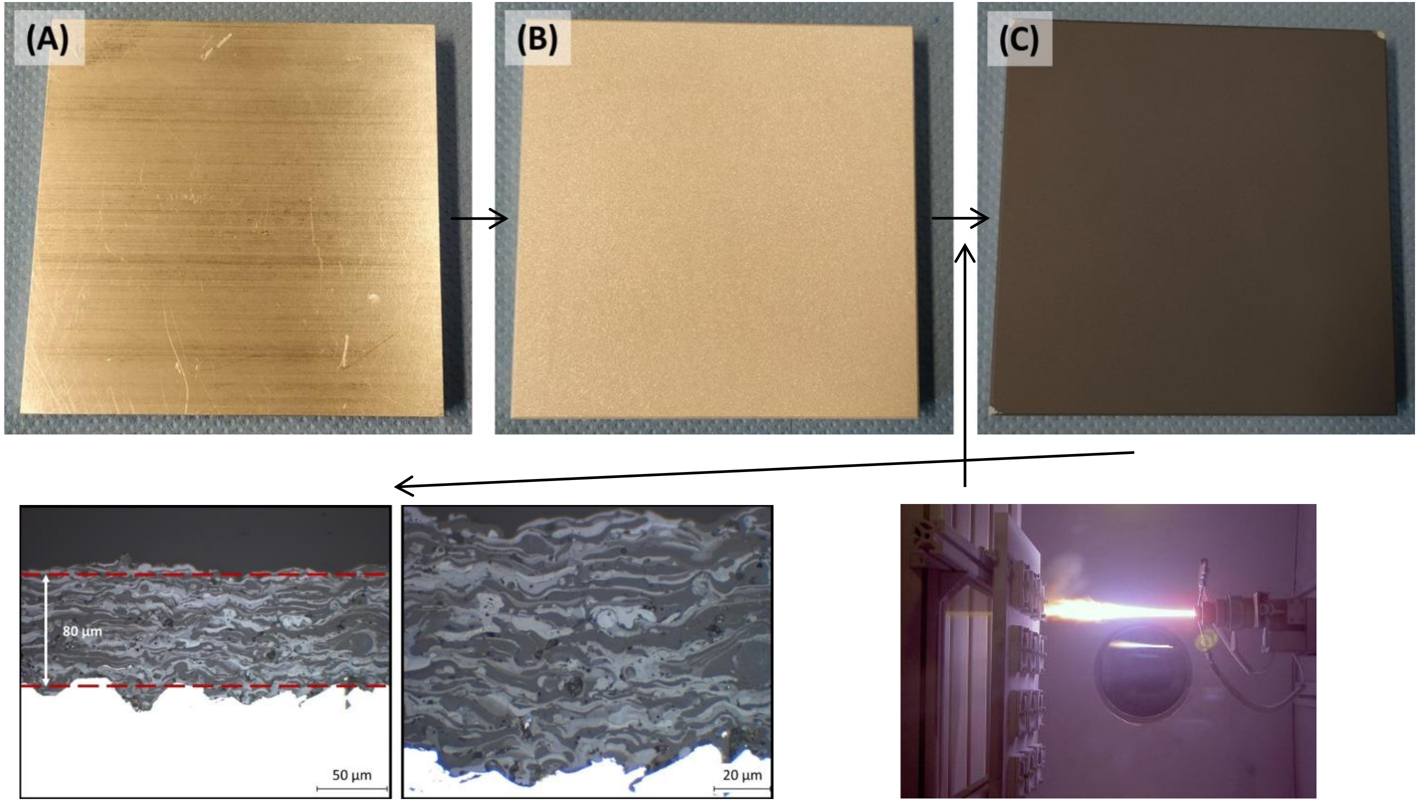
- Sample production
- Measurements
- Model
- Comparison
- Results:
  - Dependency on absorptivity
  - Angle dependency suppression
- Conclusion and outlook







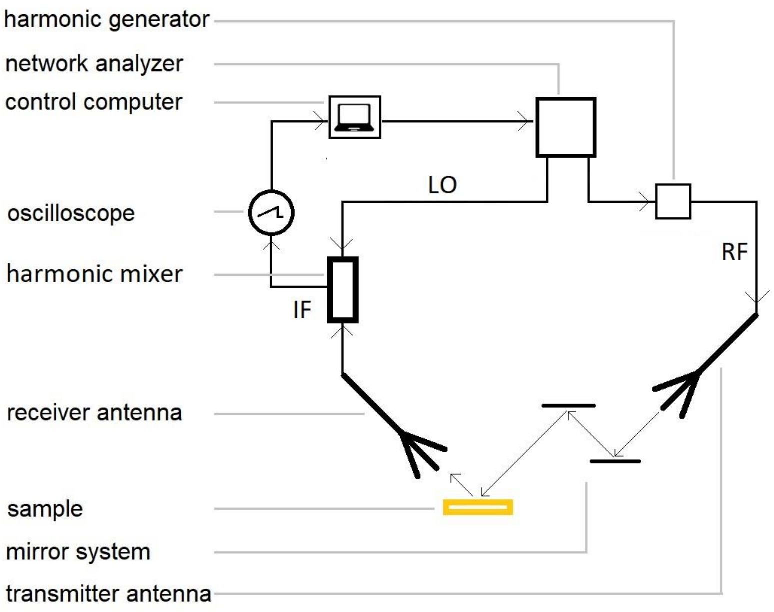
Sample Production
Grit blasting and plasma spraying

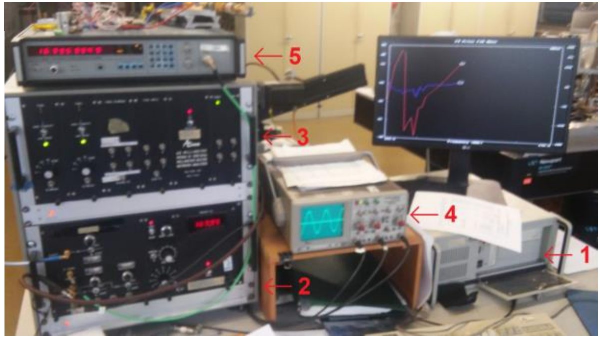


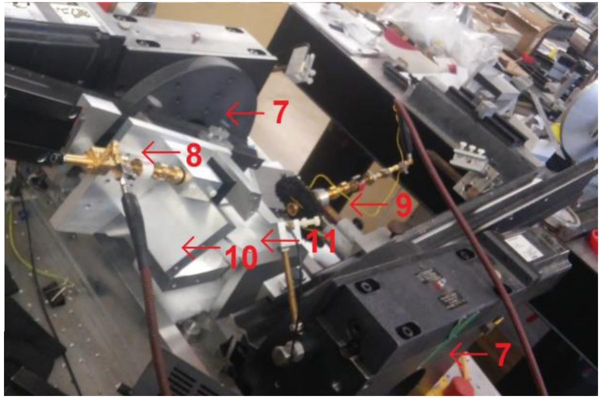
Measurements
Network analyzer, 2 horn antennas and enough patience

Restrictions:

- high reflectivities problematic
- incidence angle limited
- quite old setup







Model
Plane waves

Summary:

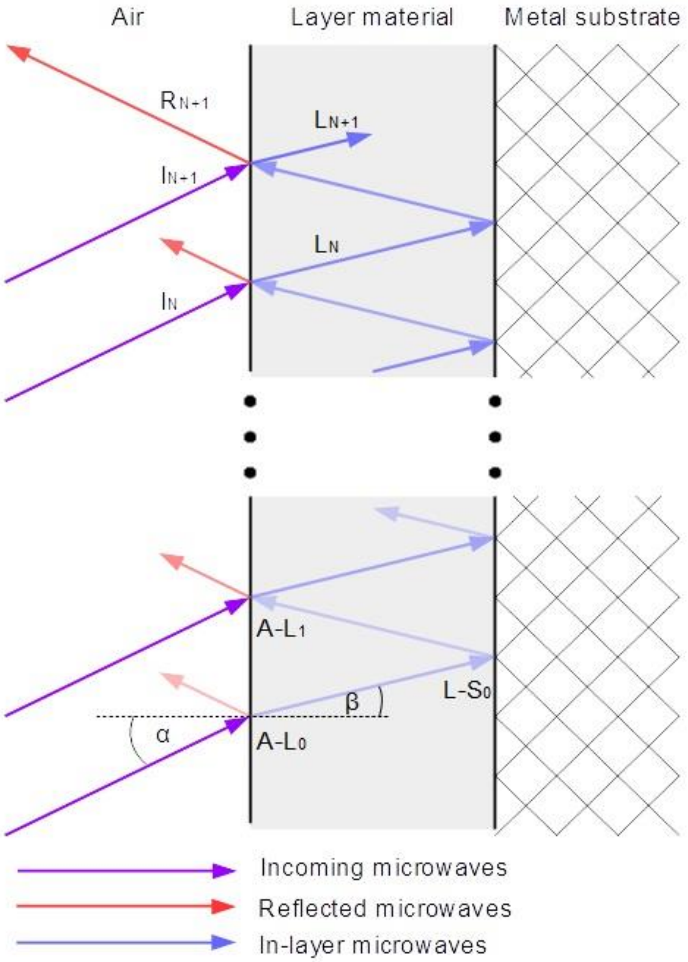
- plane waves
- multiple reflections
- intermediate absorptivity

$$k_{layer} = \sqrt{\frac{\sqrt{n_{layer}^4 k_0^4 + k_0^2 c^2 \mu_{layer}^2 A_{layer}^2} + n_{layer}^2 k_0^2}{2}}$$

With: $A_{layer} = \omega * \epsilon'' + \sigma$

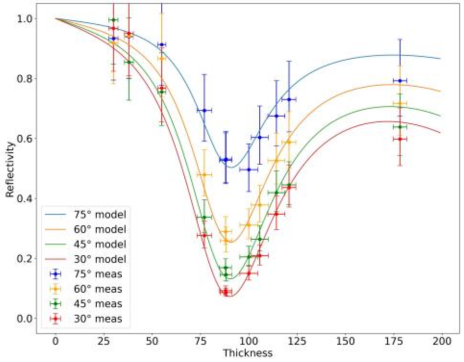
Restrictions:

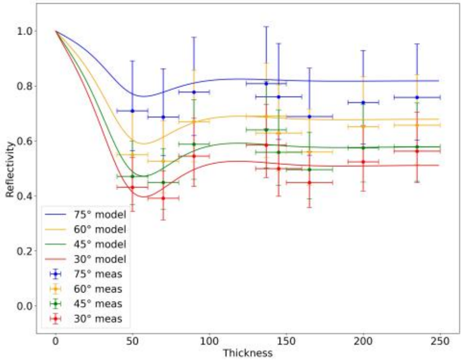
- surface roughness ignored
- evanescent waves in metal ignored
- single frequency only
- too high absorption or too thick layers lead to bad fits

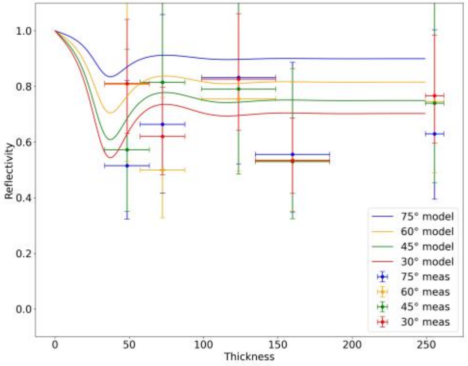


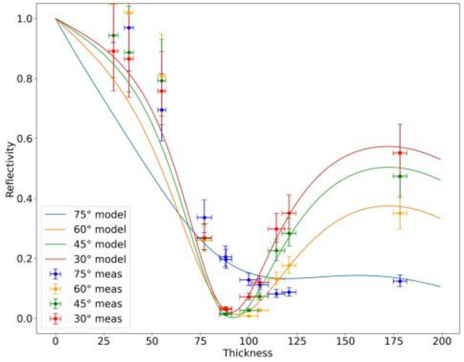
Comparison
Thickness dependency

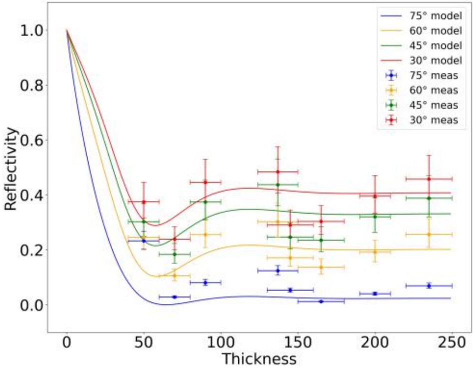
Al_2O_3-TiO_2 (40/60) | Cr_2O_3 | TiO_2

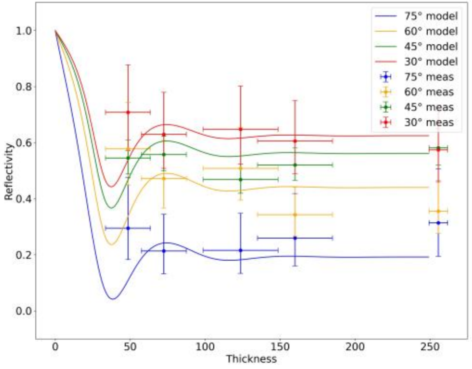




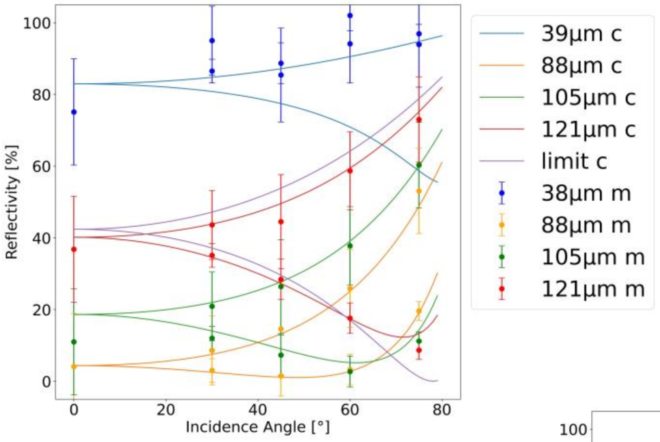






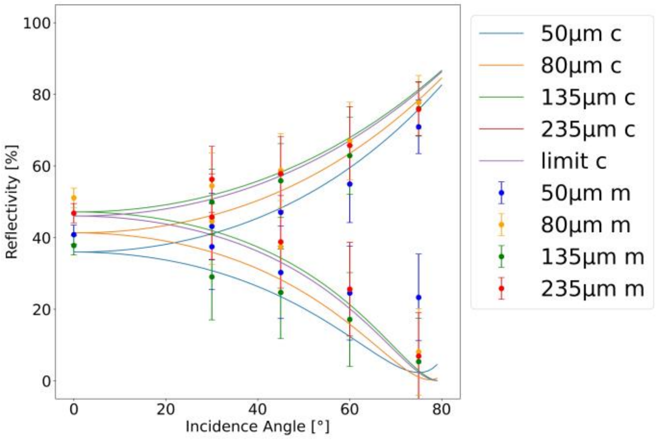


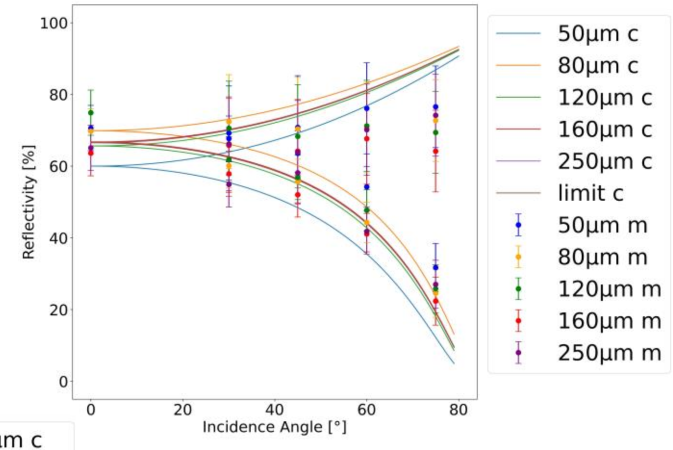
Comparison
Angle dependency



Al2O3-TiO2

Cr2O3



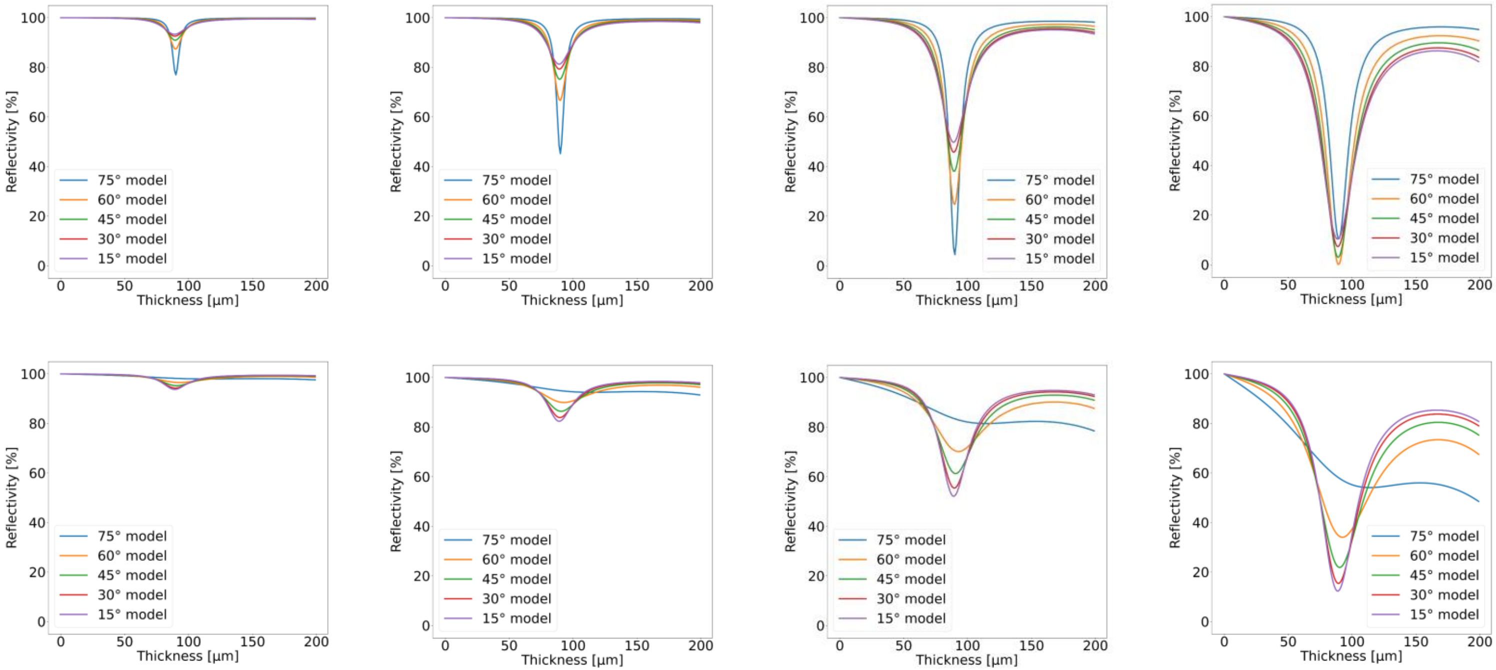


TiO2

Results
Counter-intuitive absorption coefficient dependency

o

p



Low

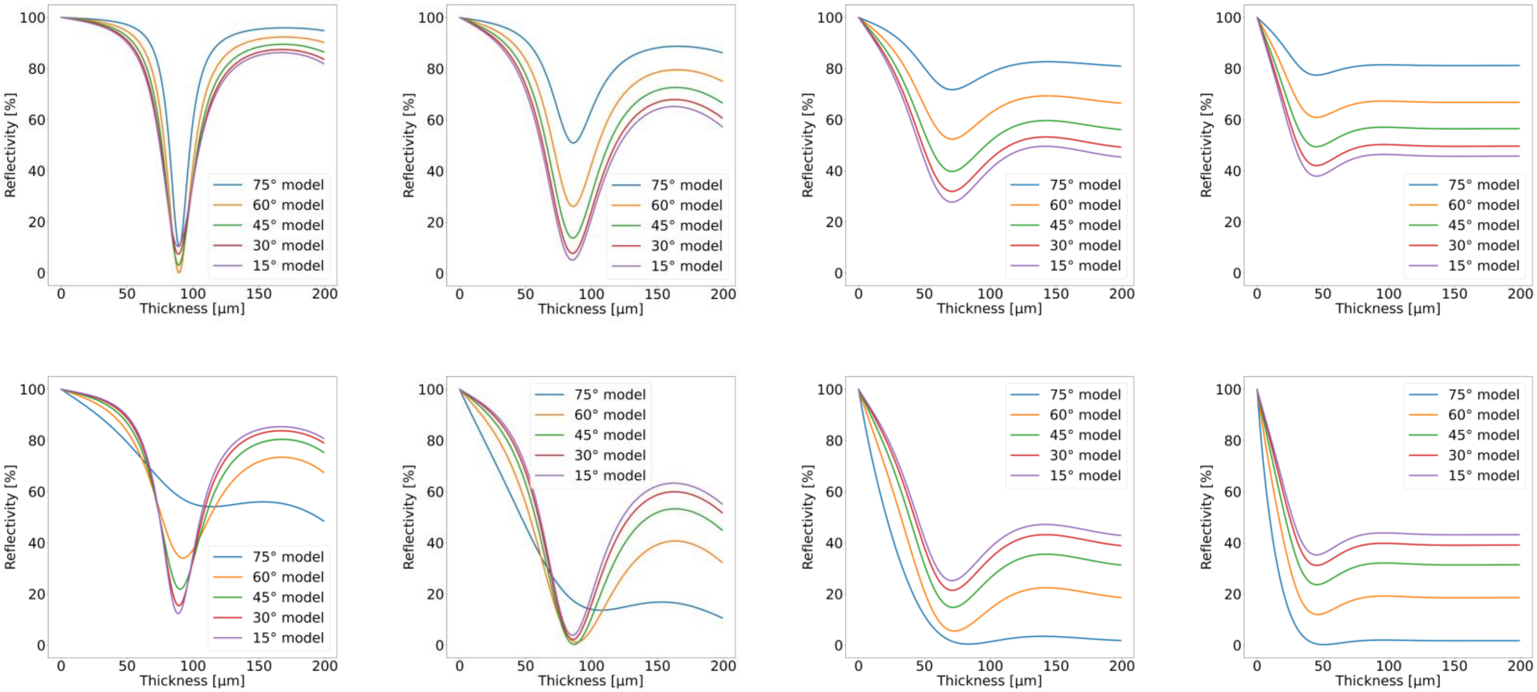
Medium

Results

Counter-intuitive absorption coefficient dependency

o

p



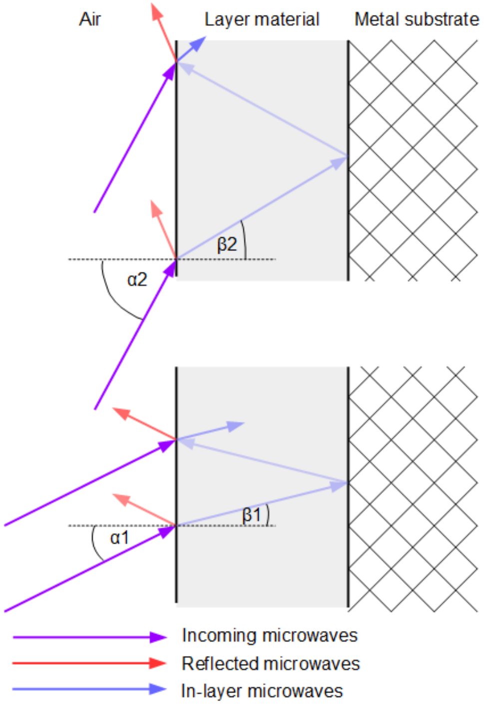
Medium

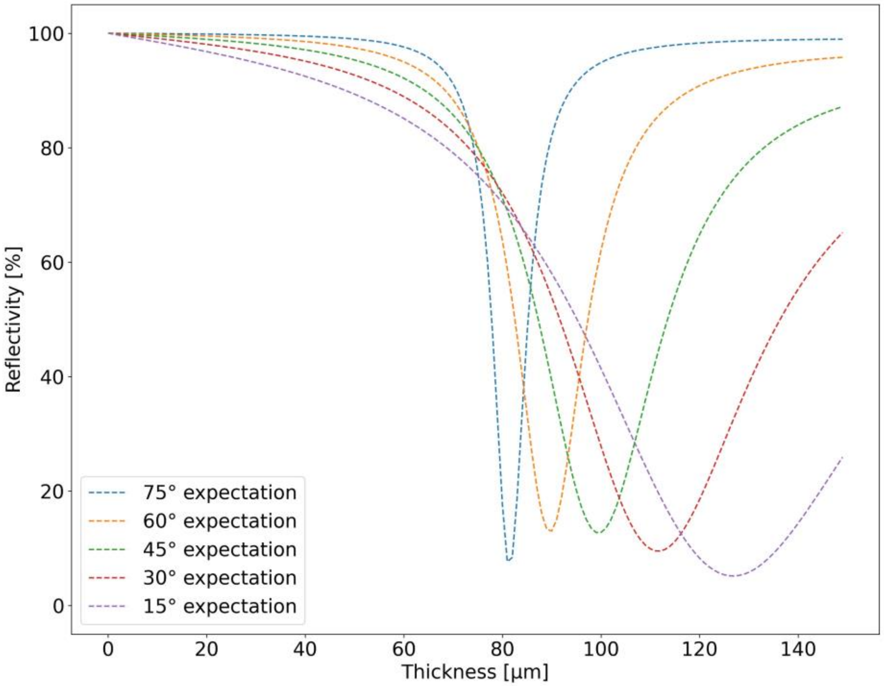
High

Results

Suppression of angle dependency

Expectation: Incidence angle changes resonant thickness



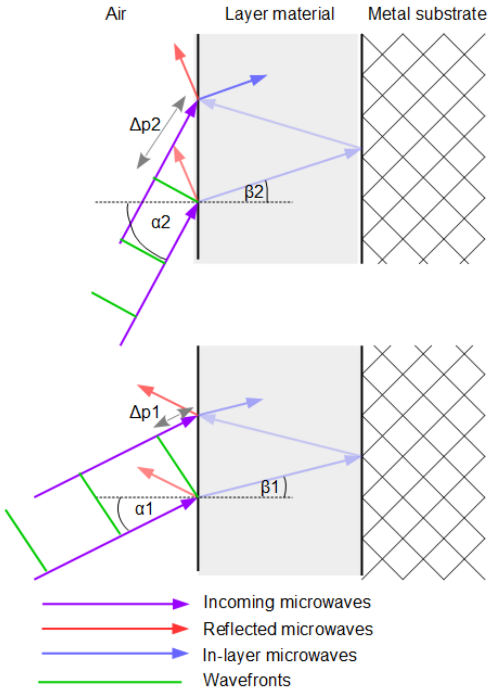


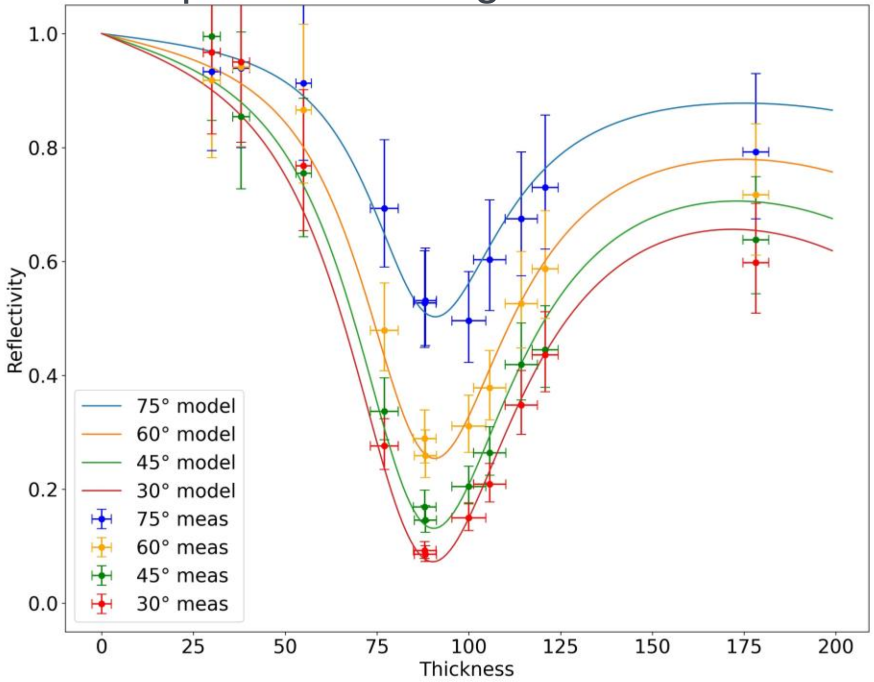
No correct model, just to show possible wrong expectation!

Results

Suppression of angle dependency

Reality: Resonant thickness almost independent of angle





1. High refractive index
2. Phase difference in air counteracts

Conclusion and Outlook

- Samples can be produced reliably with plasma spraying
- Aluminium-Titaniumoxid = best candidate
- Plane wave model describes dependencies sufficiently
- Depending on polarization and angle, 50% - >90% at the resonance thickness is realistic
- “A lot helps a lot” not true for absorption coefficient here
- Surprisingly good for stray radiation

- Next:
  - Change proportions for beam dump by design
  - Temperature dependency + stability

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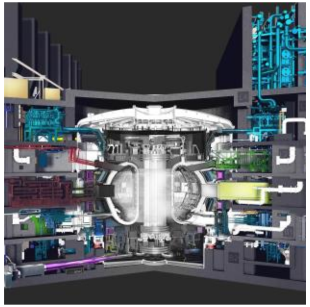
Thank you!



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Further information:

- Conference proceedings for more exact description of dependencies
- "Resonant Atmospheric Plasma-Sprayed Ceramic Layers Effectively absorb Microwaves at 170 GHz" in International Journal of Infrared and Millimeter Waves (accepted) for more exact description of material, measurements and model