Development of Innovative Insulation Systems on the Basis of Vacuum Insulation Panels

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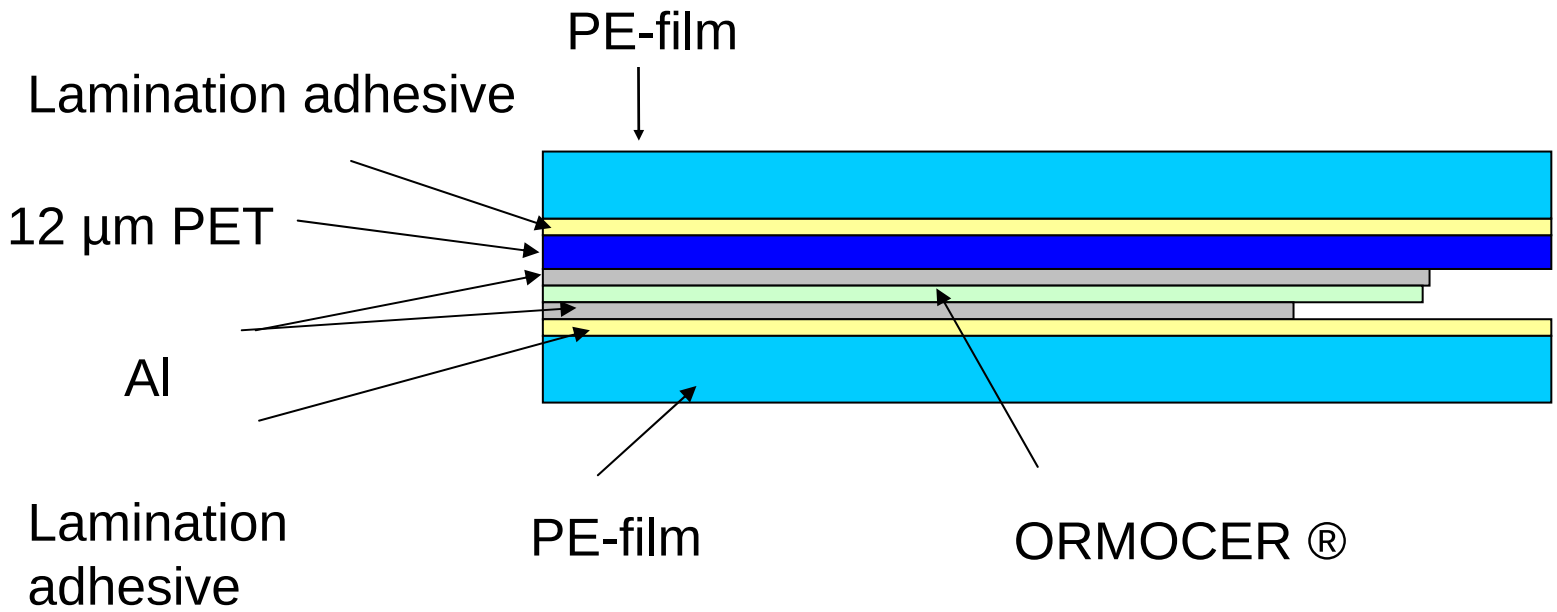
Overview

- Barrier film development
- Influence of panel production on barrier films
- Heat flux measurements and simulation
- Design of exterior wall insulation system
- Evaluation and monitoring
- Conclusions

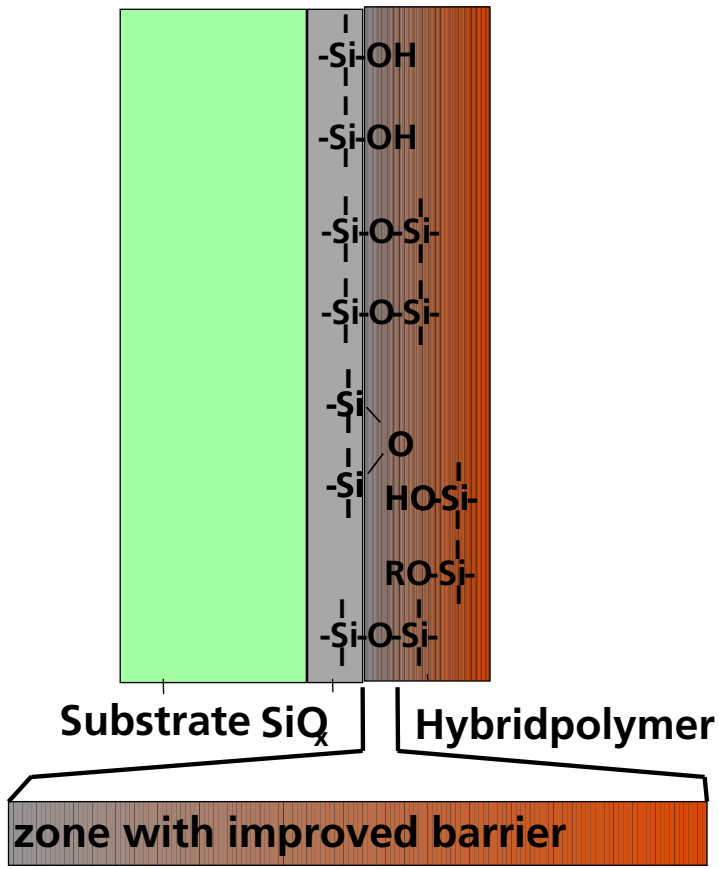
Barrier Film Development

- Alternative Layer composition

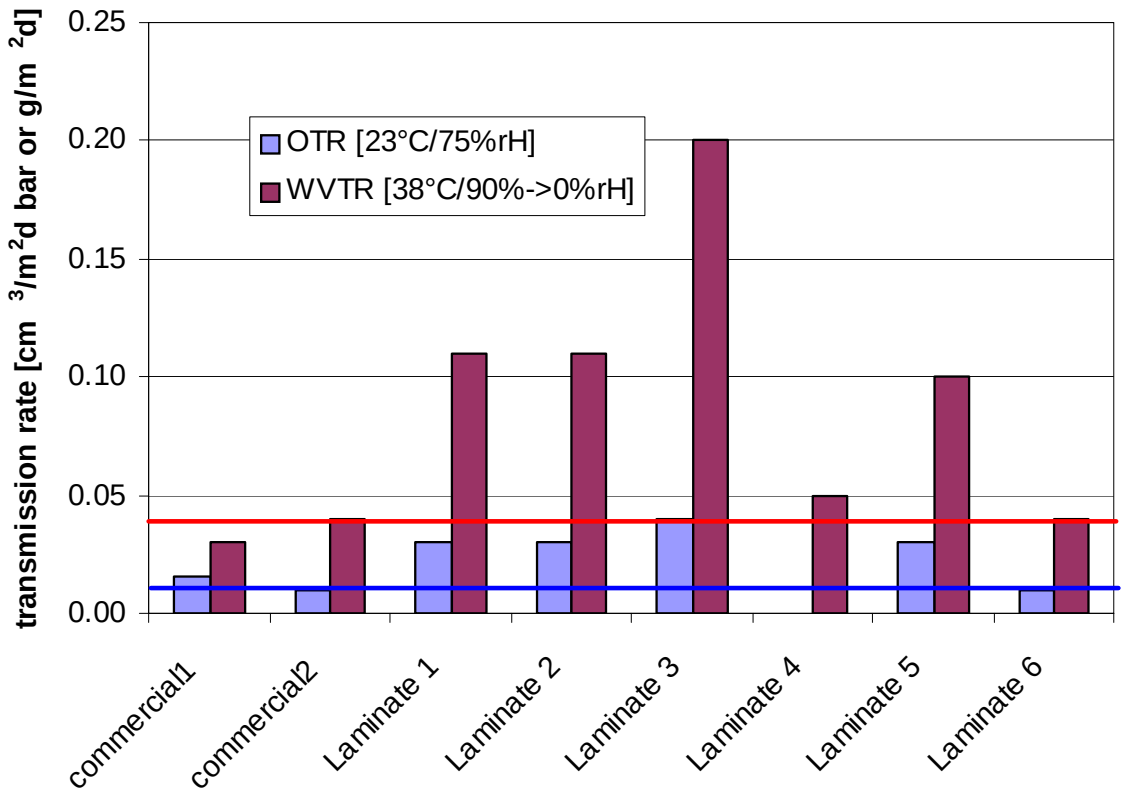


Interface Aluminum and Ormocer

- Previous studies show improved barrier potential for ORMOCER®s on anorganic layers
  - formation of covalent bonds
  - regular boundary layer



Results from prototype laminates

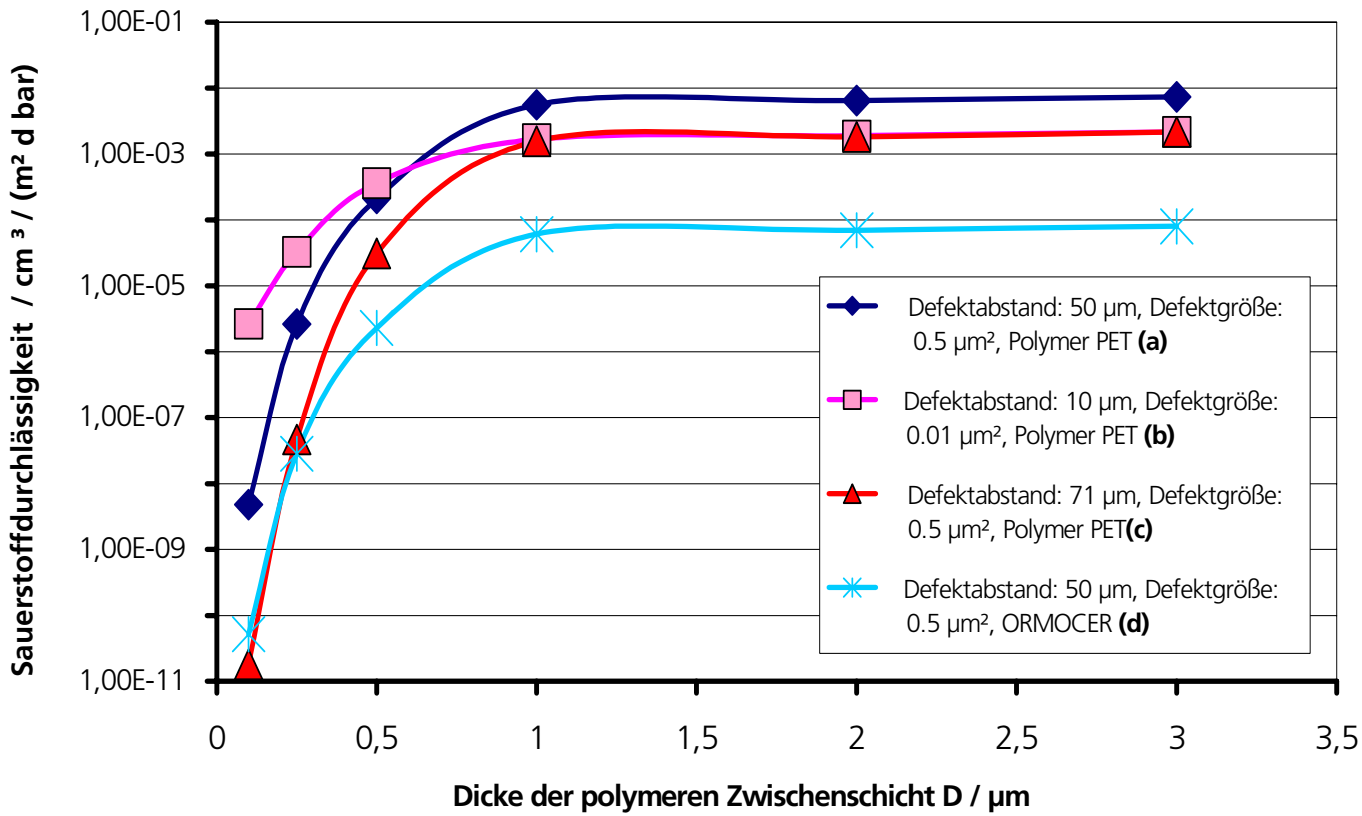


Potential of optimisation

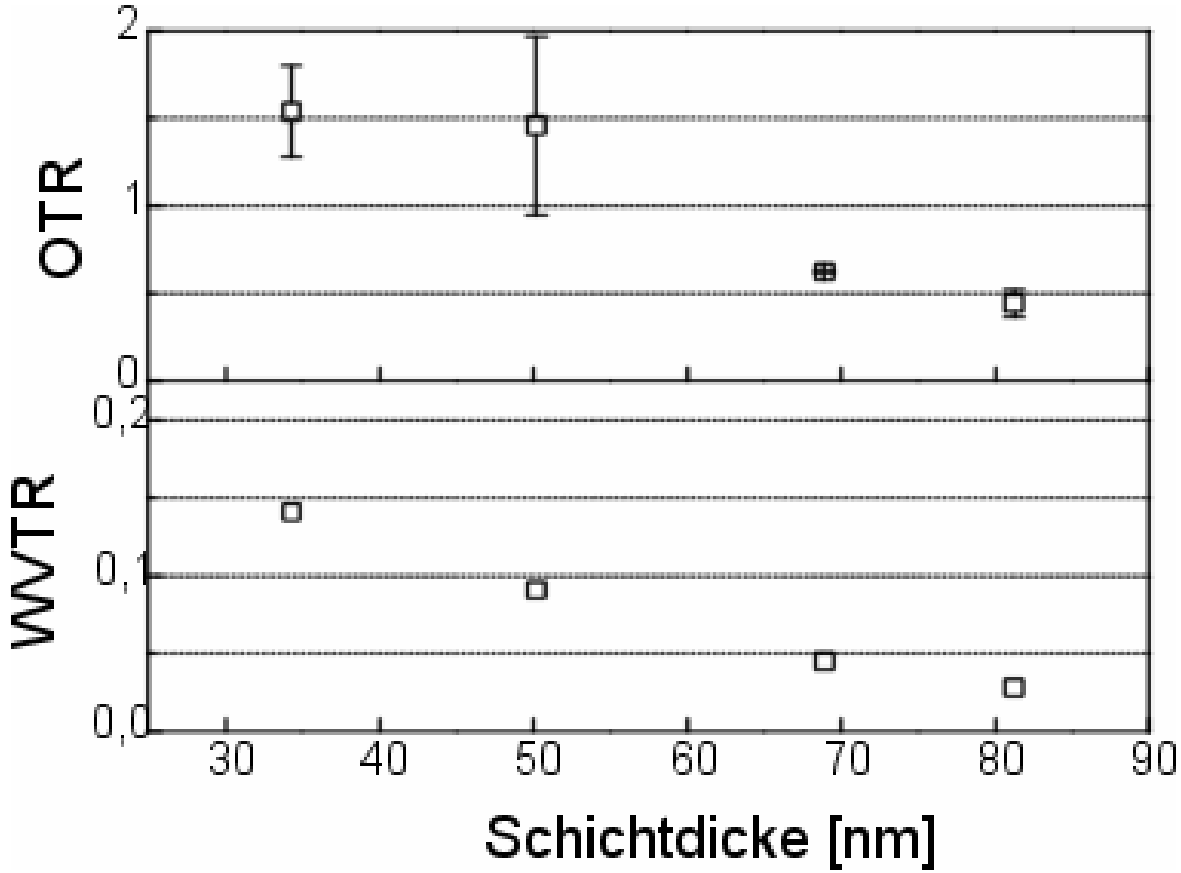
- Increase of aluminum layer thickness
- Change of standard lacquer Ormocer® 08 against further developped lacquers used already within the project in other tests
- Reduction of Ormocers® layer thickness

=> expected consequence:
improvement of 1-2 orders of magnitude

Theoretical Simulation Ormocer Layer Thickness

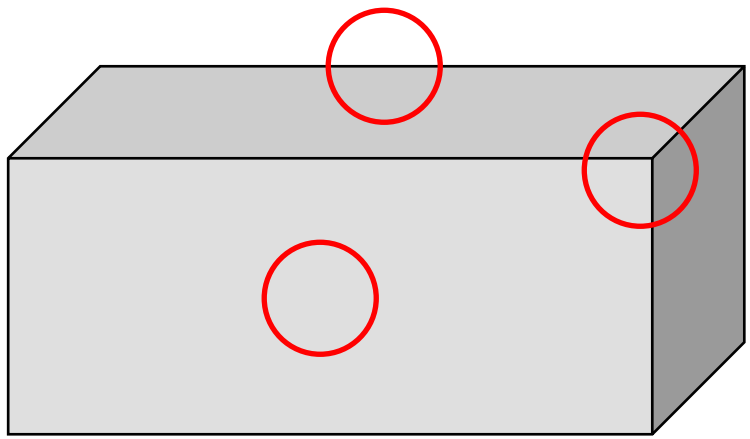


Influence of Aluminum Thickness



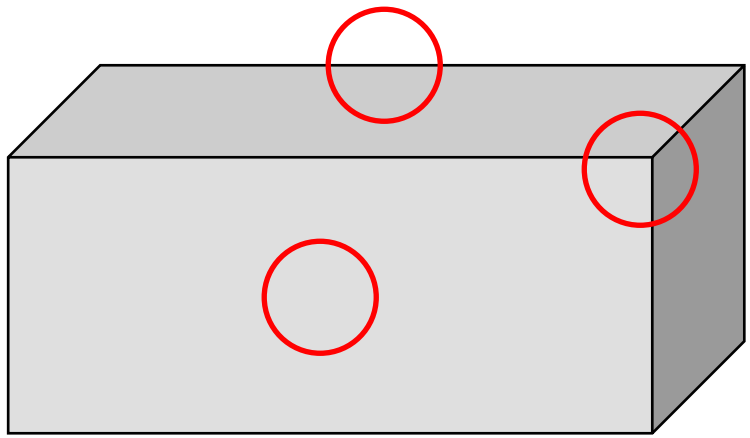
VIP Panel characterisation

- Films were cut from different positions of a thin (10mm) and a thick (20mm) VIP panel
- OTR and WVTR were determined
- 3 commercial films used for panel production



VIP Panel characterisation results

- Depending on film deterioration of film properties in corners and edges was observed
- worst case more than factor 10 deterioration in corners best case still factor 4 deterioration for WVTR
- no significant difference between thin and thick panels



Panel heat transport

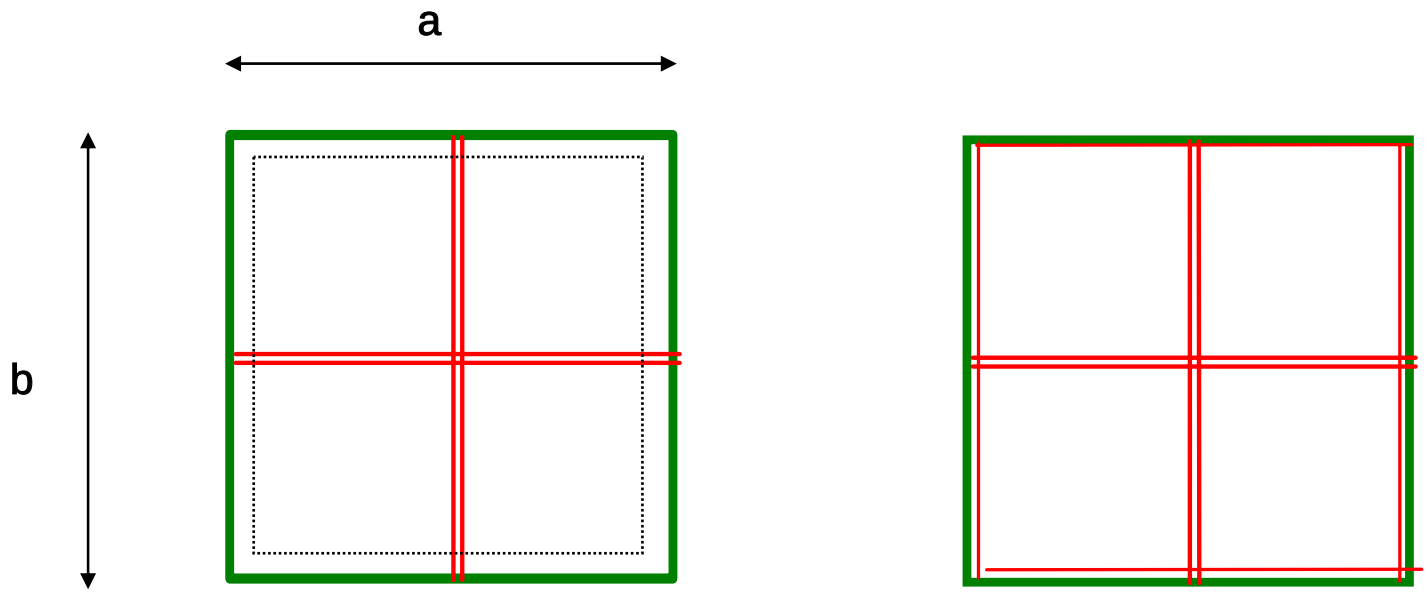
- Linear thermal conductance

$$U = U_0 + \frac{\Psi \cdot L}{A}$$

- Contributions from two panels

$$\Psi = 2 \cdot \Psi_{1/2}$$

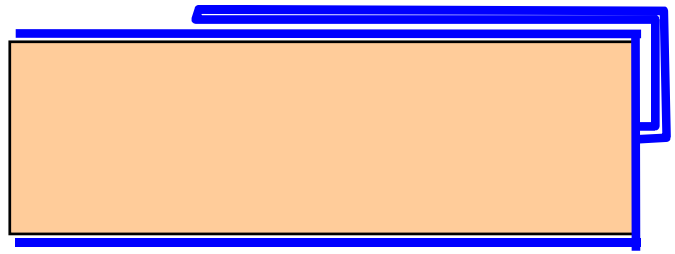
Panel heat transport



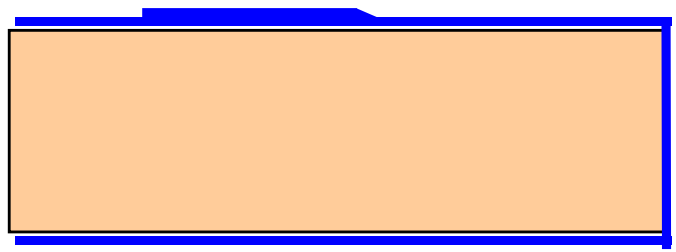
$$U_{meas} = U_0 + \frac{2 \cdot (a+b) \cdot \Psi_{1/2}}{a \cdot b} \qquad U_{avg} = U_0 + \frac{4 \cdot (a+b) \cdot \Psi_{1/2}}{a \cdot b}$$

Testing of different VIP types

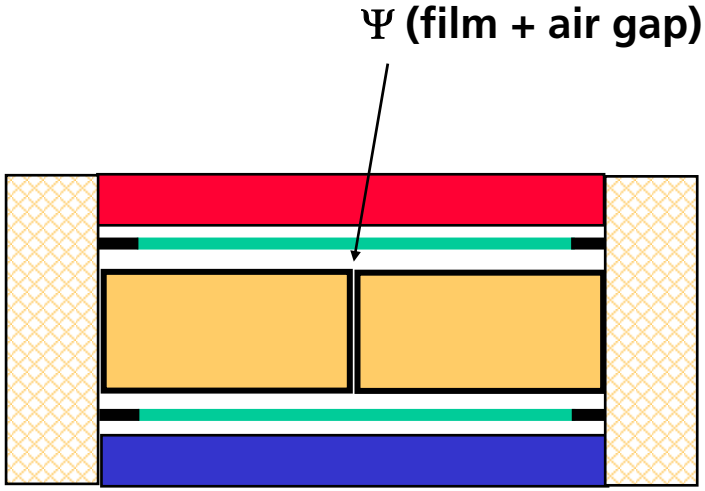
- Type VIP1

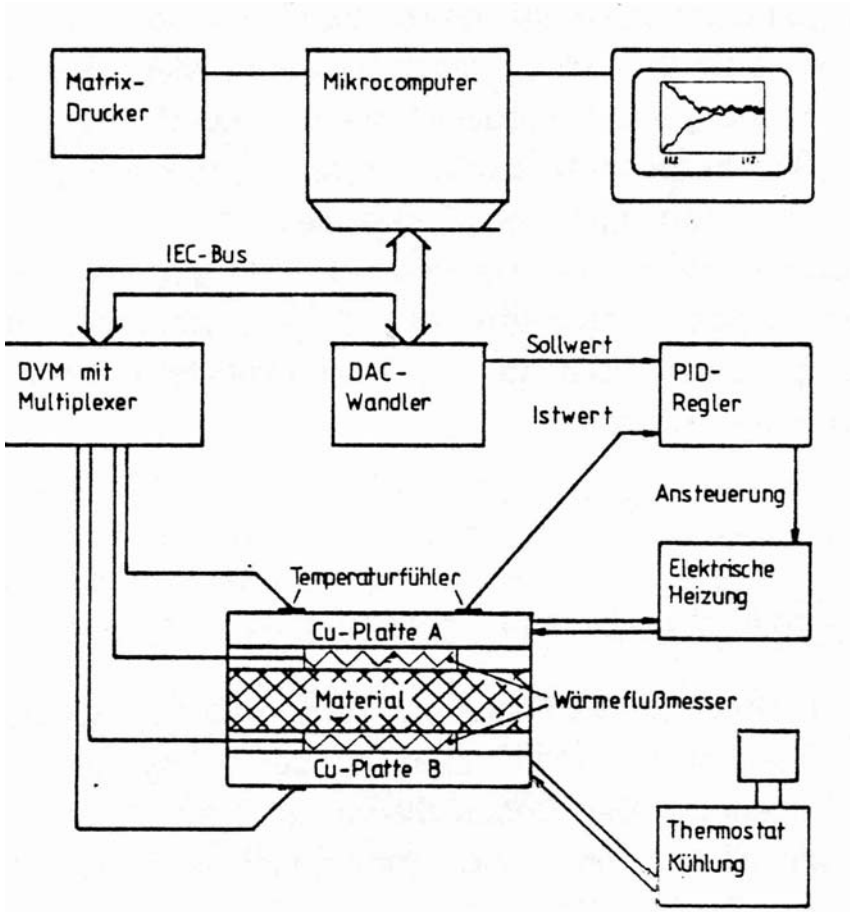


- Type VIP2 with reduced thermal bridge

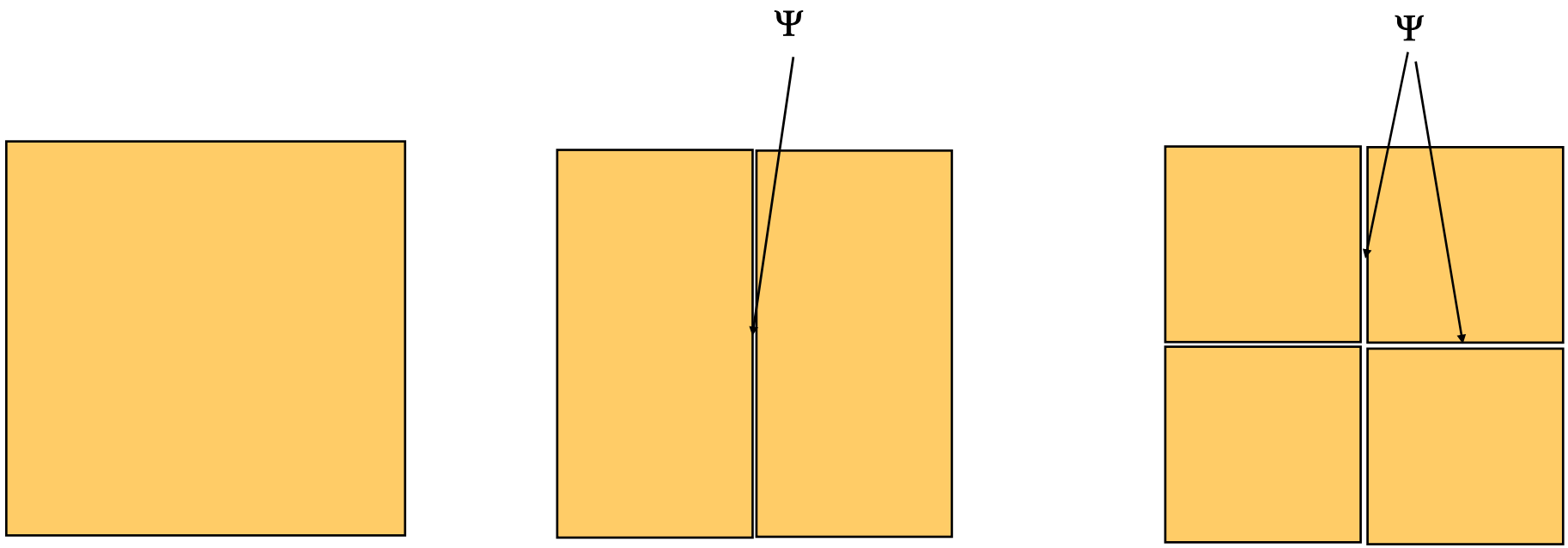


Hot-plate apparatus using heat flux meters





Testing of VIPs with different sizes

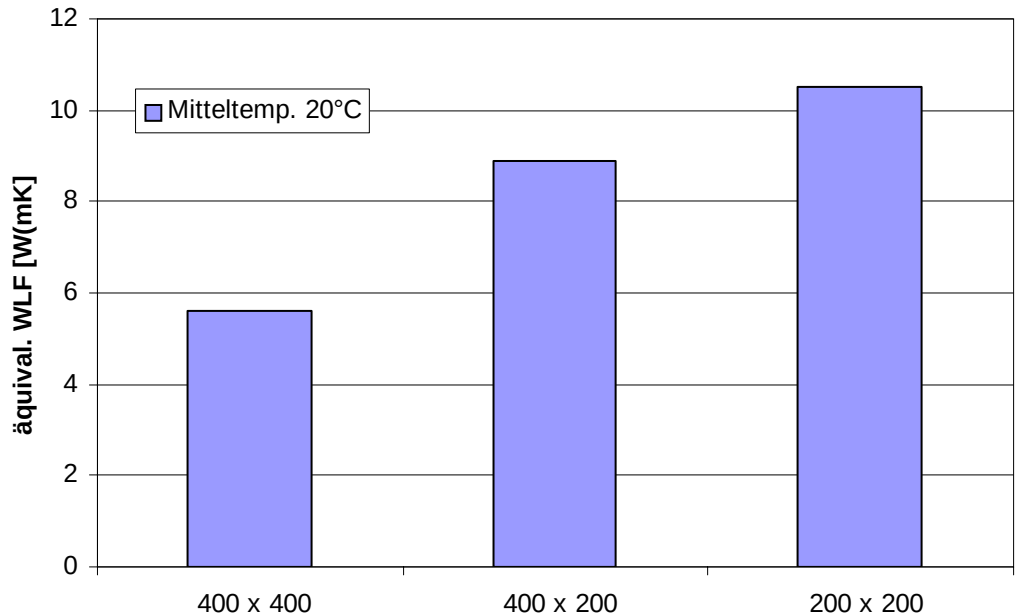


U_0

$U_0 + L/A * \Psi$

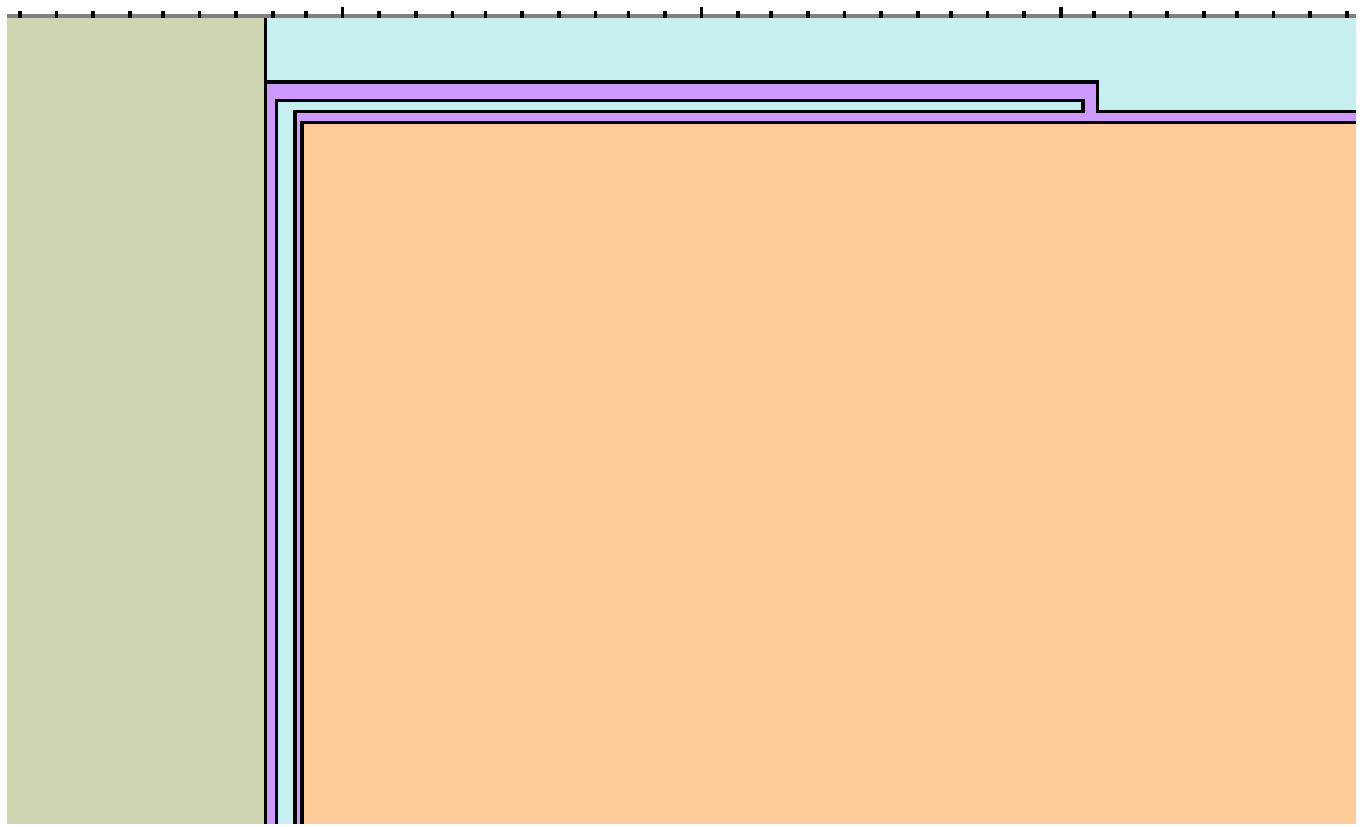
$U_0 + 2*L/A * \Psi$

Measurement results (VIP1)

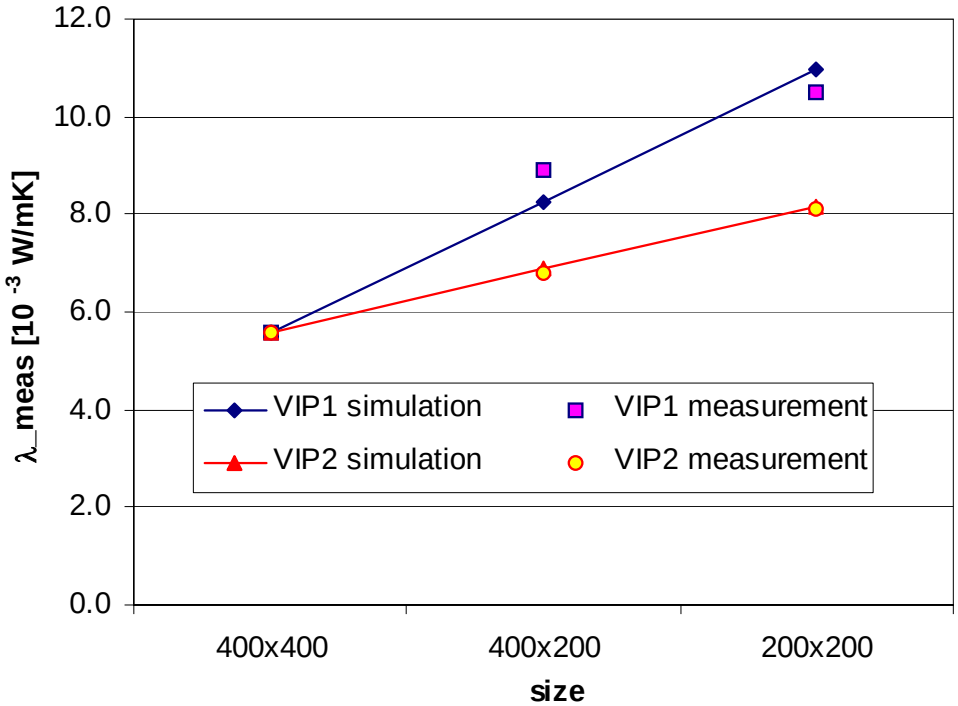


$$\Psi = (0.052 +\!\!- 0.010)\ \mathbf{W/mK}$$

Simulation of folding ears

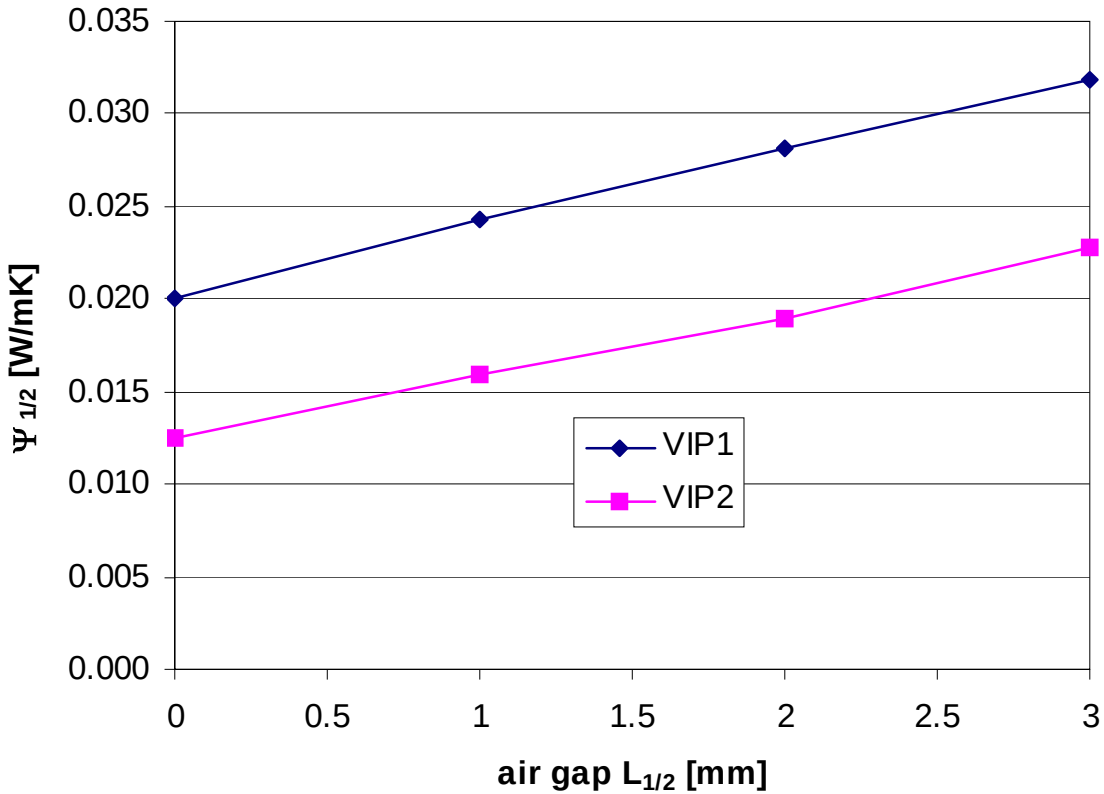


Calibration of simulation film conductivity

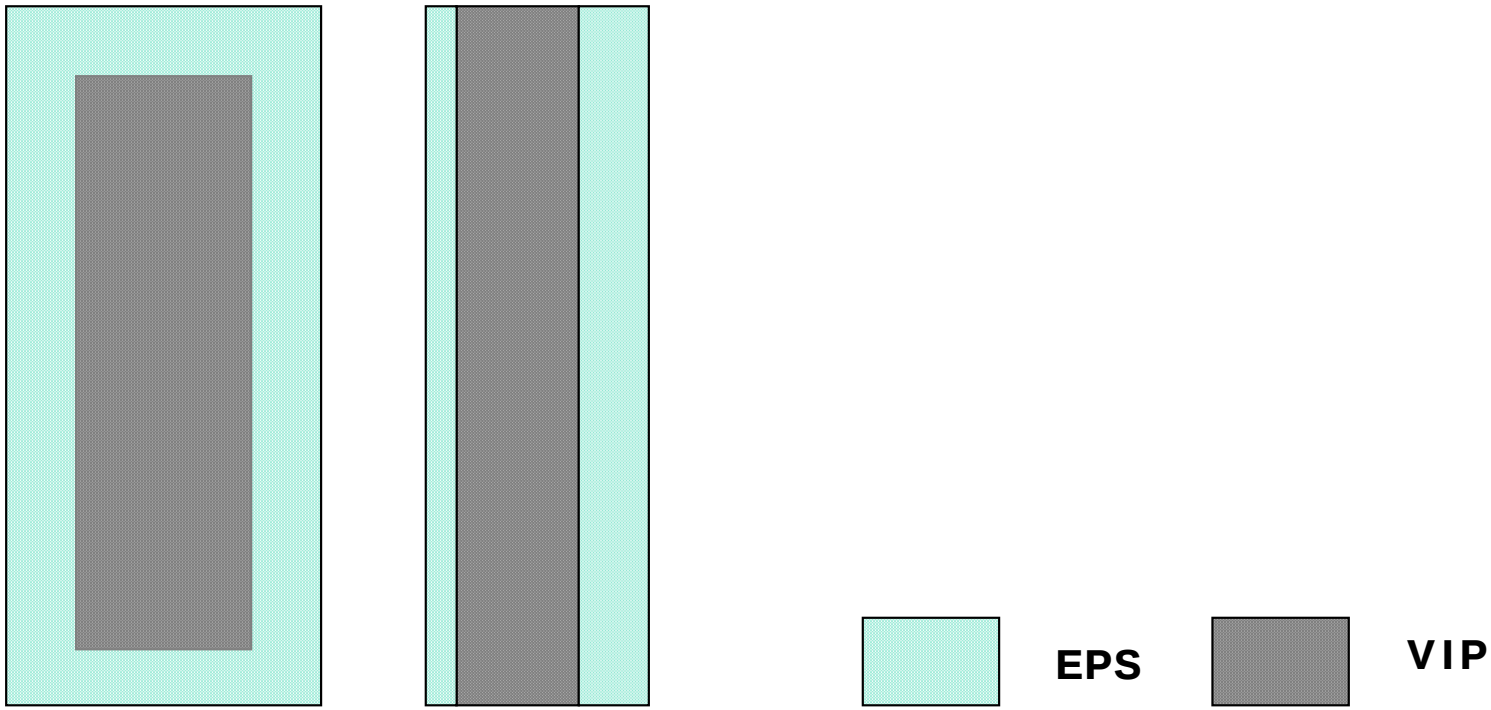


λ_{eff} (100µm) = (1.5 +- 0.4) W/mK

Results of thermal simulation

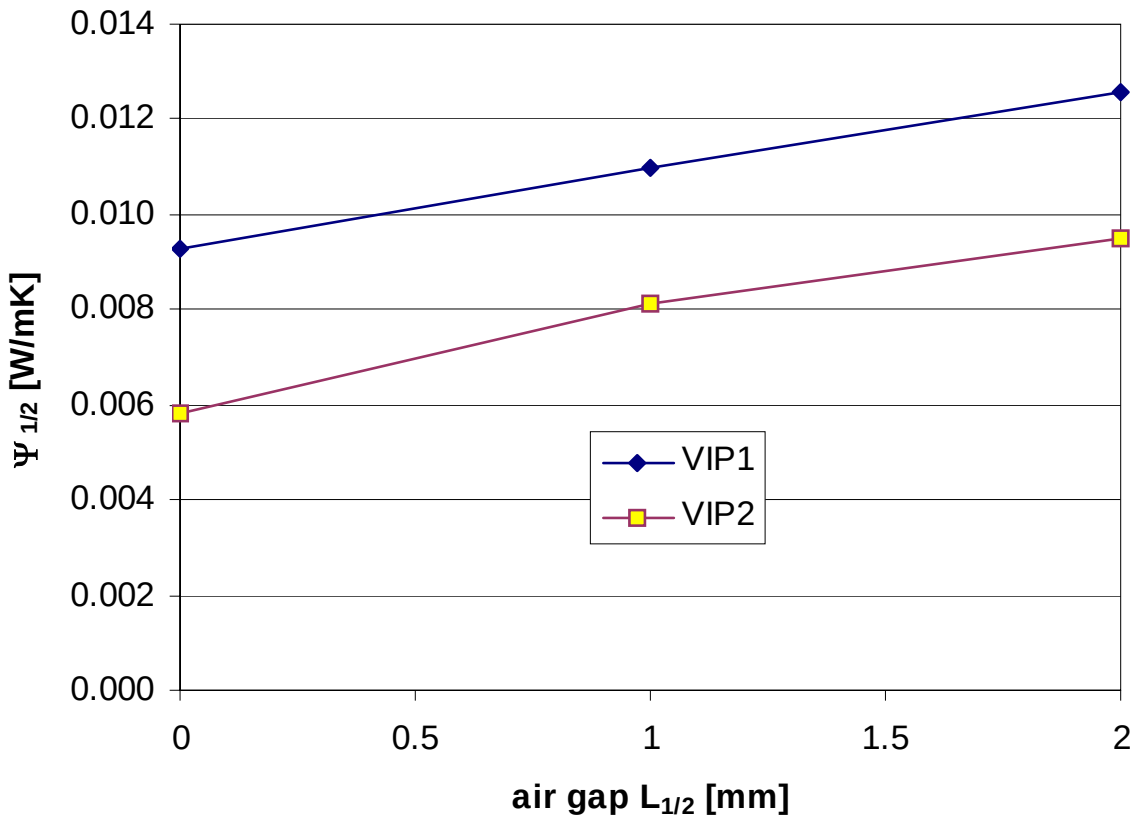


Design of exterior wall system

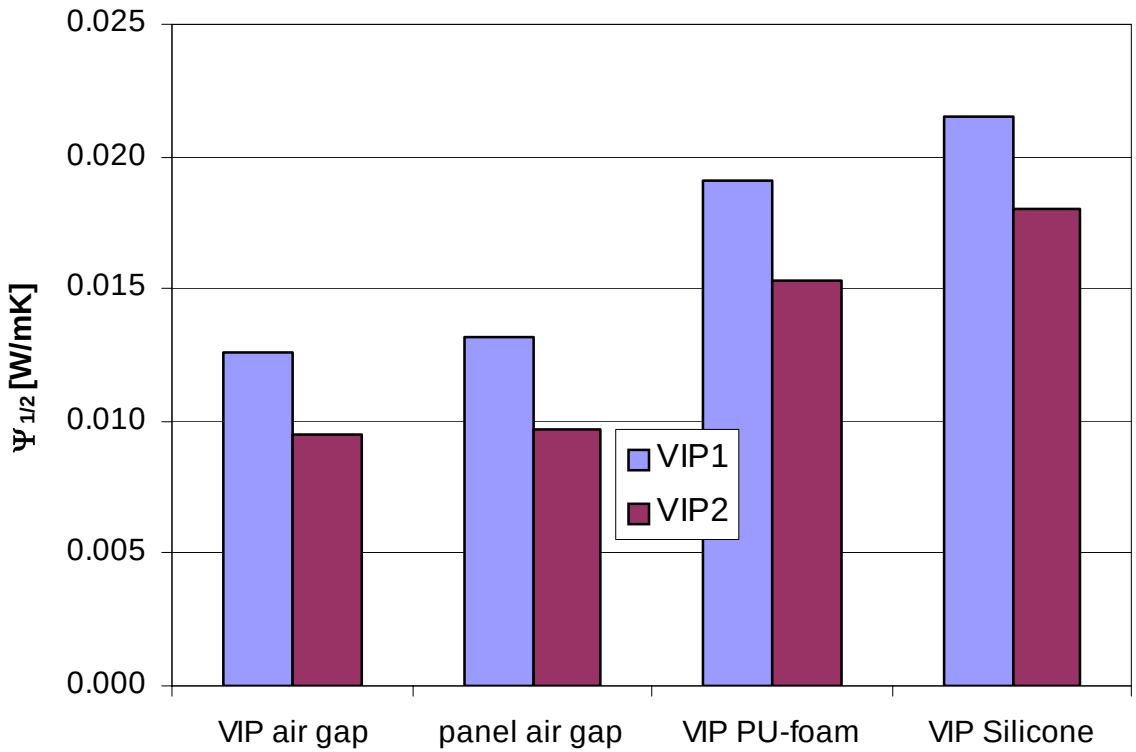


Basic systems A and B for encapsulating VIP in polystyrene foam EPS

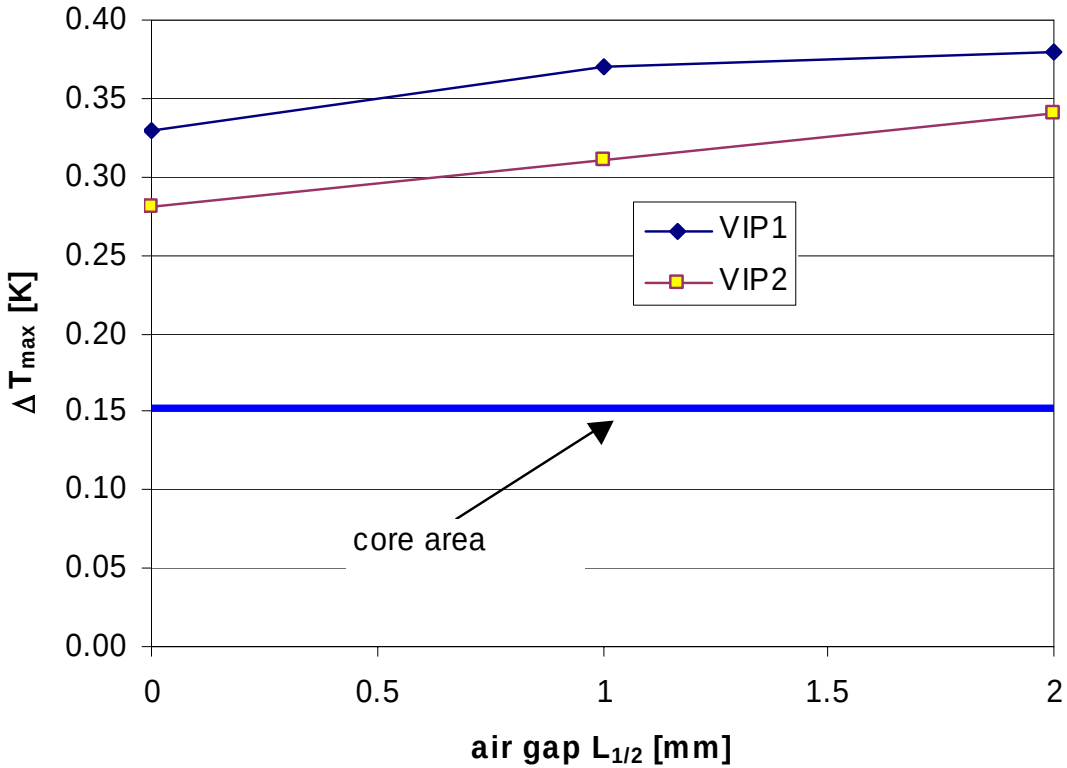
Simulation - effect of air gaps for system B



Simulation - effect of closing air gaps 2x2mm

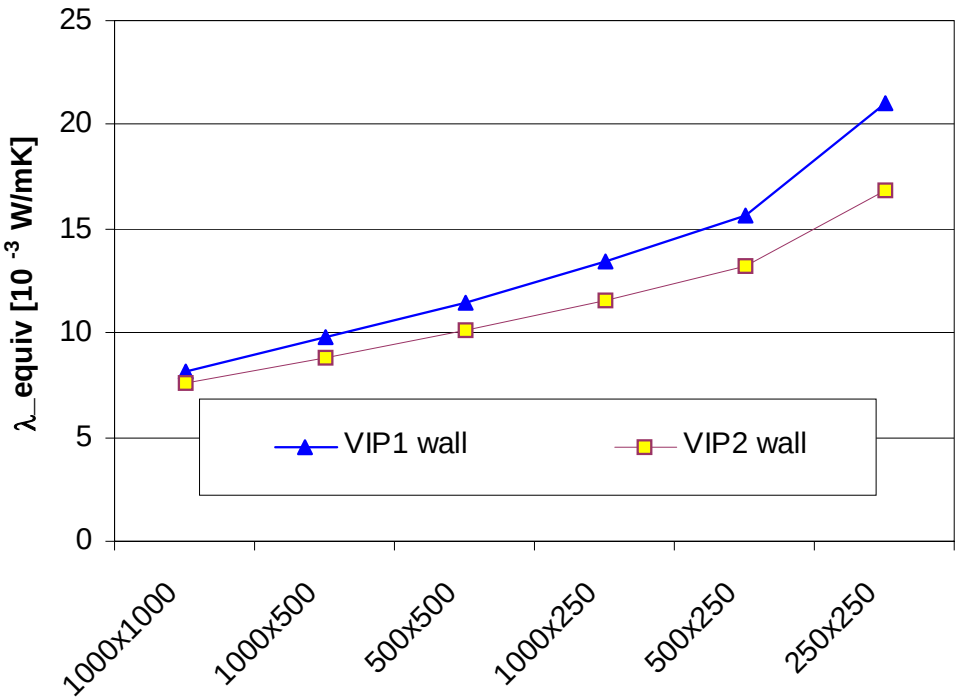


Surface temperature variations - outside air temperature 0°C

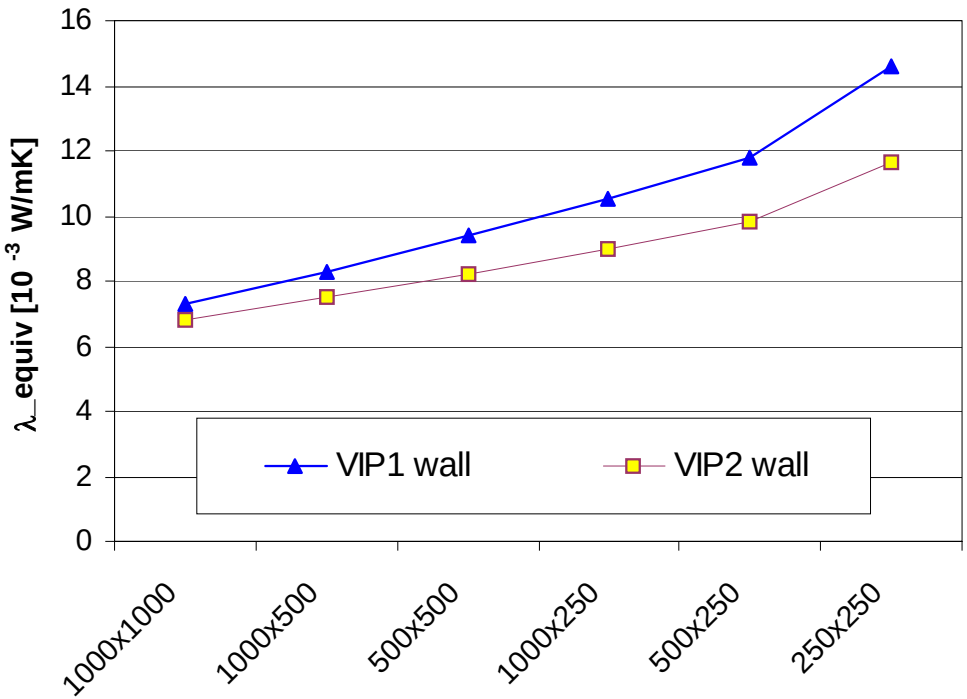


Equivalent conductivity of VIP-panel in EWIS - size dependance

Air gap filled with PU-foam

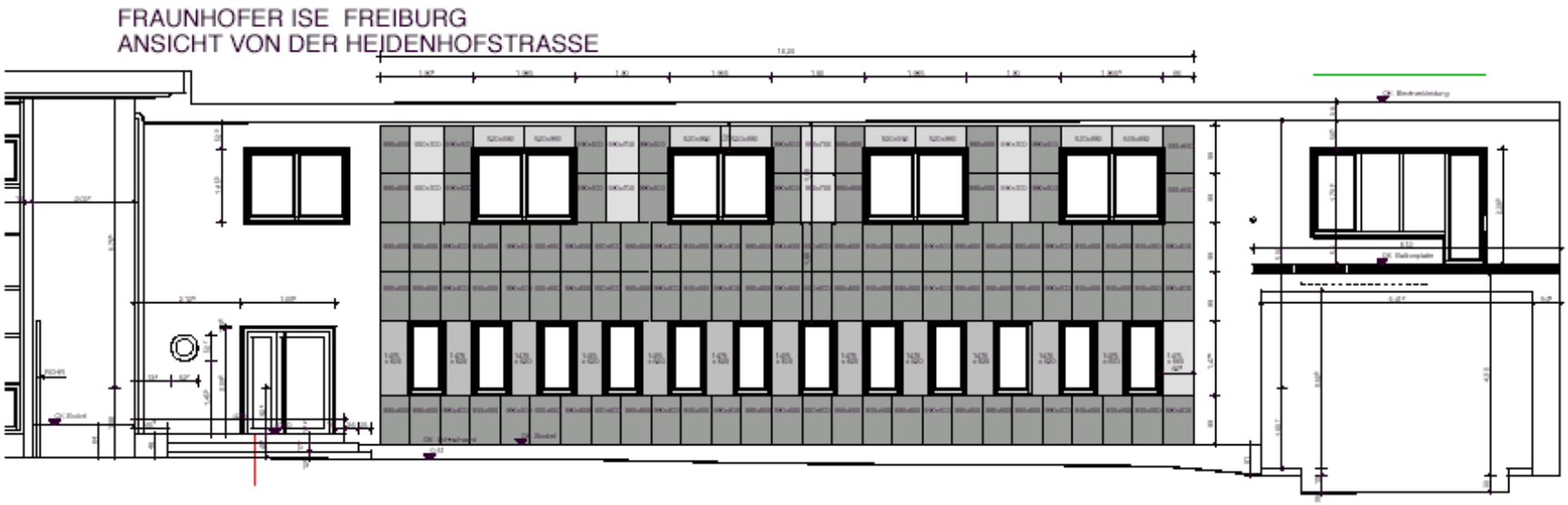


Equivalent conductivity of VIP-panel in EWIS - size dependance



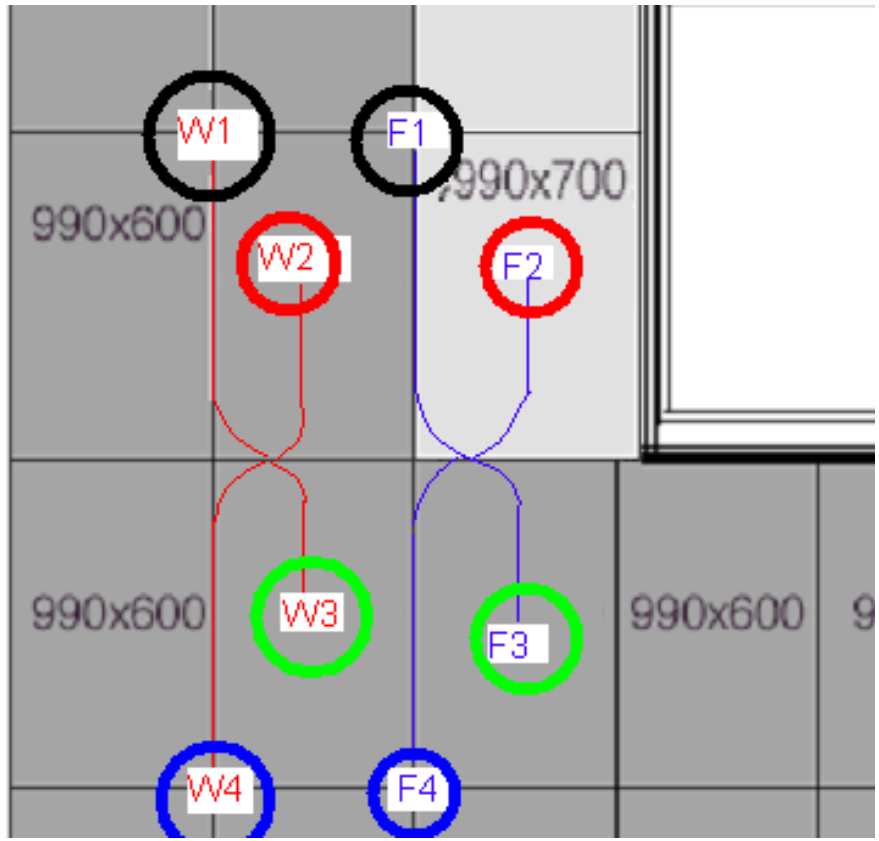
Air gap filled with foamed rubber

Planning of demonstration facade



Ultraslim prototype facade

Monitoring of facade



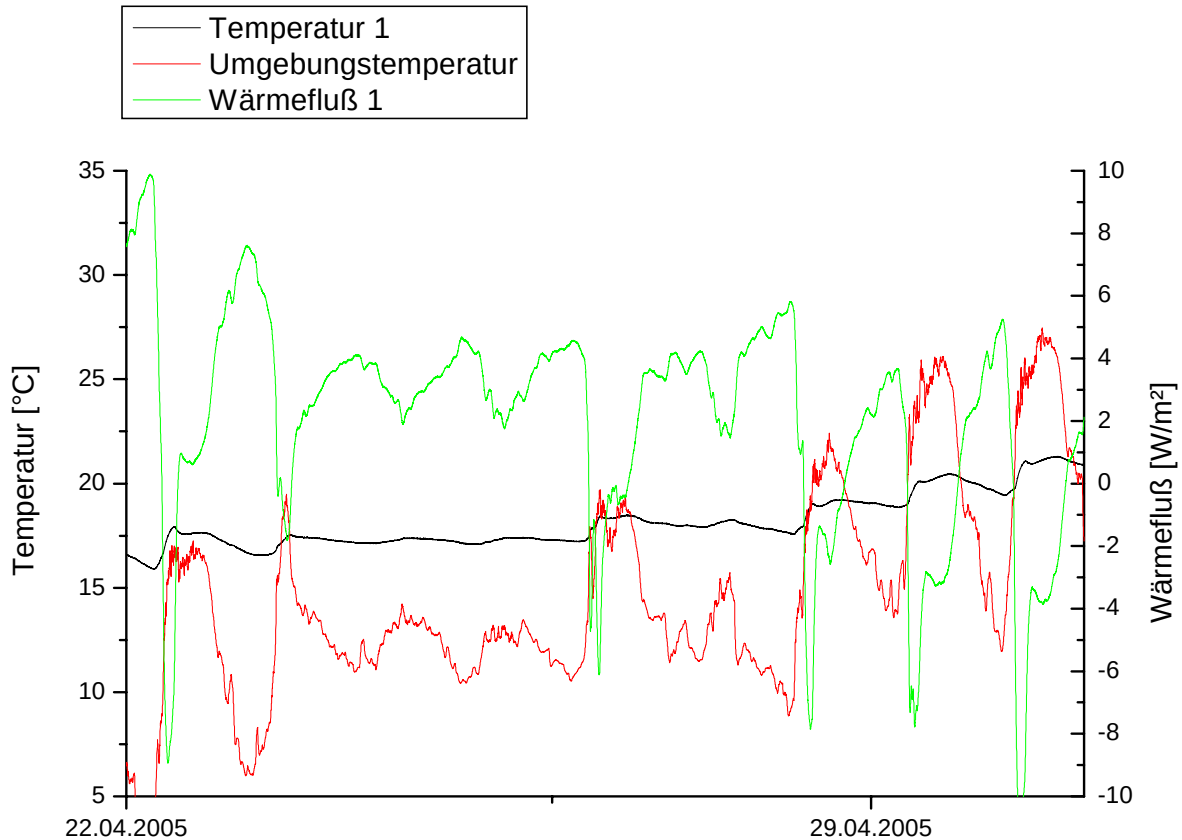
Monitoring of facade

Position between VIPs

Heat flux

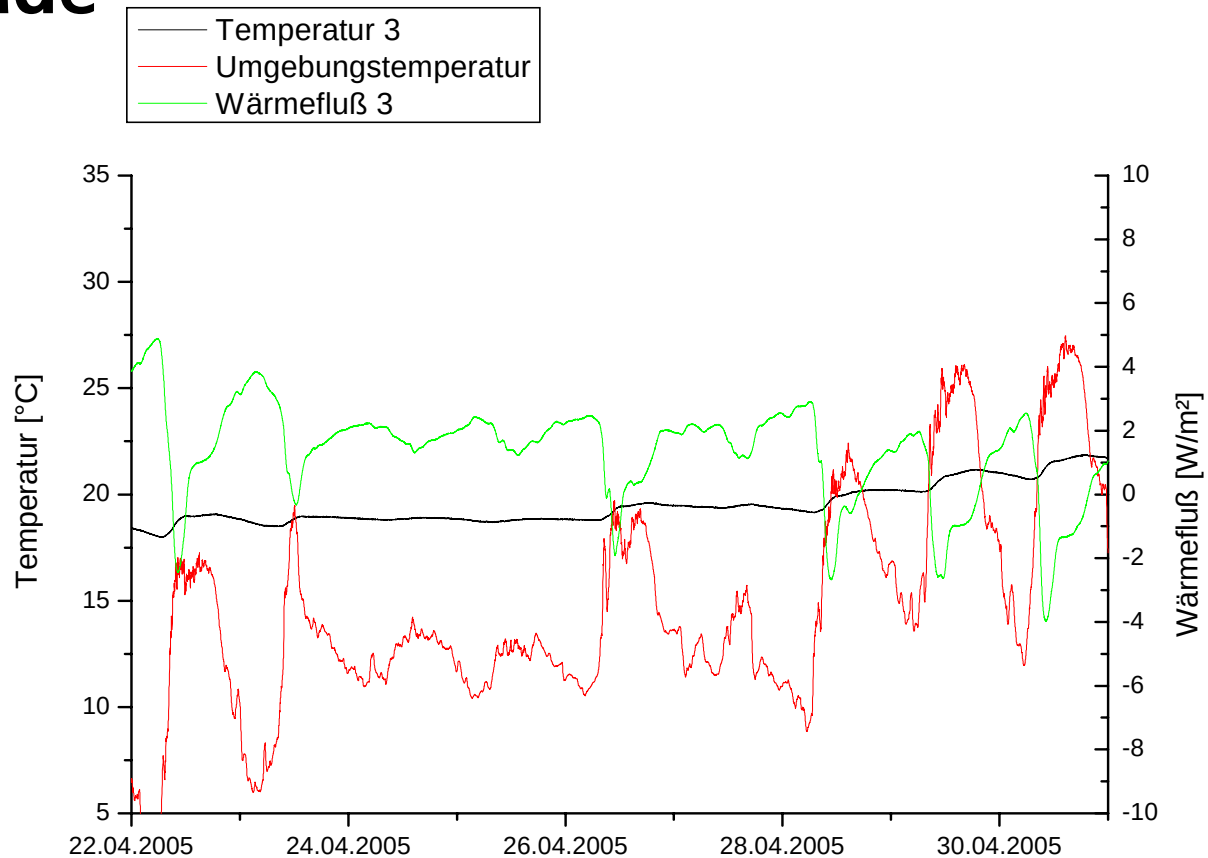
Contact temperature

Ambient temperature



Monitoring of facade

Centre position



Heat flux

Contact temperature

Ambient temperature

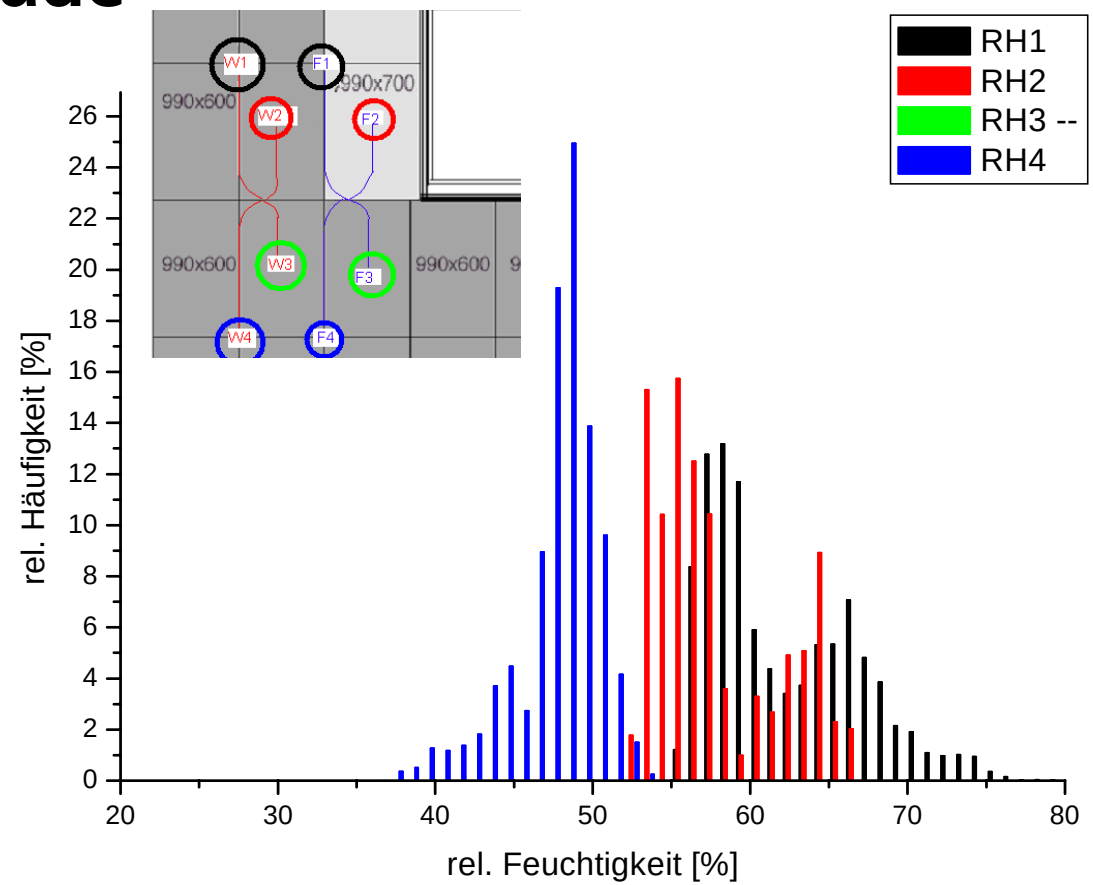
Monitoring of facade

Humidity behind VIP

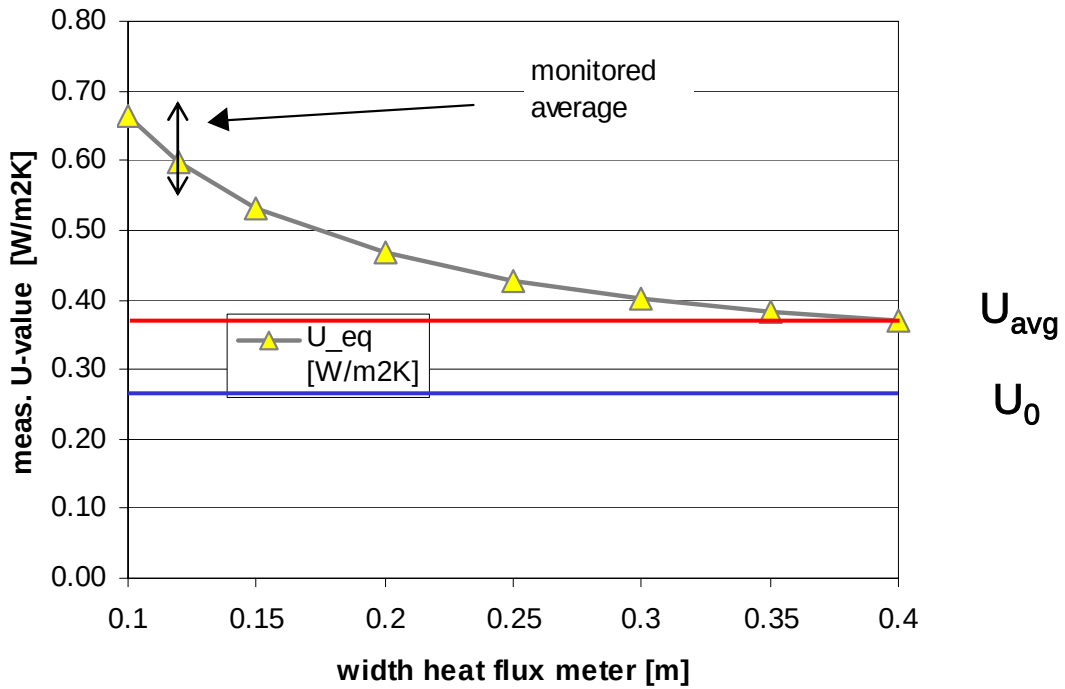
Edge heated wall

Edge unheated wall

Centre unheated wall



Size effect of heat flux meter measurement



Summary

- Barrier film development encountered difficulties
  potential improvement over state of the art considerable

- Prototype panels have been measured and simulated consistently - considerable impact of gaps

- Exterior wall systems have been designed, simulated and monitored - reduction of thermal bridges needed

Acknowledgements

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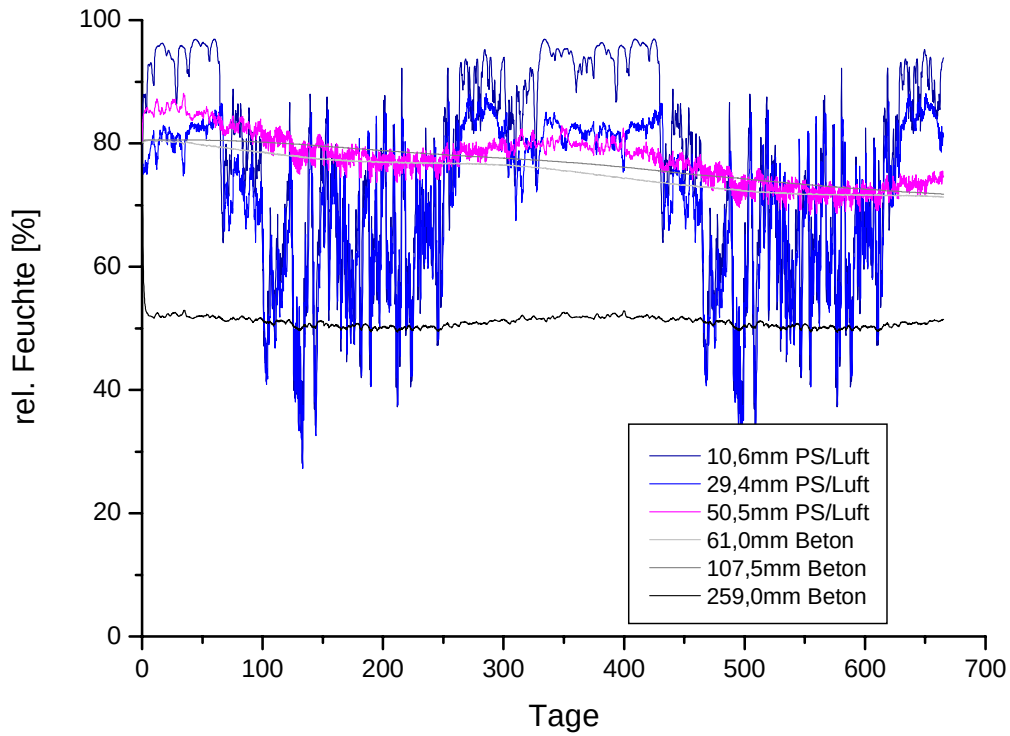
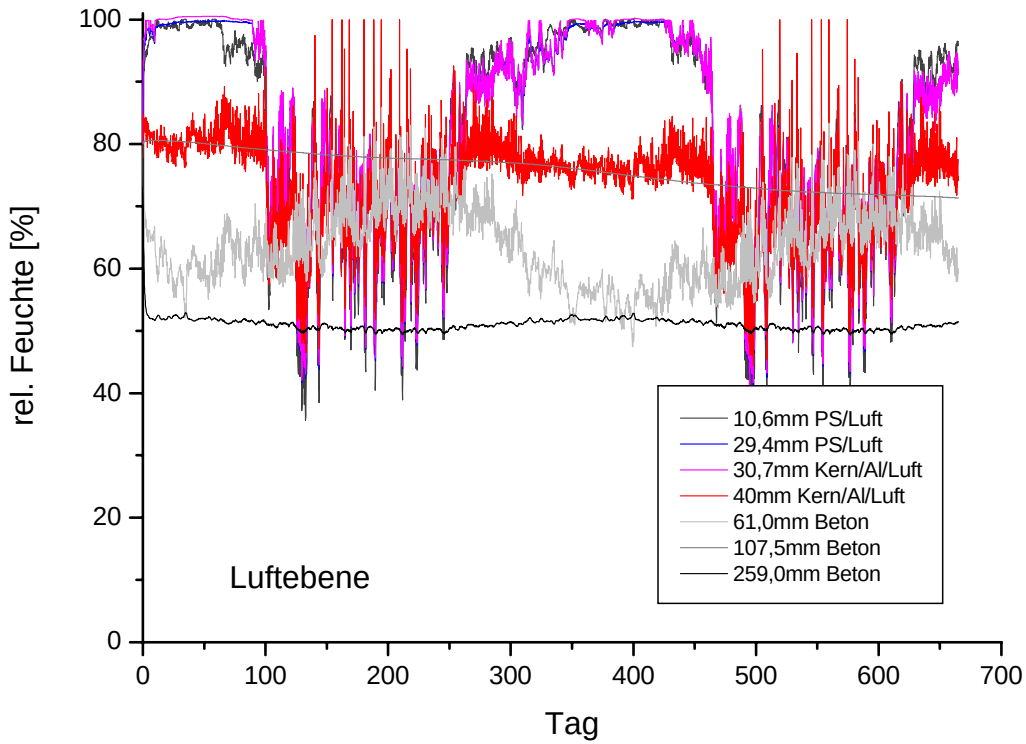
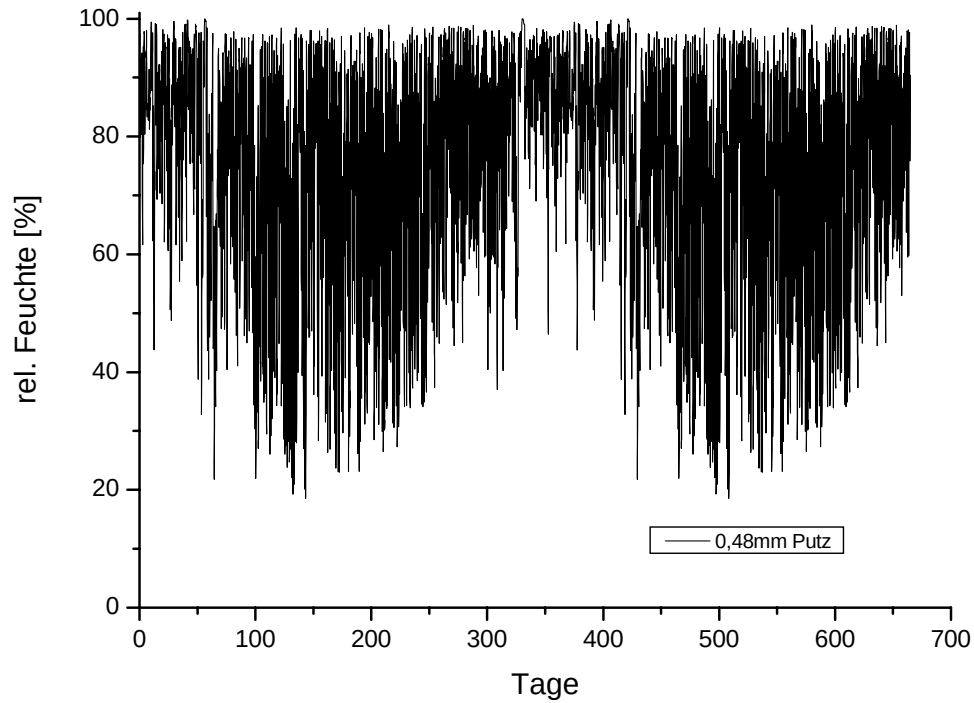
Humidity simulation - central region



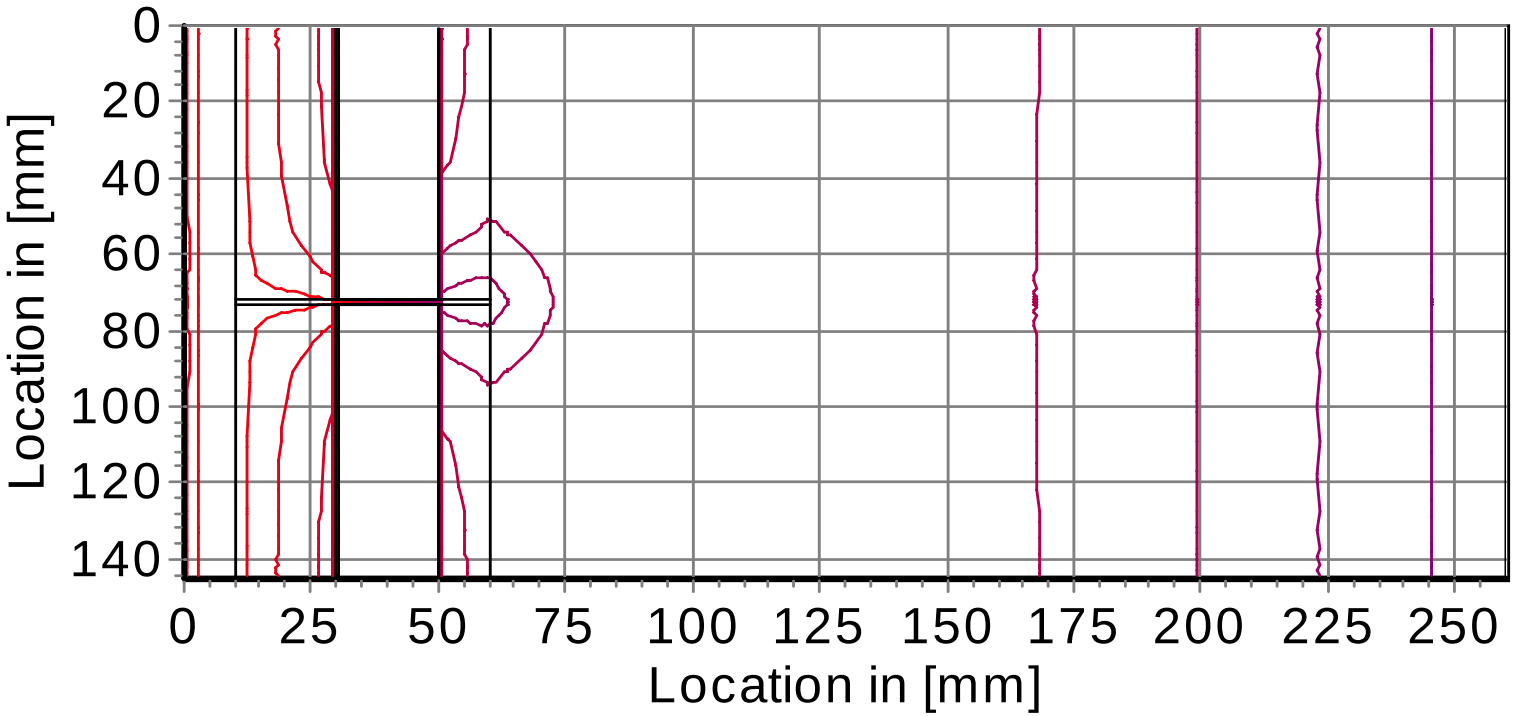
Humidity simulation - gap region



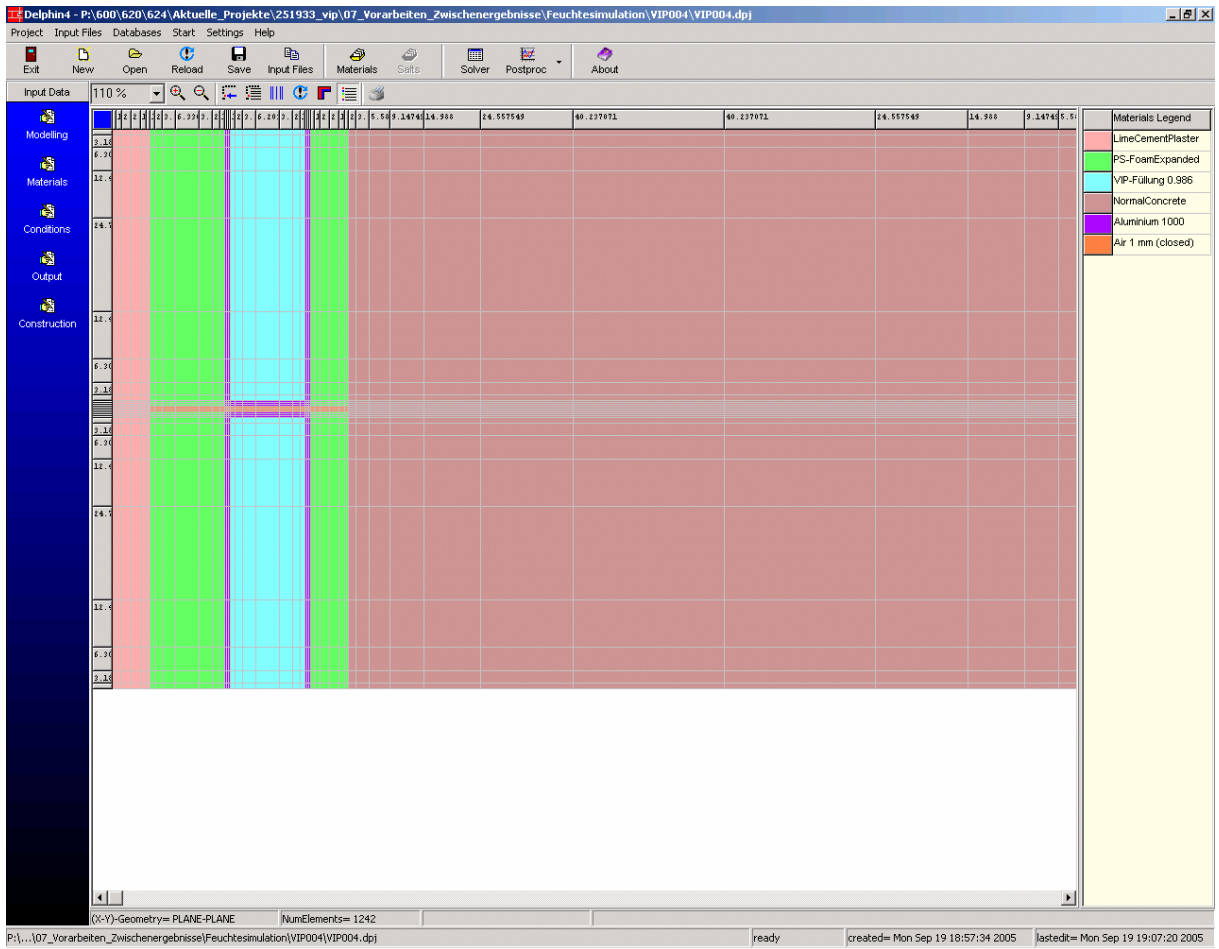
Humidity simulation - exterior layer



Humidity simulation - distribution



Humidity simulation using DELPHIN software



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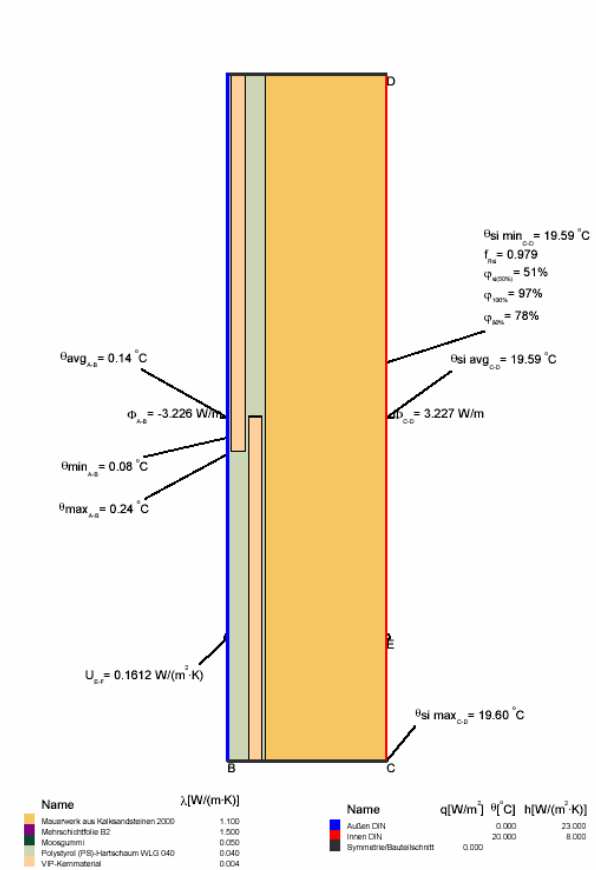
New design of VIP-EWIS system

Thermal bridge reduced to zero



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