Use of NIR in processing of composites

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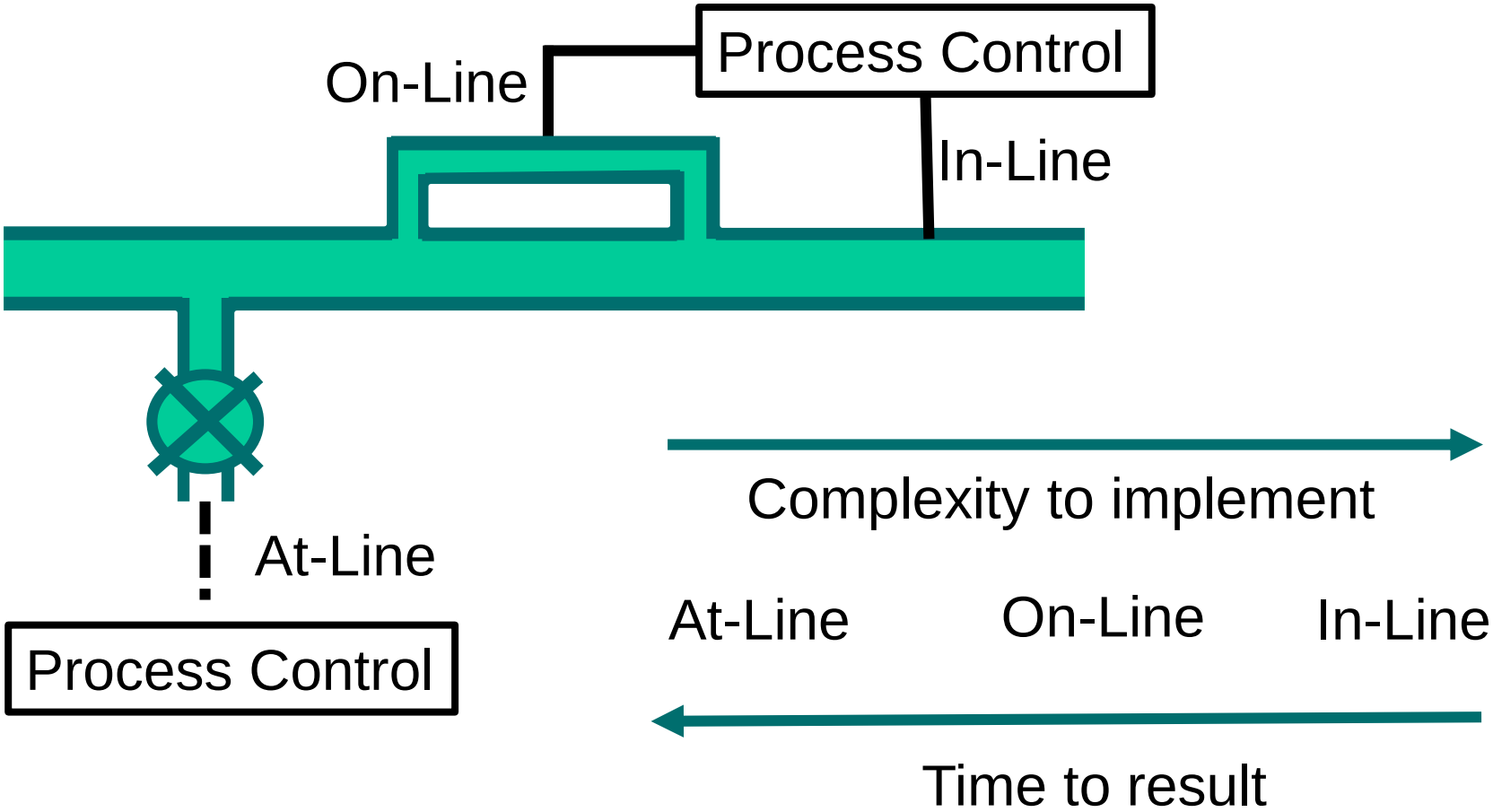
Content

- Process-Monitoring
- Near-Infrared-Spetroscopy (NIR)
- Application in Process
- Potential Applications

Process monitoring

Increasing Automation requires efficient monitoring methods



Near-Infrared-Spectroscopy

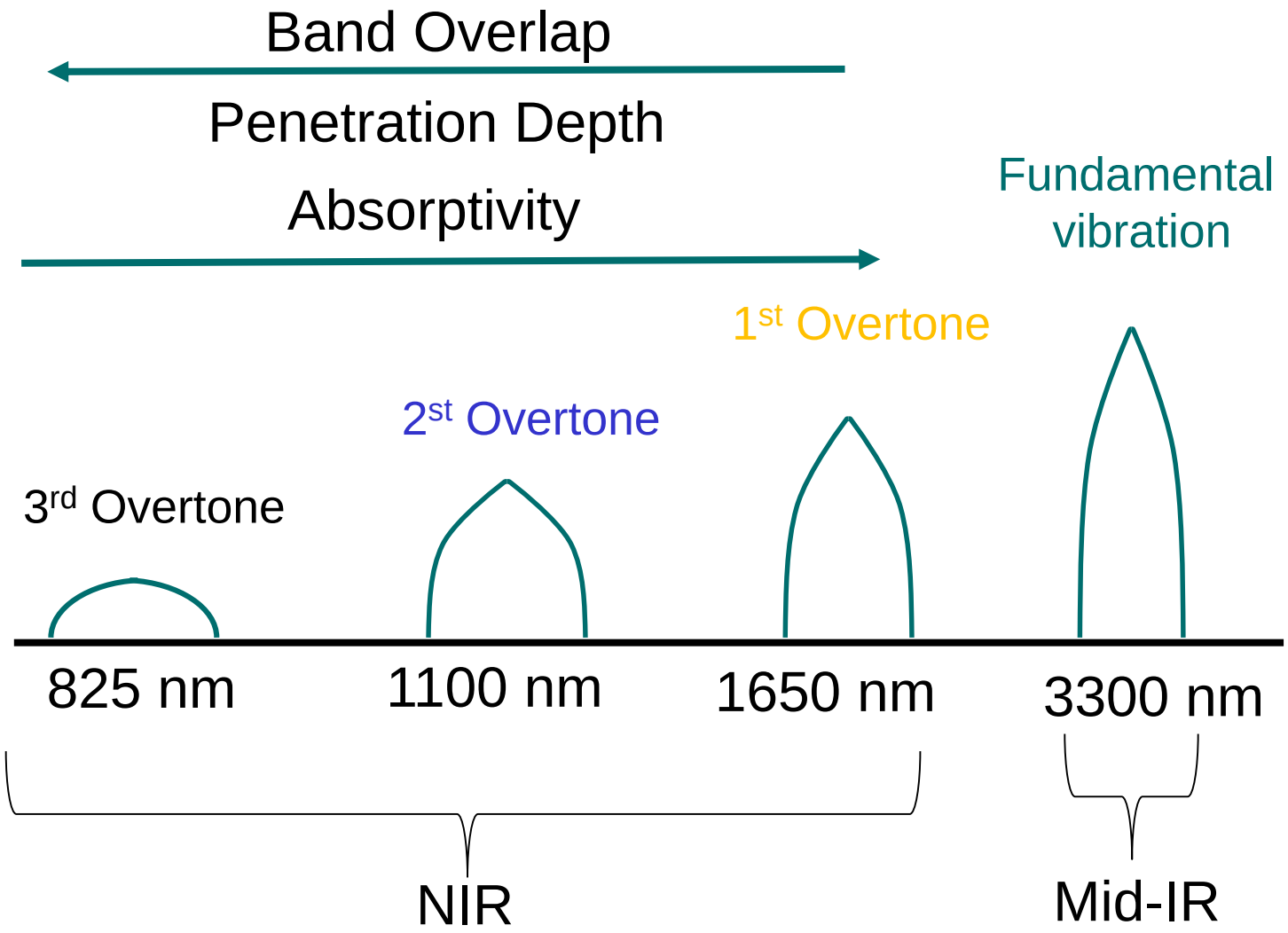
Spectroscopy: Study of interaction between matter and electromagnetic radiation

	UV-light	Visible light	Near Infrared	Infrared	Mikro-wave
λ [nm]	←	400	700	2500	25.000 →
		Excitation of non-binding electrons	Overtone and combination vibrations	Fundamental molecular vibrations	

Spectroscopy

Electron	UV/Vis	Near-Infrared	Infrared/ Raman	NMR

Near-Infrared-Spectroscopy



Near-Infrared-Spectroscopy

Advantages of NIR

+ Fast
+ Sensitive
+ Non-Destructive
+ No sample preparation
+ Provides chemical, physical and structural information

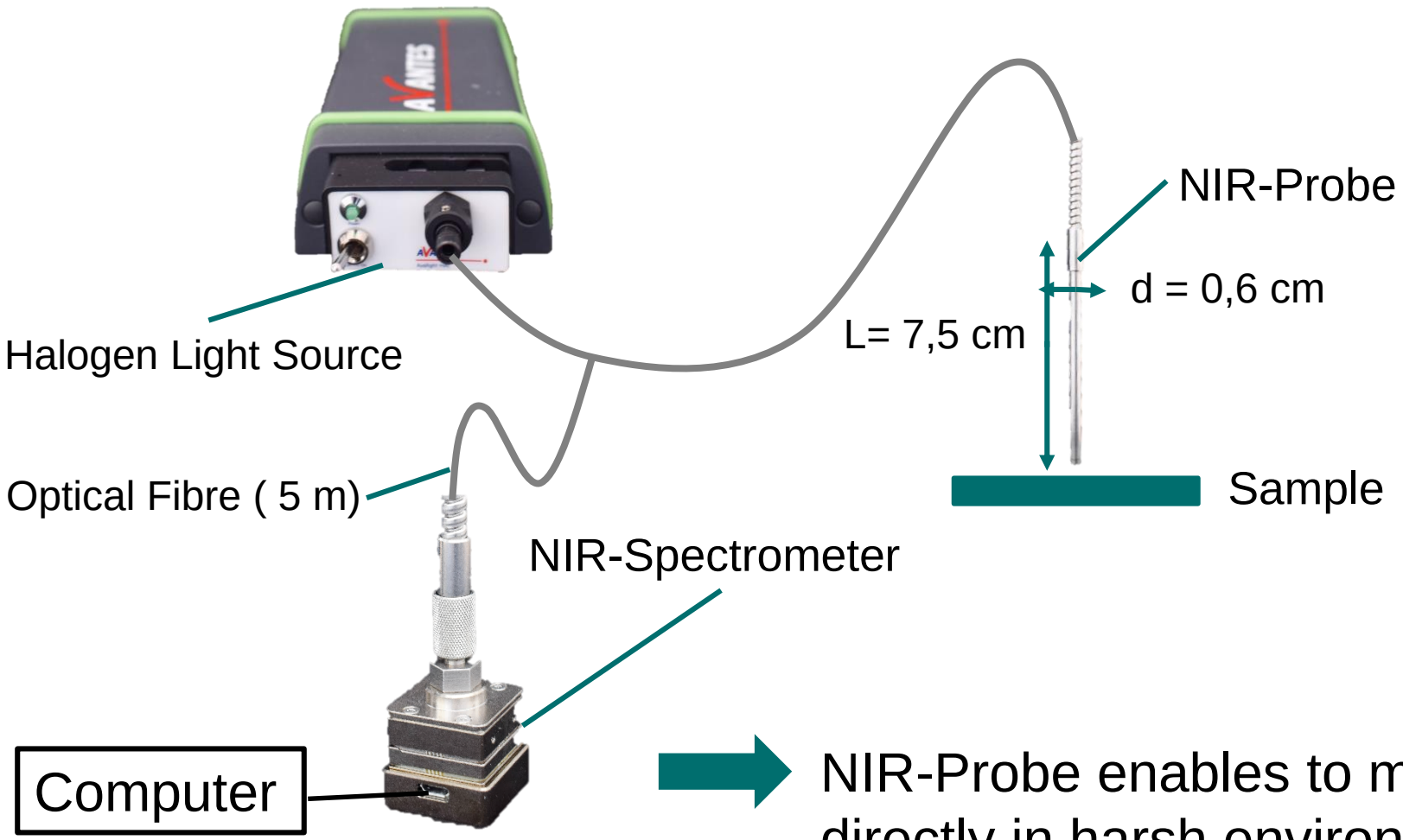
Disadvantages of NIR

- Overlapping absorption bands
- Complex Spectra

In-Line Measurement

Calibration

NIR-Equipment

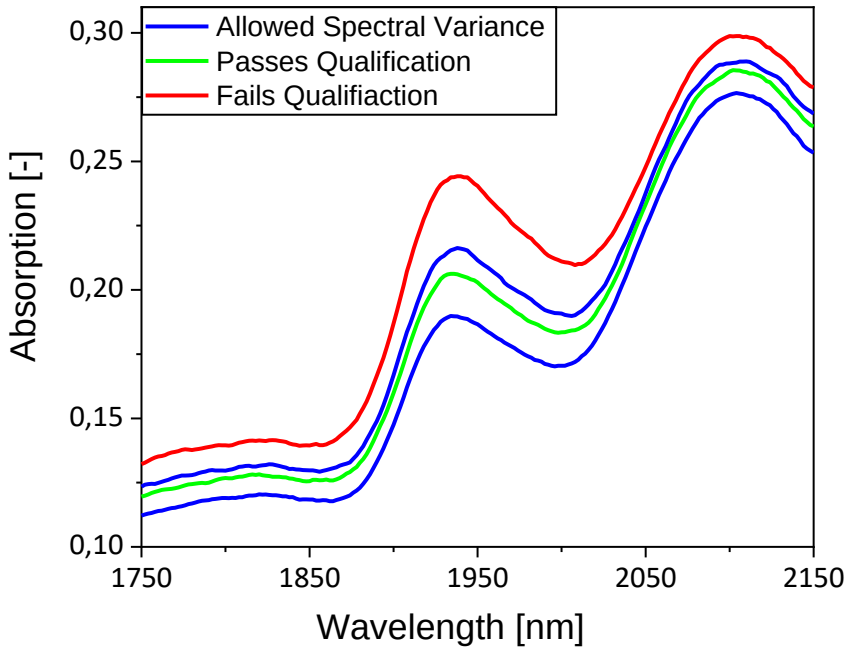


NIR-Probe enables to measure directly in harsh environment

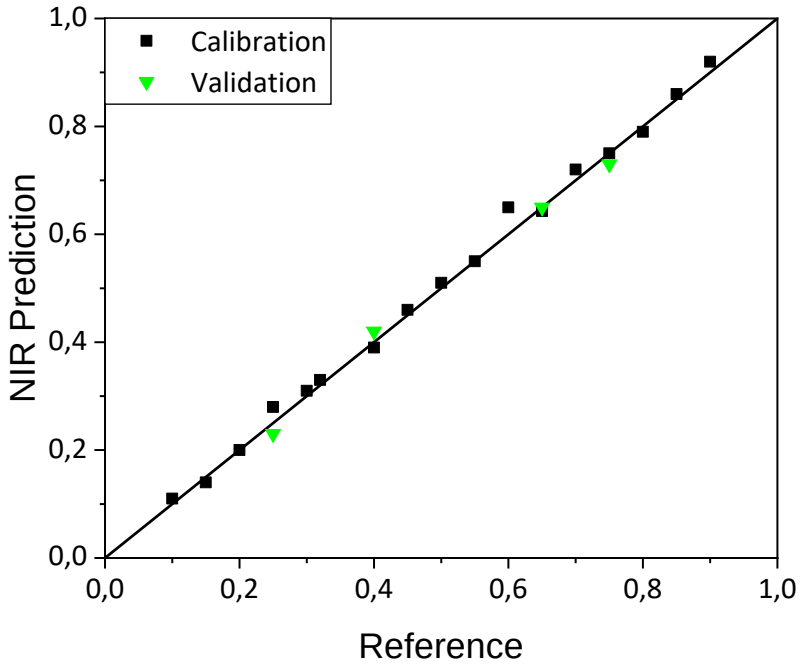
Process monitoring by NIR

Measurement

Qualitative



Quantitative



- Library based
  - Identifying Material
  - Qualifying Properties

- Use of empirical relationships between NIR-Spectra and reference method
- Allows process control

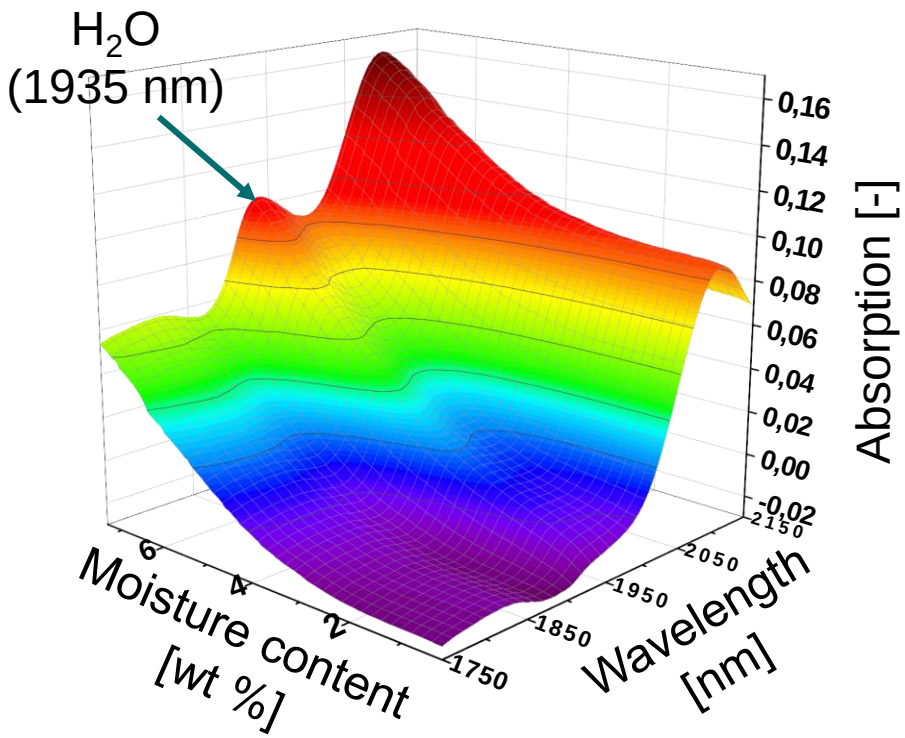
Monitoring the manufacturing process of fibre reinforced polymer (FRP) by NIR

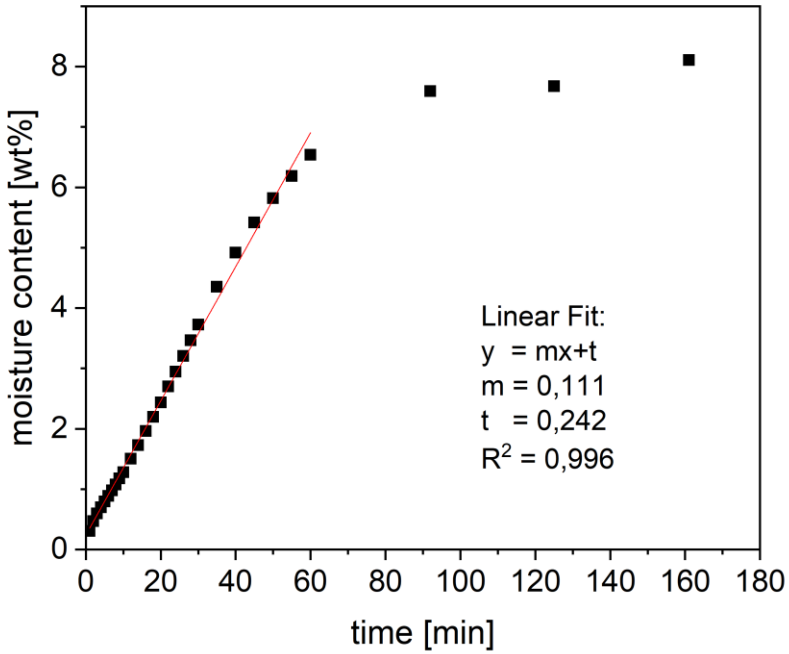
Components	Manufacturing Process	Composite
Textile Resin	Curing State	Finished Product

- Humidity content in natural fibres

Calibration model
Drying natural fibre textile

Calibration : Increasing moisture content



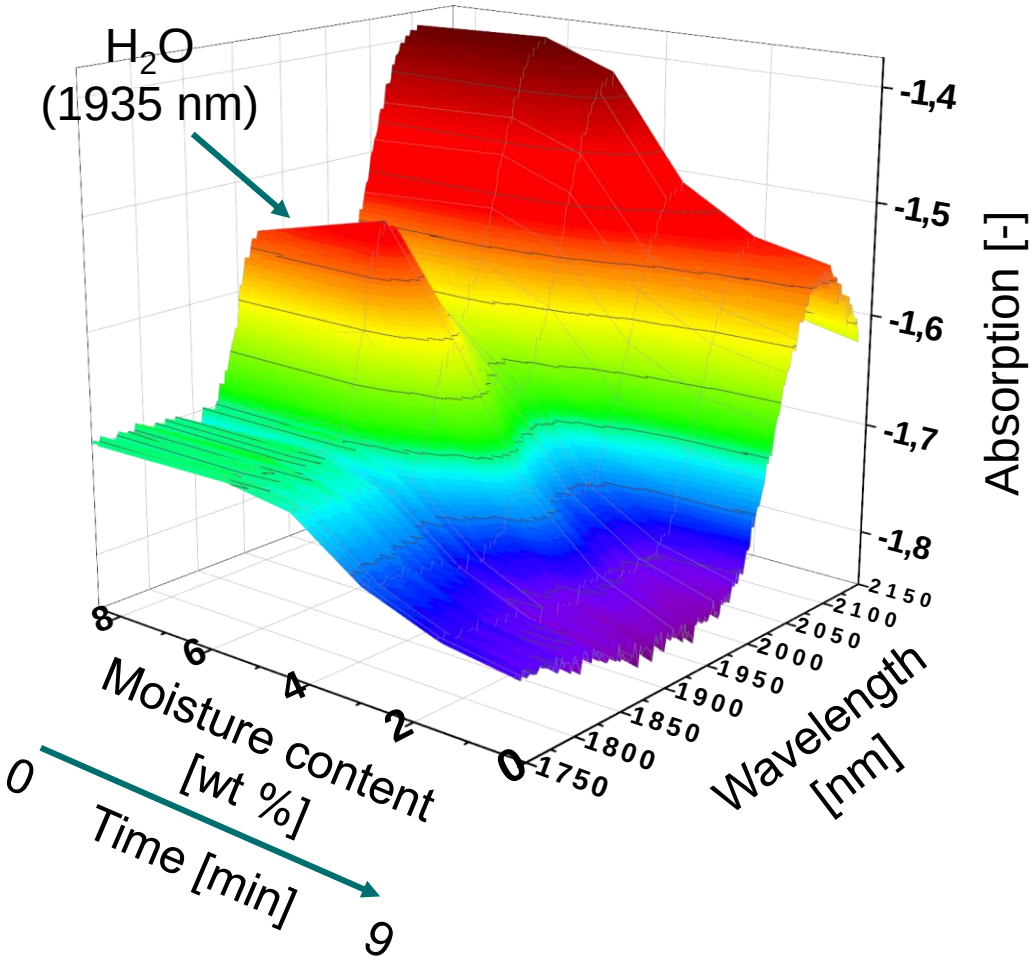


- Increasing Baseline
- Increasing Water-peak

- Linear dependency at the beginning,
- moisture content tents to 8,2 wt%

In-Situ-Drying in RTM
Drying natural fibre textile

Drying in RTM-mould: Decreasing moisture content



- Much more Absorption
- Data more scattered

- Moisture content at beginning and end are known, rest calculated

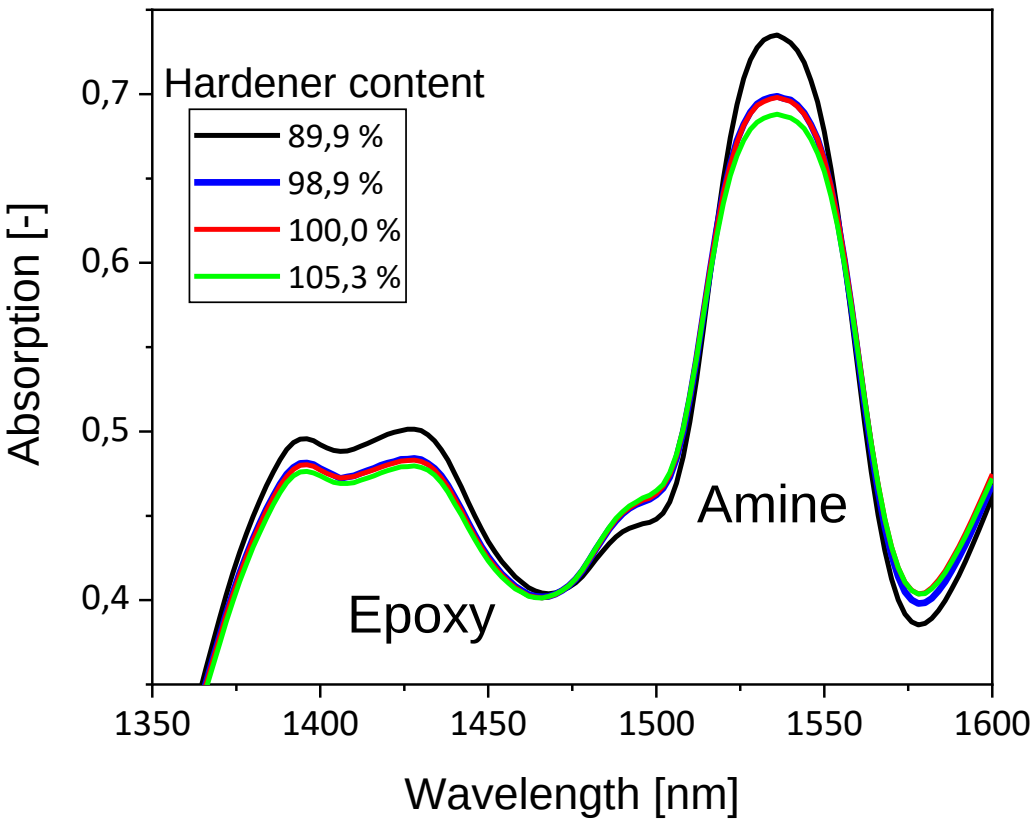
→ Peak at 7,2 wt% moisture measuring error

Monitoring the manufacturing process of fibre reinforced polymer (FRP) by NIR

Components	Manufacturing Process	Composite
Textile Resin	Curing State	Finished Product

- Humidity content in natural fibres
- Mixing ratio

Mixing Ratio



- Even small changes recognizable
- Reduction in Amine-Peak due to coloured hardener

Monitoring the manufacturing process of fibre reinforced polymer (FRP) by NIR

Components | Manufacturing process | Composite

- Humidity content in natural fibres
- Mixing ratio
- Curing process

Monitoring the manufacturing process of fibre reinforced polymer (FRP) by NIR

Components	Manufacturing process	Composite
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- Humidity content in natural fibres
- Mixing ratio

- Curing process

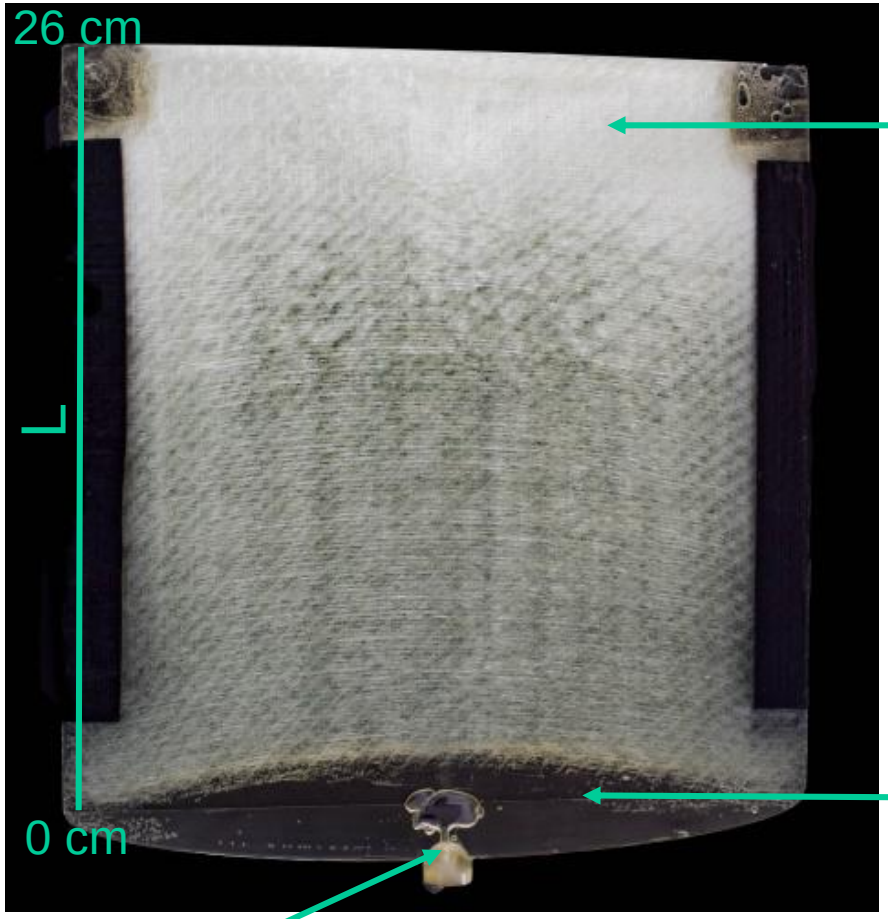
- Fibre volume

Fibre Volume

Glass fibre reinforced composite with fibre washout

Flow direction

Increasing Fibre content

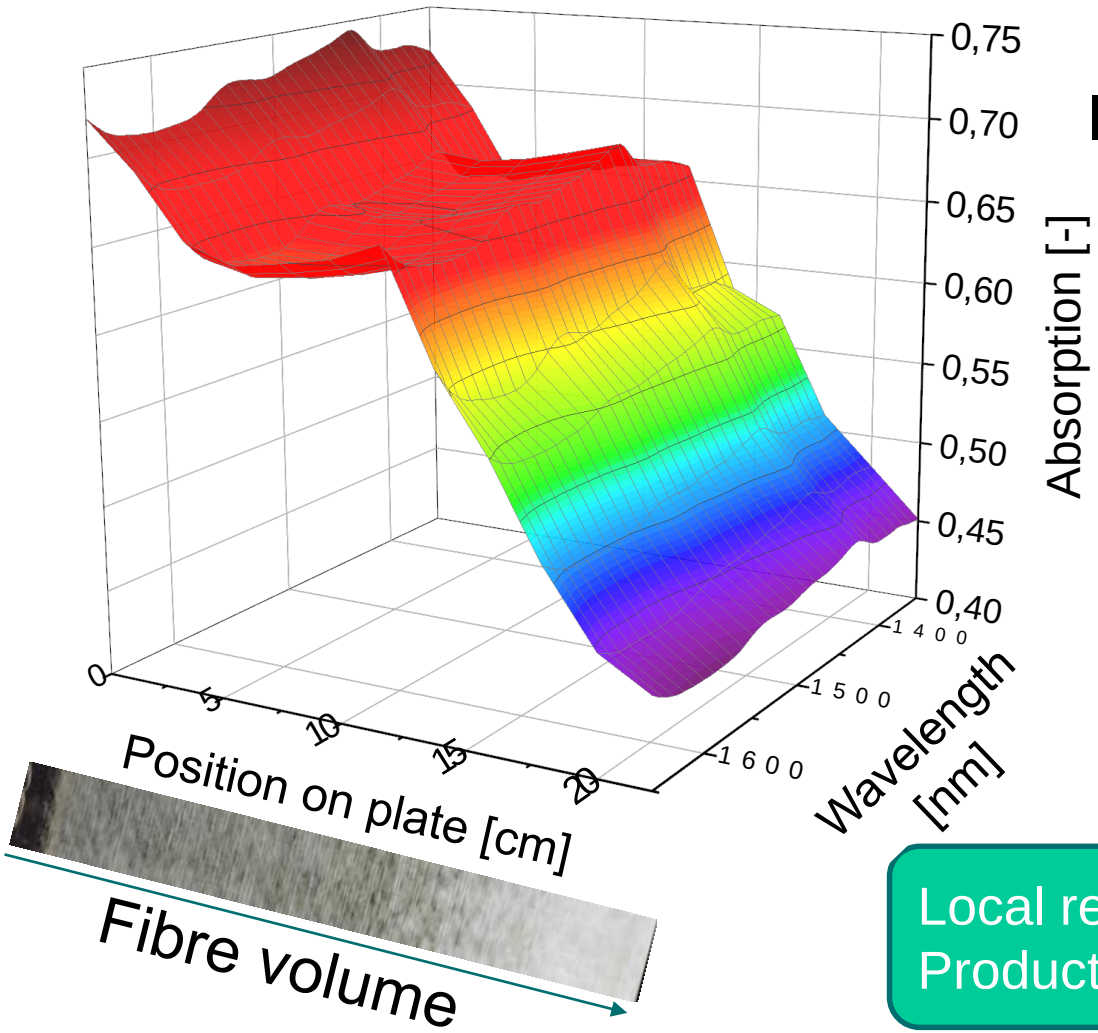


Composite

Resin

Sprue

Fibre Volume



Increasing Fibre volume:

- Decreasing Absorption
- Decreasing Peak intensity

Local resolution would allow fast Product control

Summary

NIR for monitoring the manufacturing process FRP:

- Fast
- Sensitive
- Provides chemical, physical and structural information

Textile → Resin → Curing State → Finished Product

- Humidity content in natural fibres
- Mixing ratio
- Curing process
- Fibre volume

Vielen Dank für Ihre Aufmerksamkeit

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