Sensor-Based and Data-Driven Thermoset Manufacturing Optimization

Alec Redmann, PhD

SPE TOPCON - 2023

sens✕PERT®

EXPAND your sense of the possible

&

Parent Company:
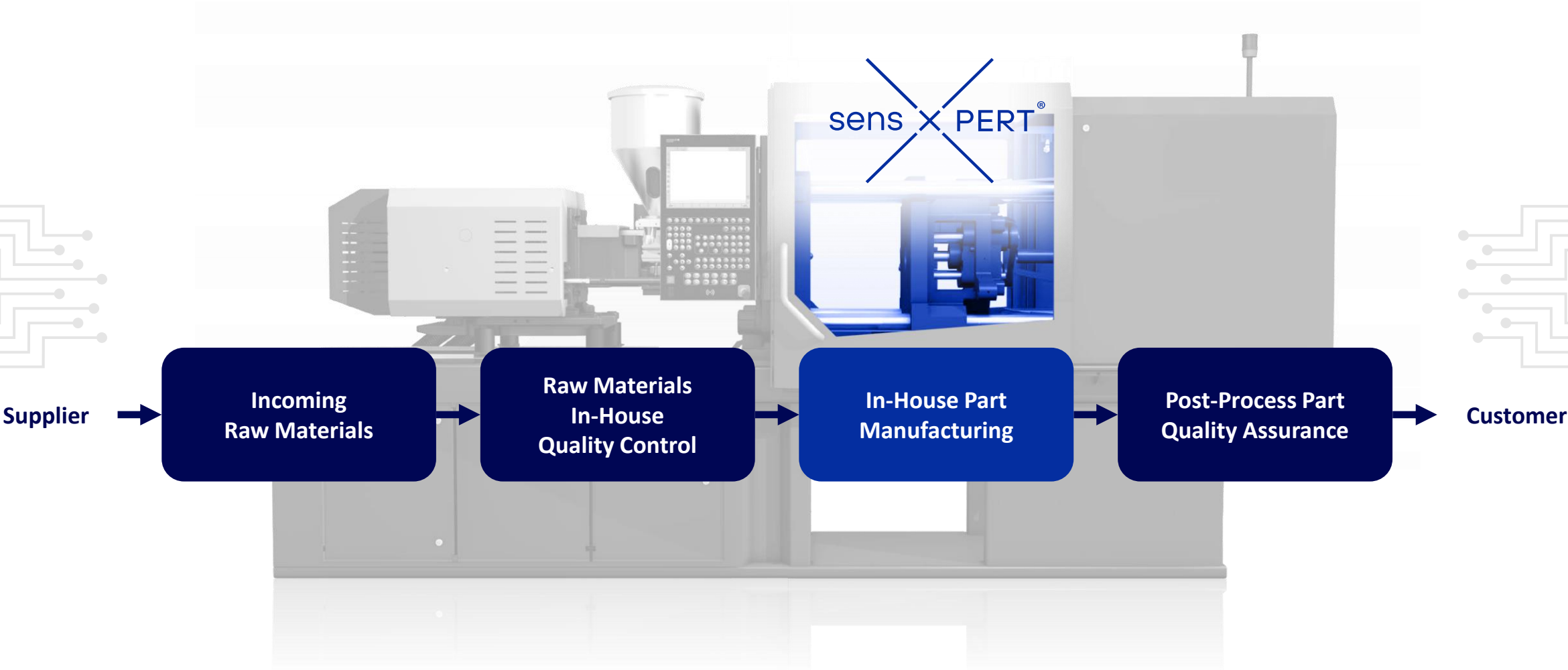**NETZSCH**

Founded:
1962 (Analyzing and Testing)

Global scientific instrument and thermal analysis leader with 3700+ employees present in 36 countries

Corporate Venture:
NETZSCH Process Intelligence GmbH

Founded:
2019

Technology startup developing intelligent manufacturing solutions

sensXPERT Introduction

Supplier →

Incoming Raw Materials →

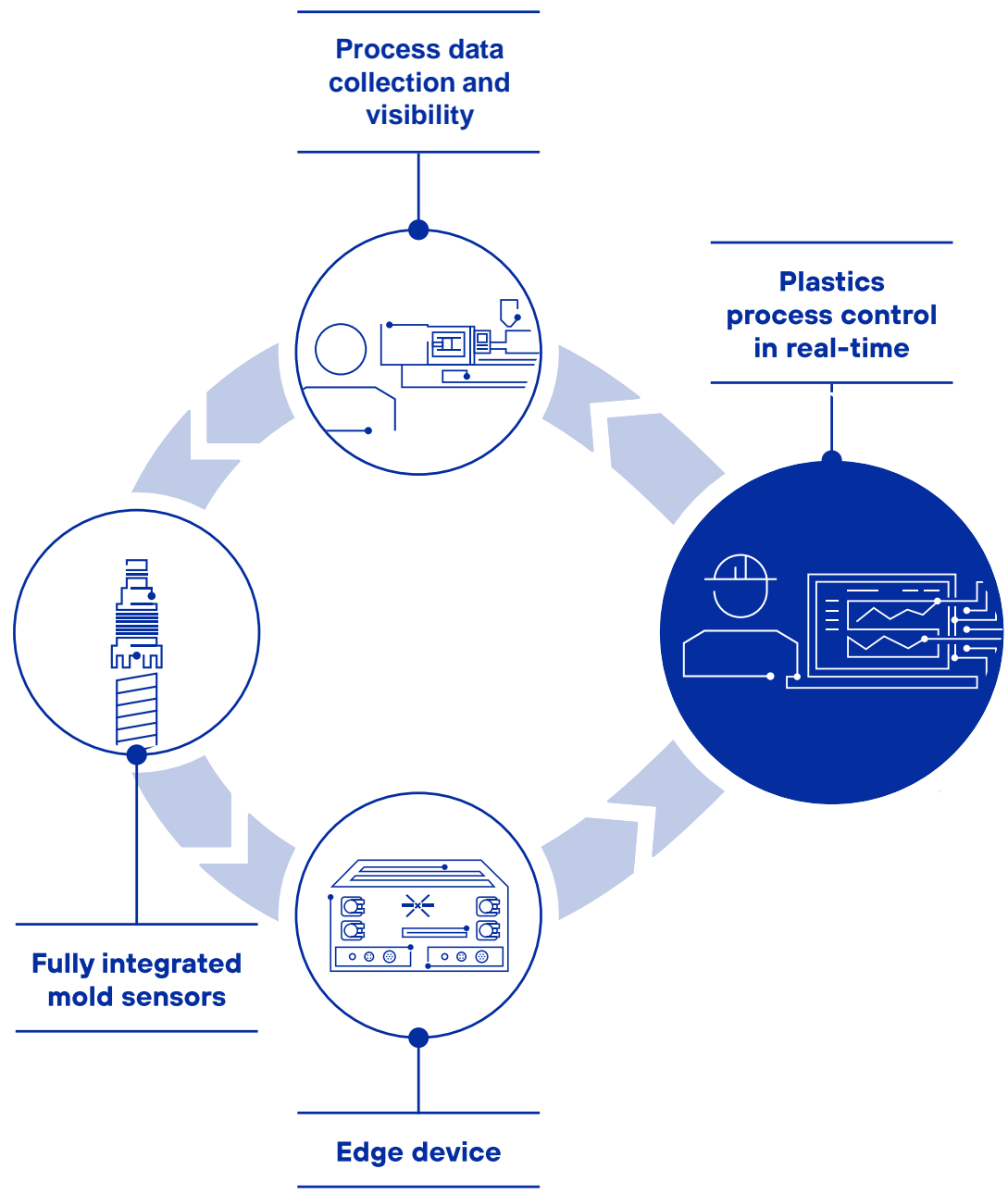**Raw Materials In-House Quality Control** →

In-House Part Manufacturing →

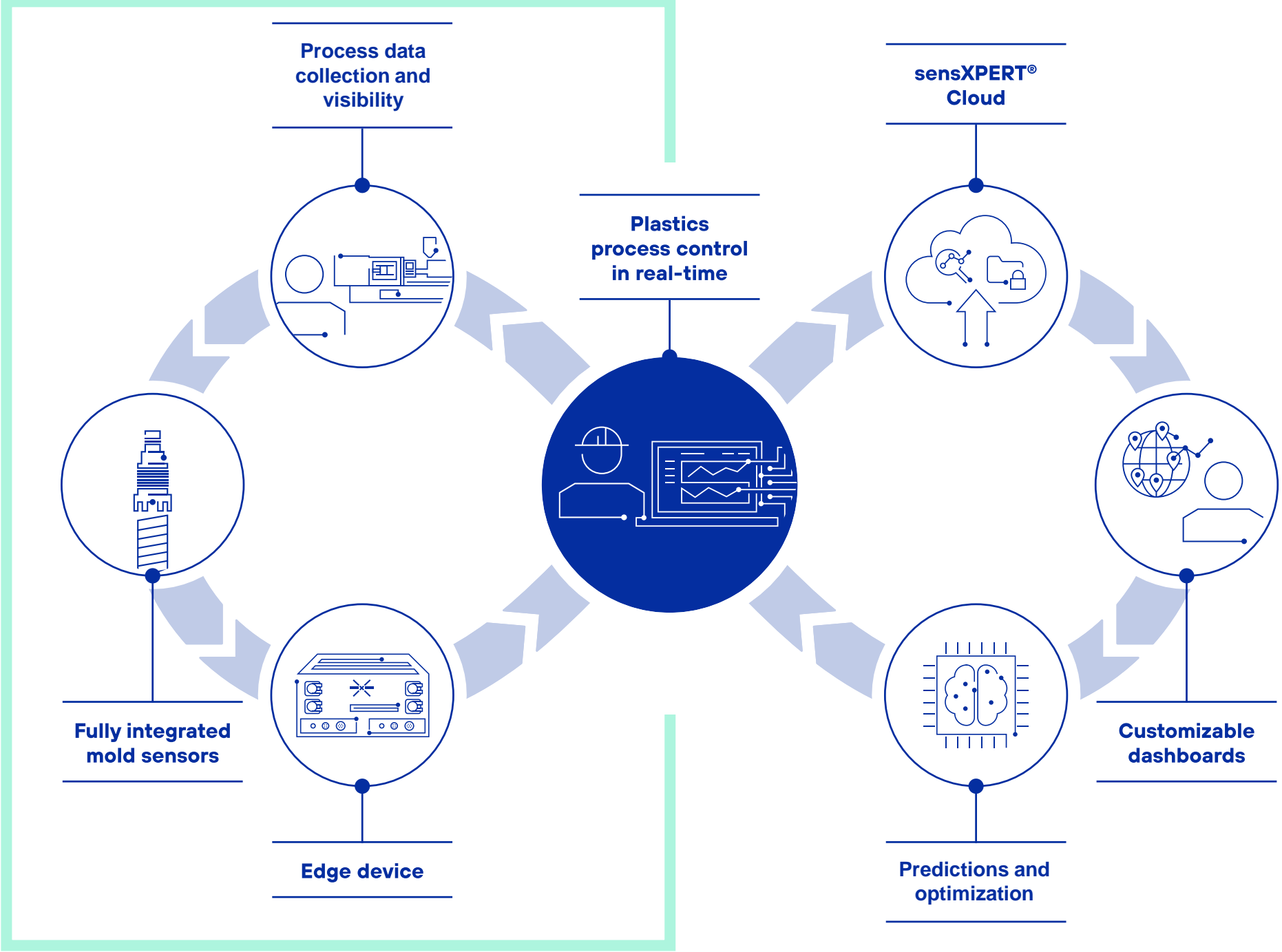**Post-Process Part Quality Assurance** →

Customer

sensXPERT Introduction

Equipment-As-A-Service Technology

- integrated sensor hardware to measure critical process parameters

- edge device to evaluate machine and material data for automated process optimization

- cloud service for customizable dashboards

Process data
collection and
visibility

Plastics
process control
in real-time

Fully integrated
mold sensors

Edge device

sens✕PERT®
at a glance

Process data collection and visibility

sensXPERT® Cloud

Plastics process control in real-time

sensXPERT® at a glance

Fully integrated mold sensors

Customizable dashboards

Edge device

Predictions and optimization

Real-Time Material Characterization with Dielectric Sensors

- Measuring material behavior

  - **resin viscosity, degree of cure, glass-transition, material condition (mixing ratio, ageing, shrinkage, contamination)**

- Combined with third-party measurement devices (pressure transducers, thermocouples, and more)

MATERIALS

- Thermosets and thermoplastics
- Fiber reinforced polymers
- Mineral casting

PROCESSES

- (Reaction) Injection Molding
- Compression Molding
- Resin Transfer Moulding Processes
- Autoclave Curing

Dielectric Analysis
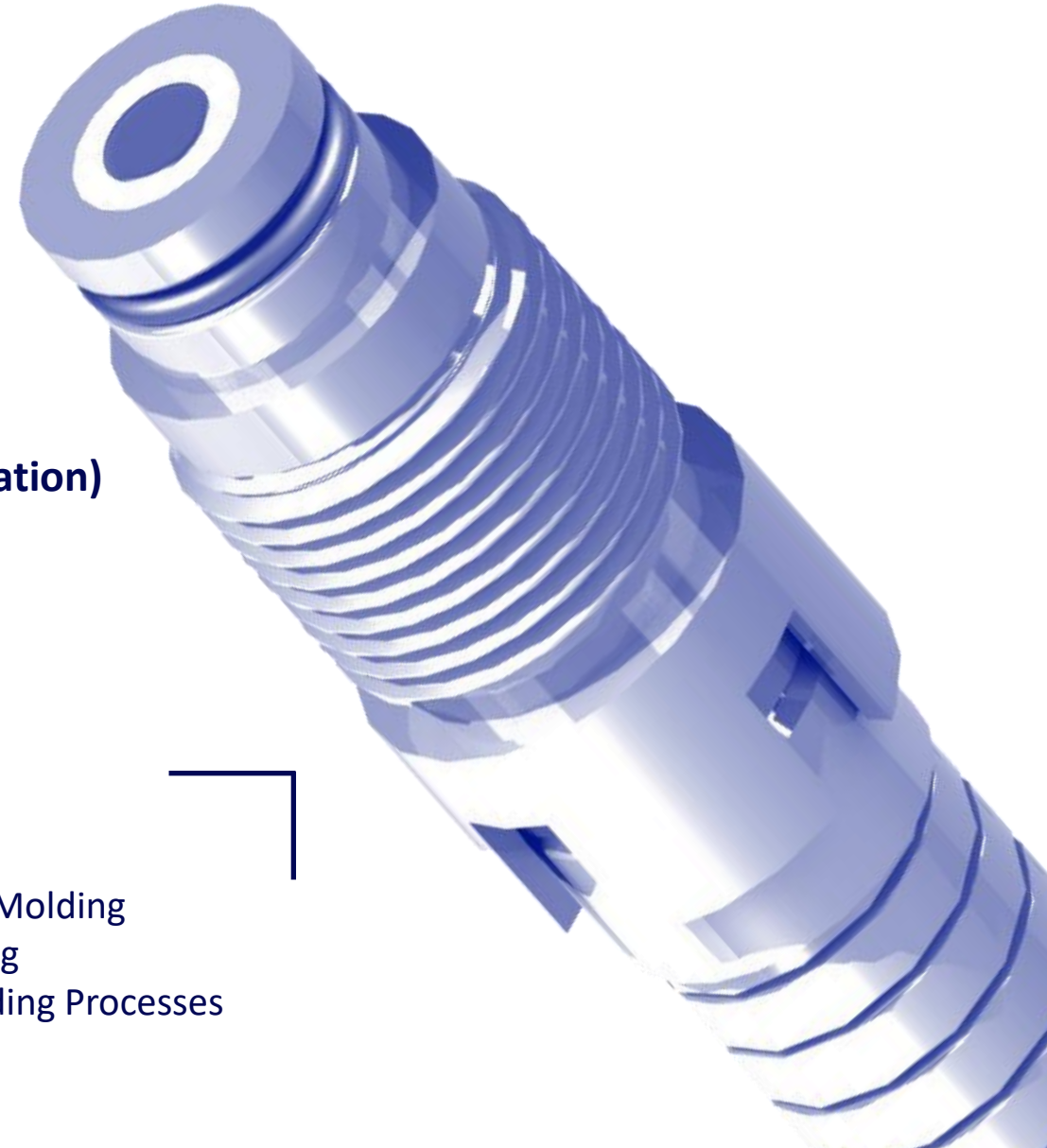
- Observes the behavior of material under the application of an electric field

- Molecules in the material sample have a net electric charge

- Interact with the electric field

- **Ion viscosity –** An analog to mechanical viscosity

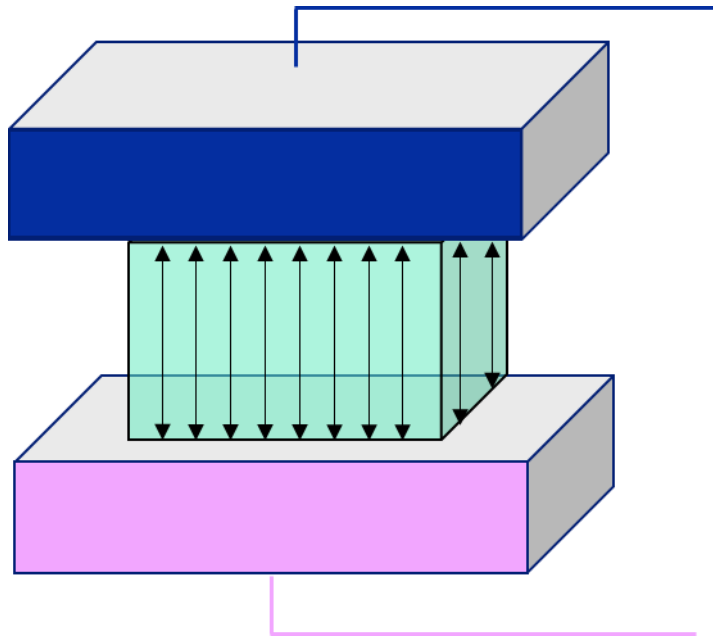Behavior of ions and dipoles inside an external electrical field
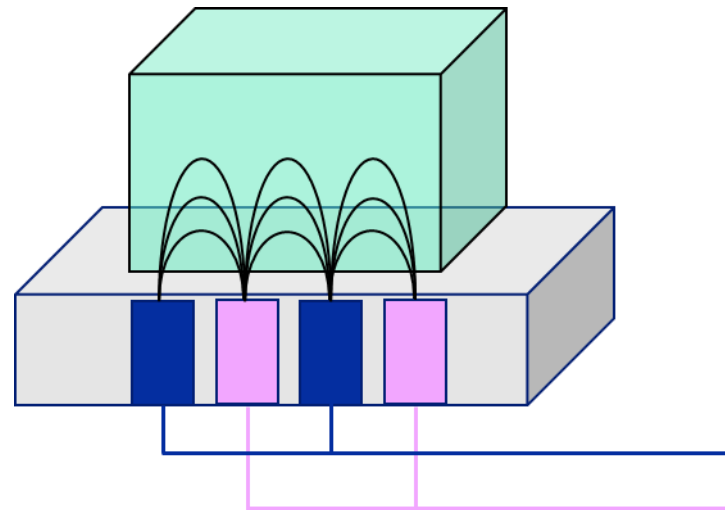
Without external electrical field
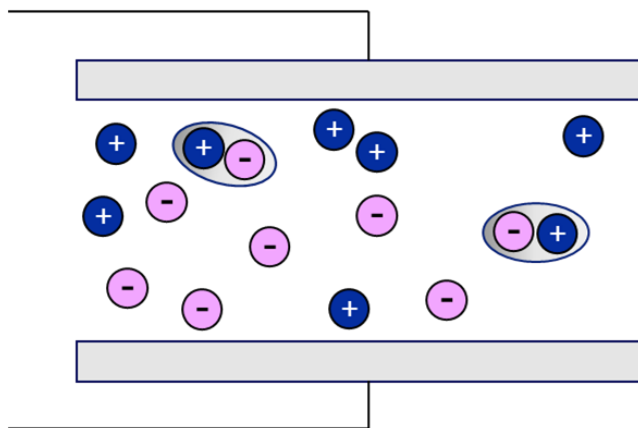
With external electrical field

Dialectric Analysis
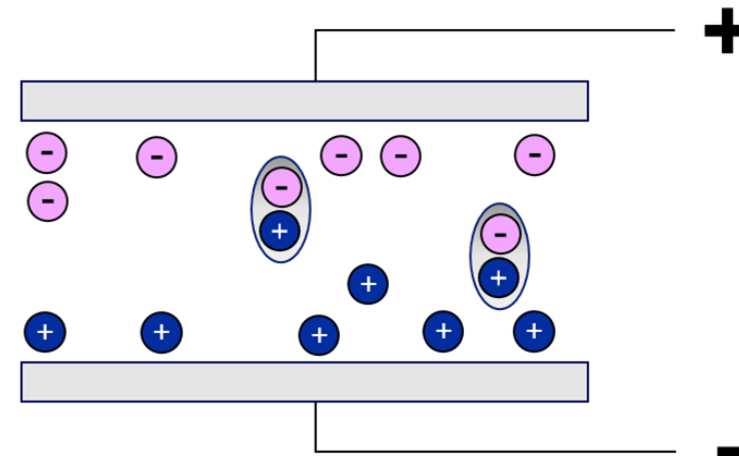
Traditional parallel plate electrodes

Interdigitated "comb" electrodes

sensXPERT in-mold sensor

Dielectric Analysis: Ion Viscosity

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RTM / Infusion Epoxy

180 °C / 350 °F mono-component epoxy system

Standard process data

- Temperature ramp
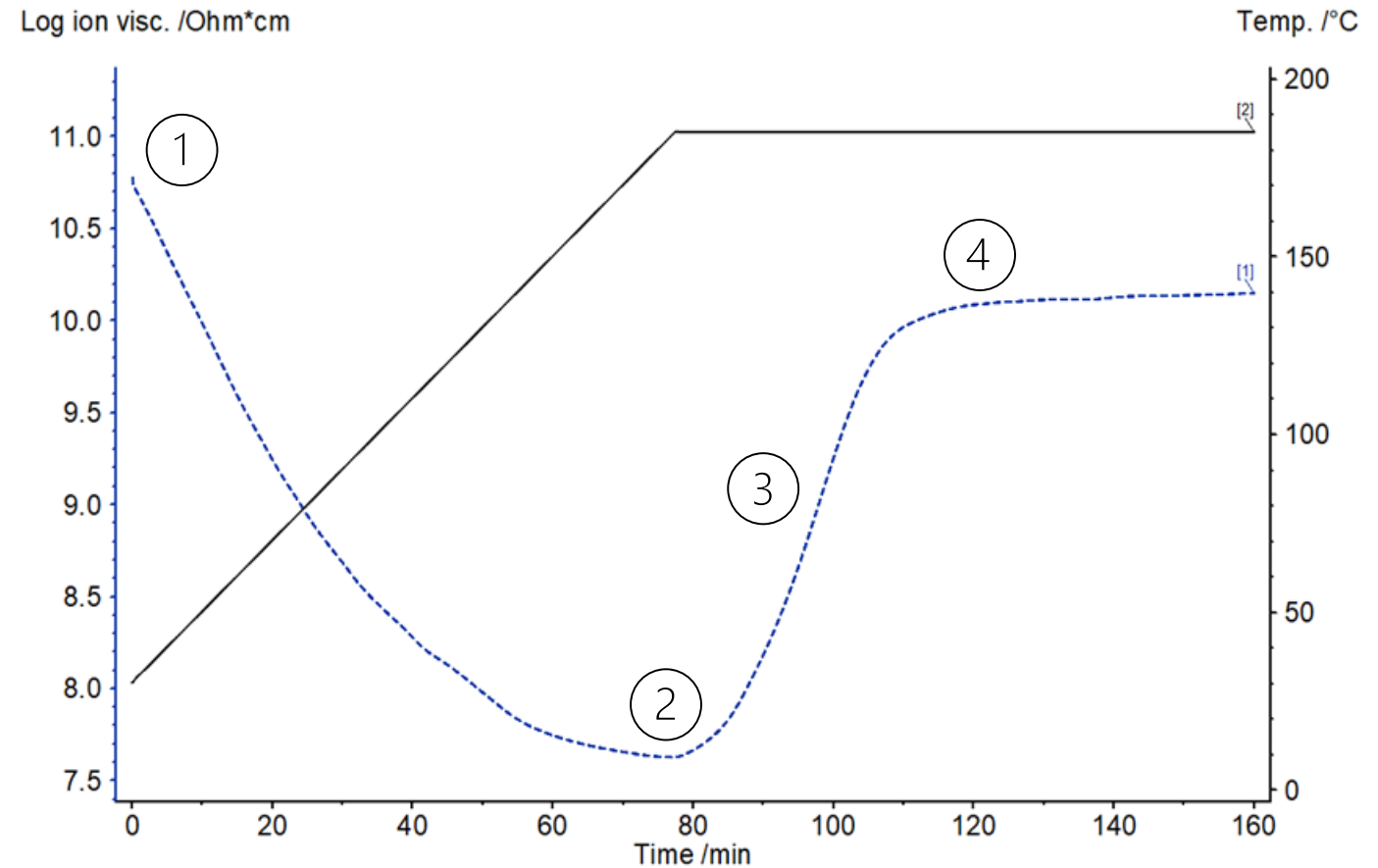
- Holding time

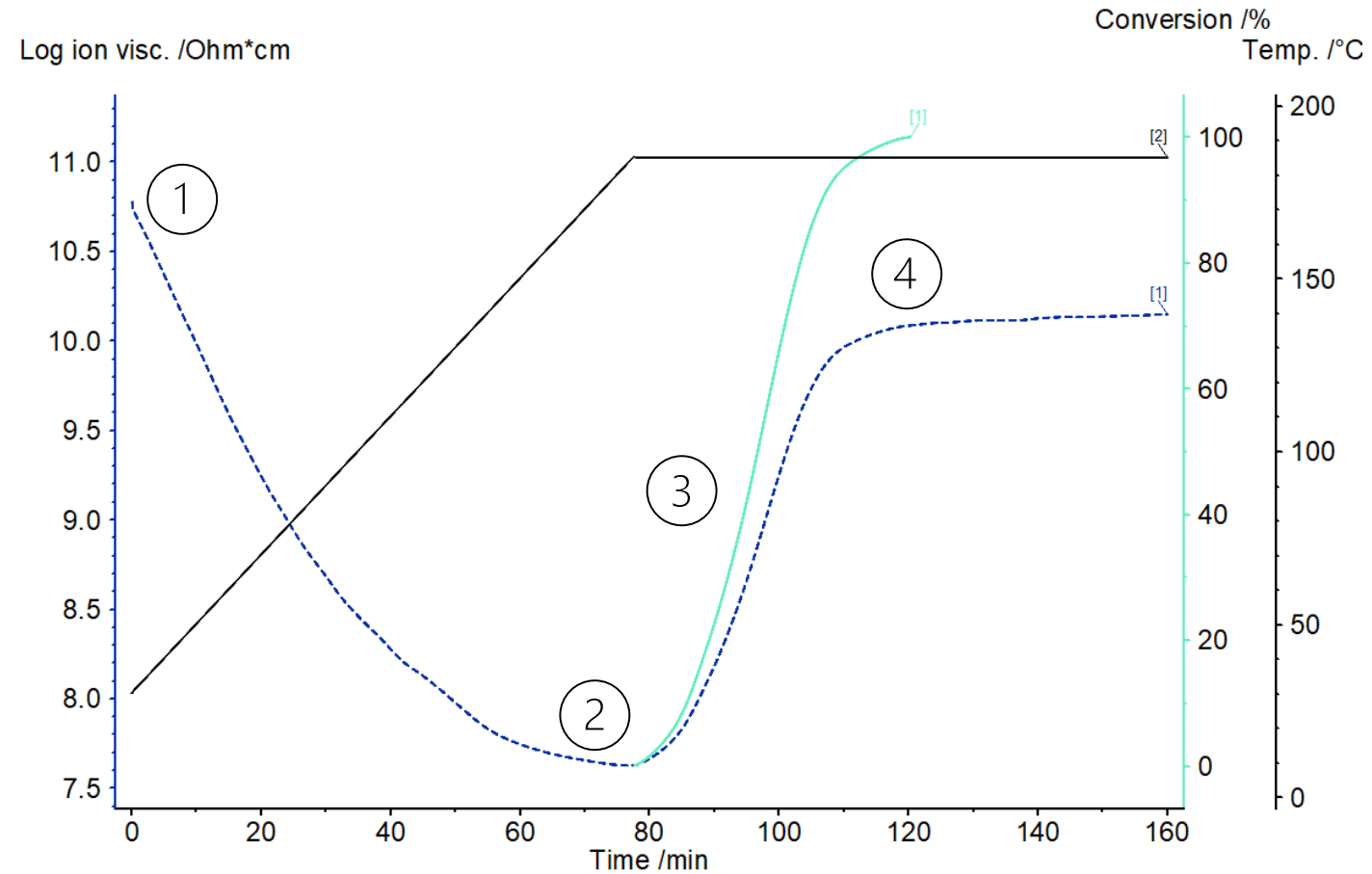- No viscosity or cure information
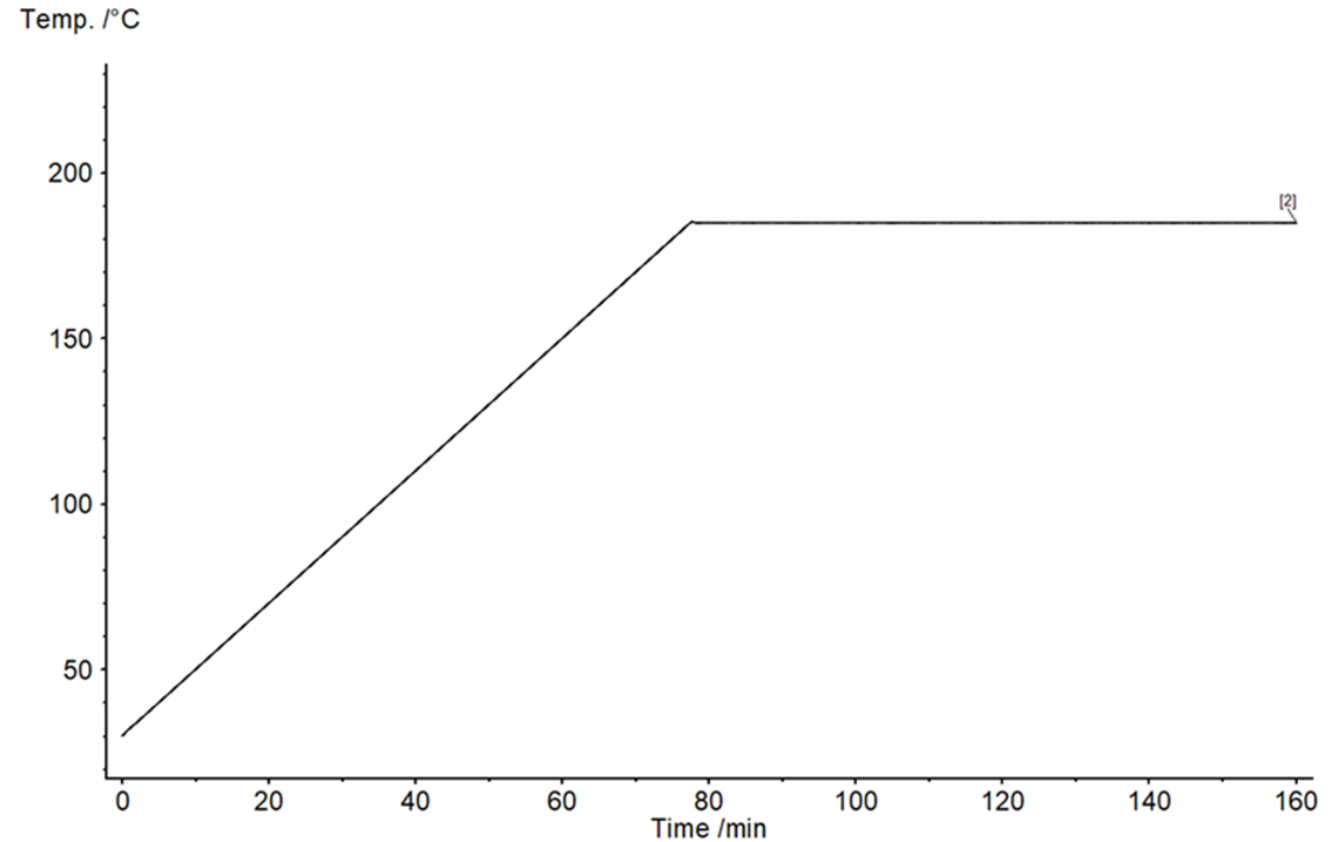
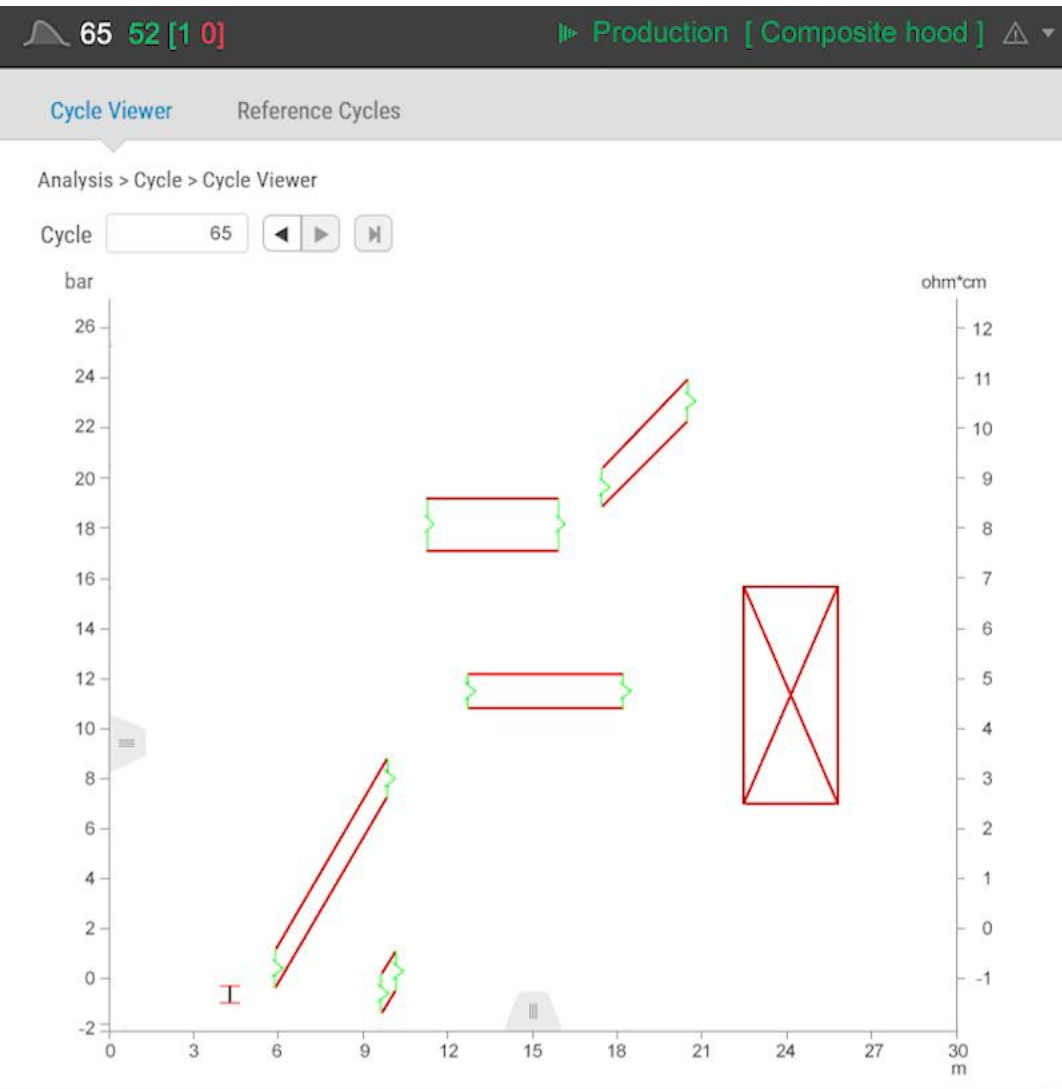# Dielectric Analysis: Ion Viscosity

RTM / Infusion Epoxy
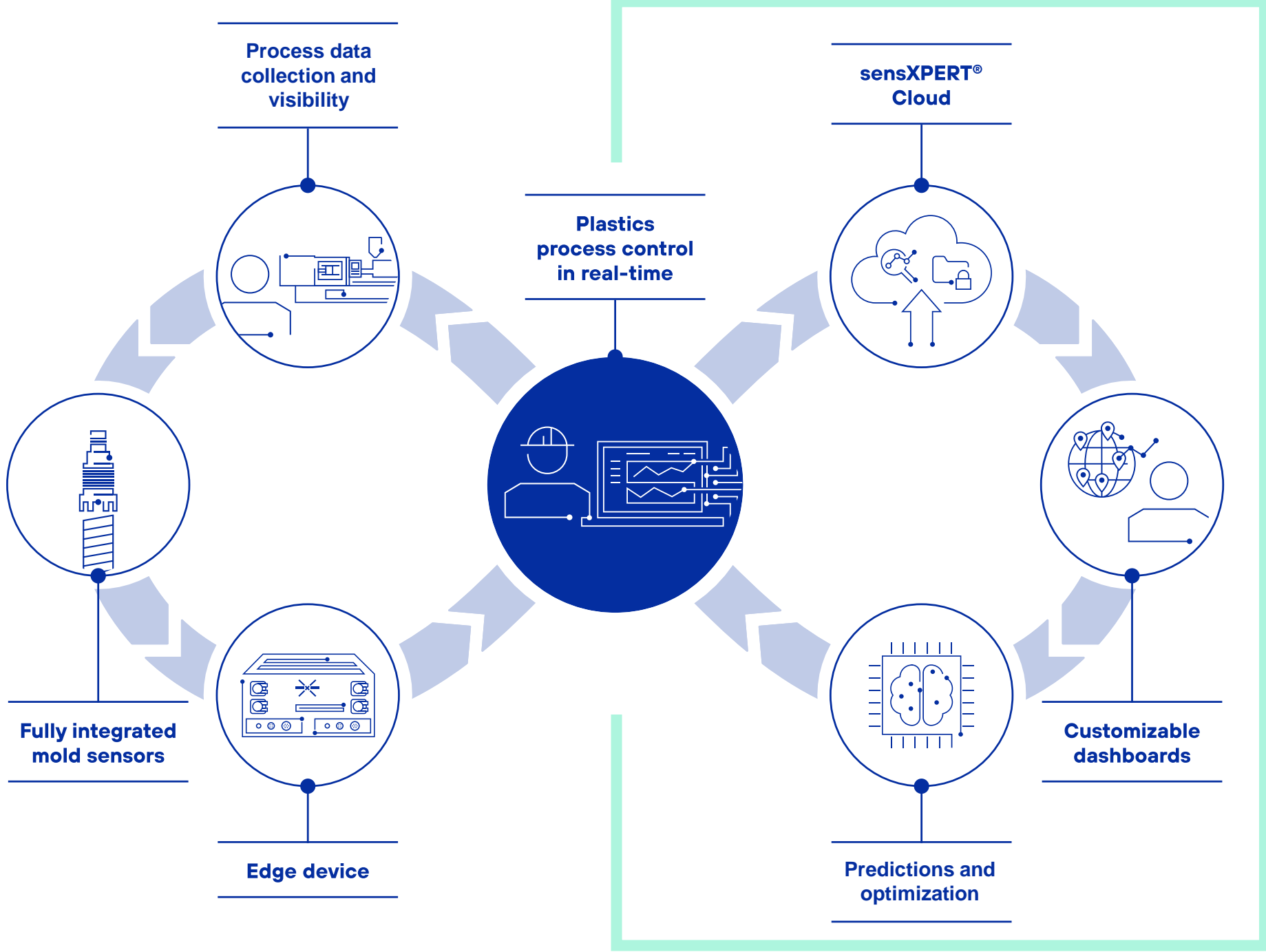
180 °C / 350 °F mono-component epoxy system

sensXPERT process data

① Introduction of the material

② Minimum resin viscosity

③ Progression of cure / gelation

④ Completion of cure

Dielectric Analysis: Ion Viscosity

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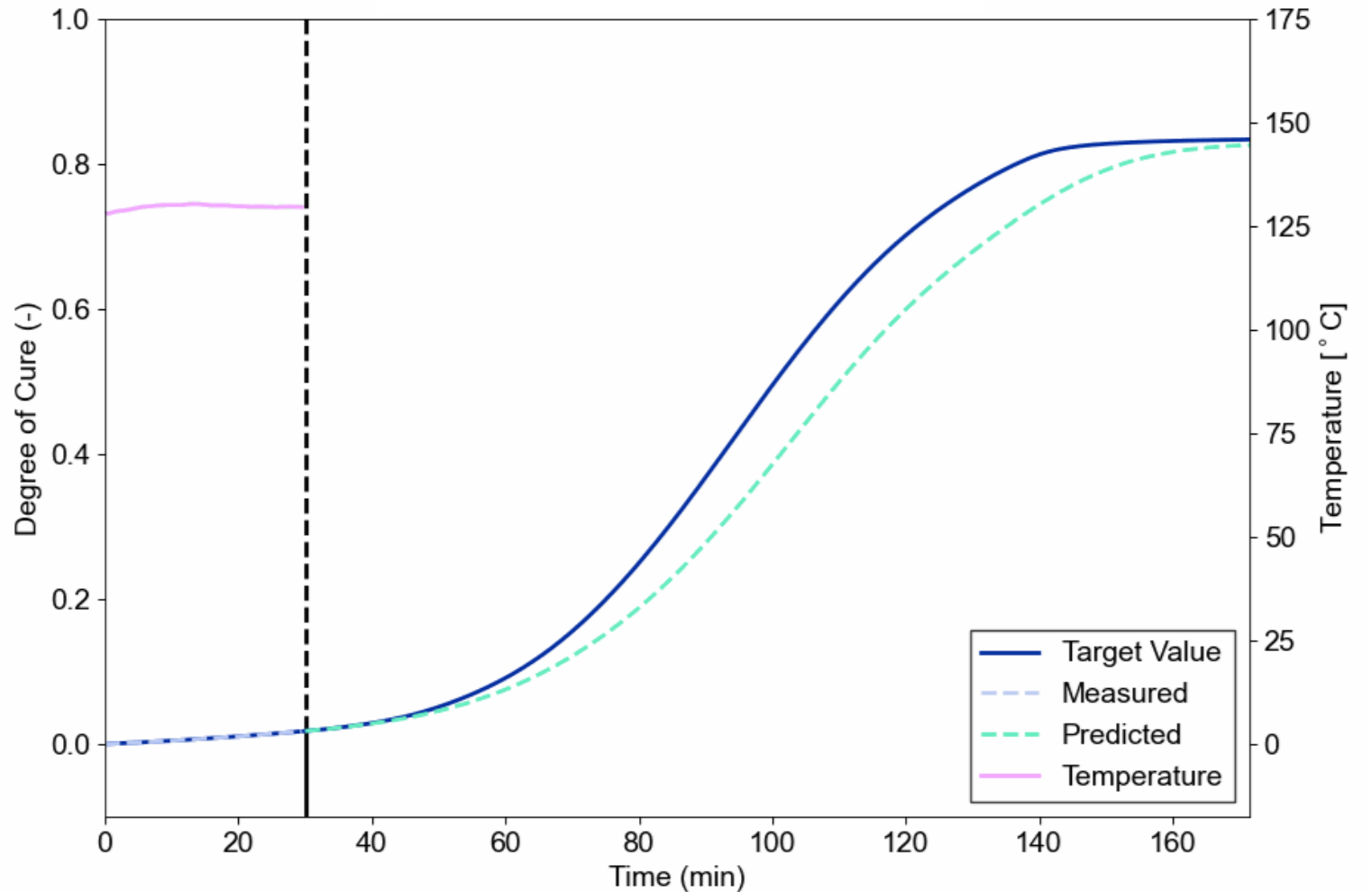
Process data collection and visibility

Plastics process control in real-time

sensXPERT® Cloud

sens✕PERT®
at a glance

Fully integrated mold sensors

Edge device

Predictions and optimization

Customizable dashboards

Process Predictions and Optimization

MACHINE LEARNING AND PROCESS OPTIMIZATION

Simulation and Optimization
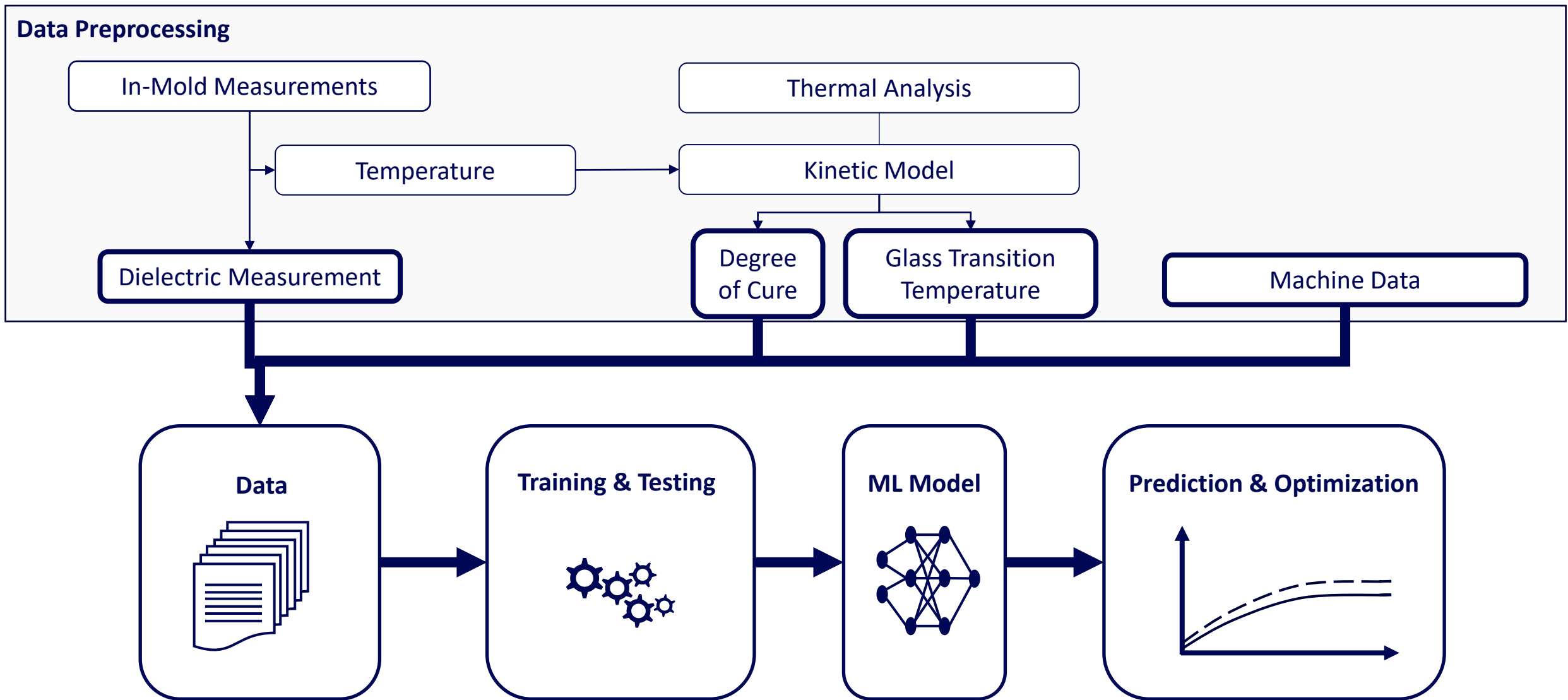
A data driven solution.

- AI model calculates and predicts material properties

- Dynamically control and adapt the process to ensure constant quality

Real-Time Process Optimization

Legend:
- Target Value
- Measured
- Predicted
- Temperature

Process Monitoring and Customized Dashboards

CLOUD SERVICE

- Process data transparency

- 24/7 access on any device

- Customizable dashboards

- OpenAPI: flexible data handling

Part 174

Measurement Details

Meta Data	Channel 1	**Channel 2**

Calculated/Predicted Data

Data Type	Value
CP1 time	0.84 min
CP2 time	3.56 min
CP3 time	6.12 min
CP4 time	13.38 min
Ending alpha	95.05 %
Ending tg	24.88 °C
Ending time	13.38 min

Master Curve (Channel 2)

11 min
Log IonViscosity   13.9 Ω*cm
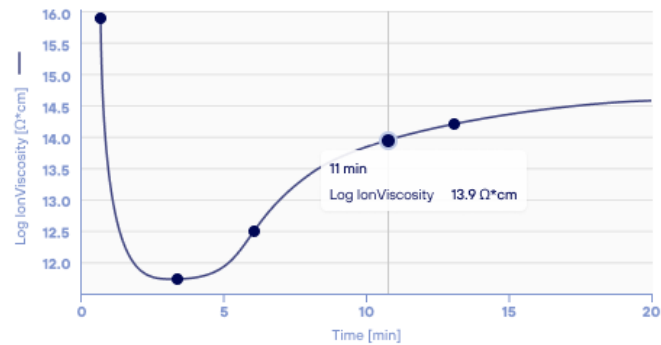
First Prediction (Channel 2)

4 min
Alpha   5.3 %
tg   12 °C
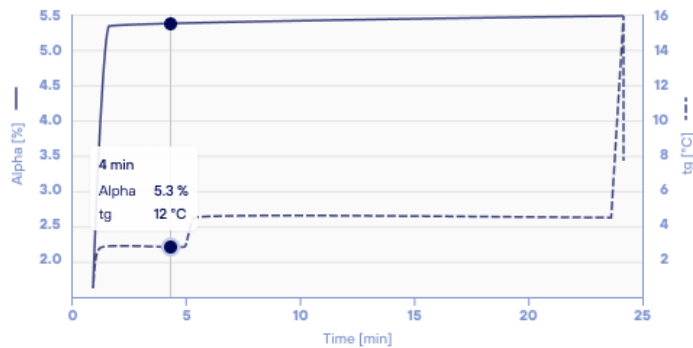
Last Prediction (Channel 2)
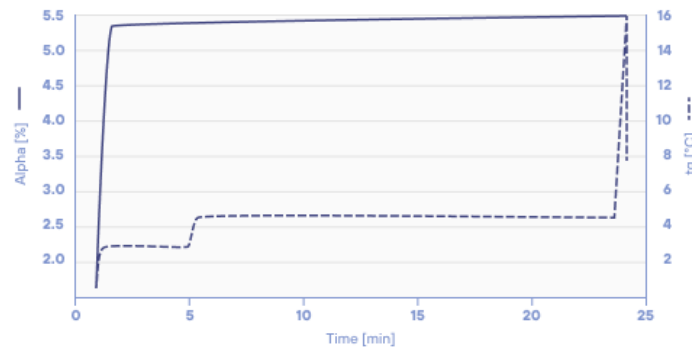
Tailgate Z15

- Transfer Molding
- Compression Molding
- Injection Molding

Engine Cover sensX

- Transfer Molding
- Injection Molding

Bumber Bar U76

- Compression Molding
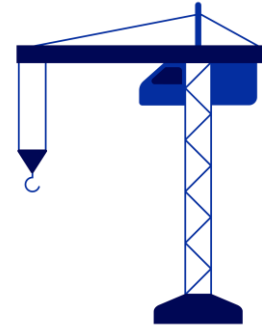
- Data History
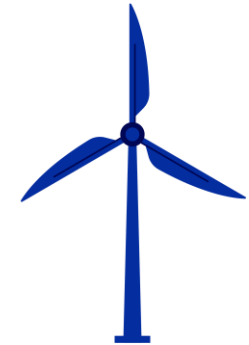- Settings
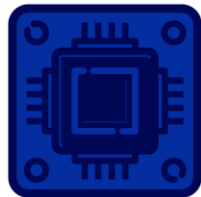- Logout

INDUSTRIES WE WORK WITH

Automotive

Aerospace

Building & Construction
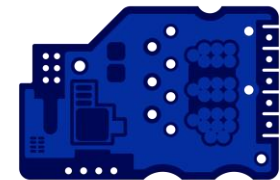
Renewable Energy

Electrical Applications

Military Defense

Consumer Goods

Electronics Encapsulation

RESULTS OF sensXPERT®

Up to

50%

of existing scrap
reduction

Up to

23%

energy savings

Up to

30%

cycle time
reduction

Up to

15 days p.a.

installation
& downtime
reduction

Alec Redmann, PhD

m: +1 781 528 5411
e: alec.redmann@netzsch.com

www.sensxpert.com