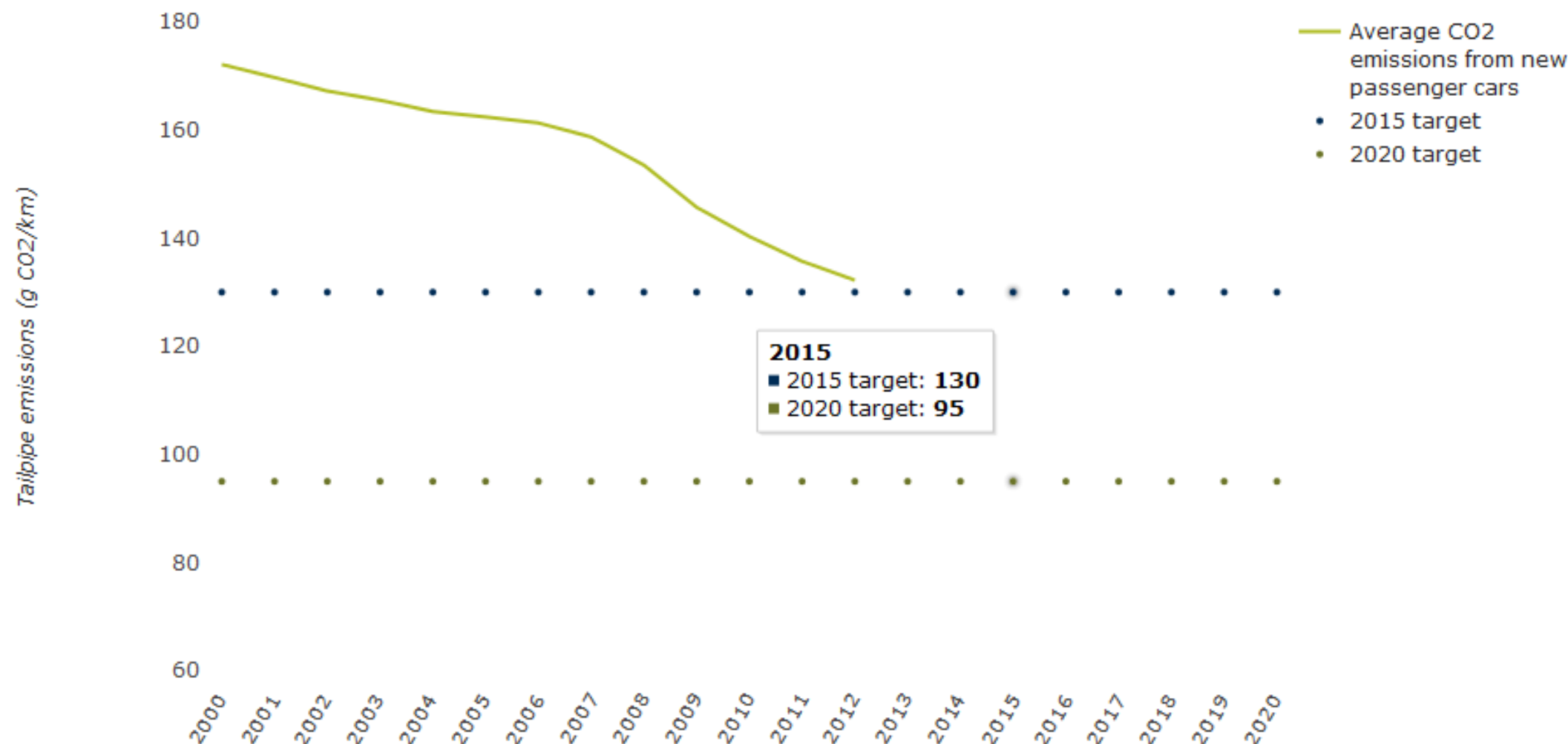


Einsatz von Mikrohohlglaskugeln (3M™ Glass Bubbles) zur Dichtereduktion in Thermoplasten

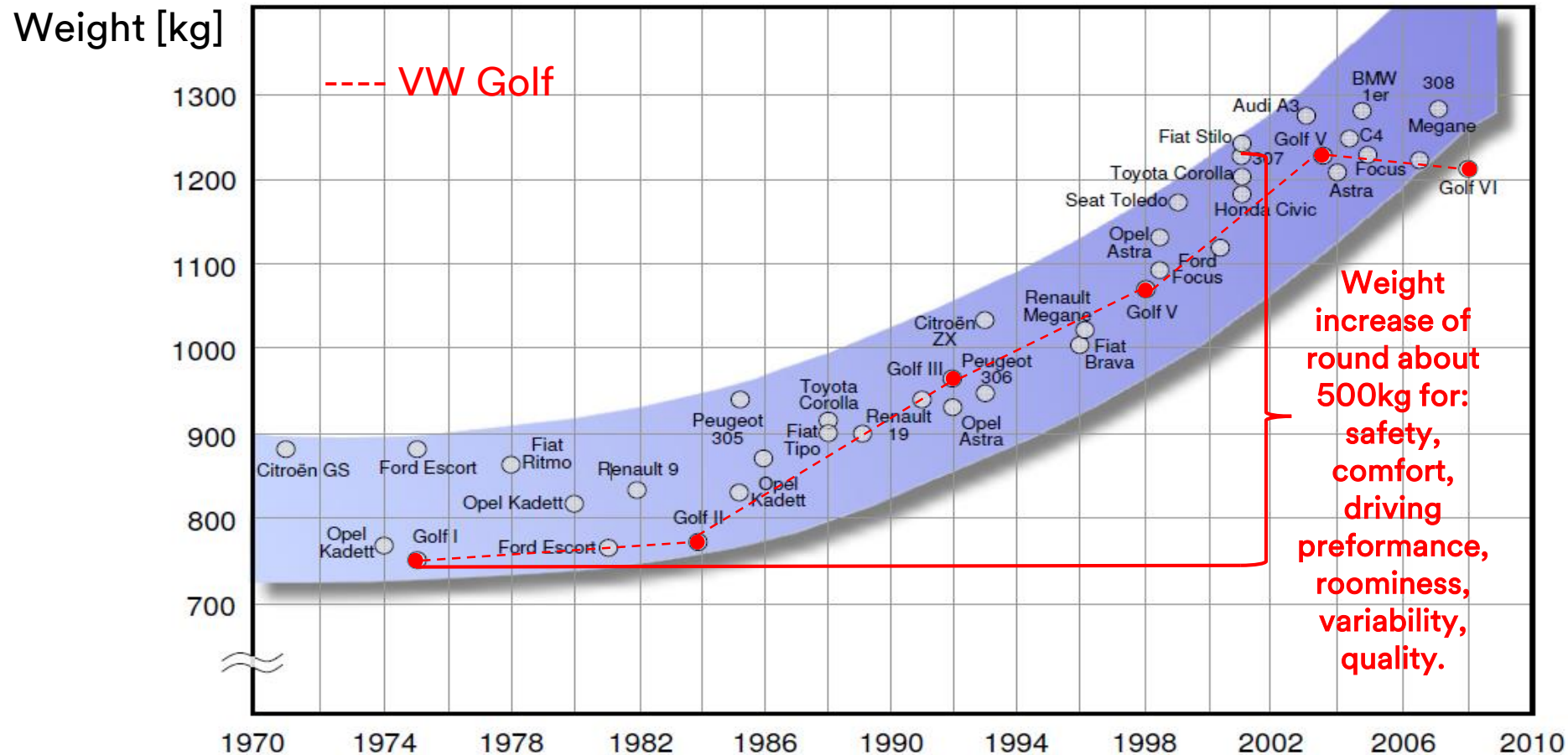
4a Technologietag 2016
Dr. Friedrich Wolff



CO₂ Fleet Emission Targets for European Car Manufacturer

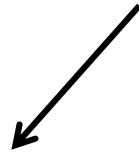


Changing Car Weight Over Time



500 kg weight increase, creates additional 65 g CO₂/km

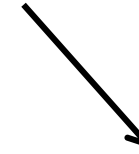
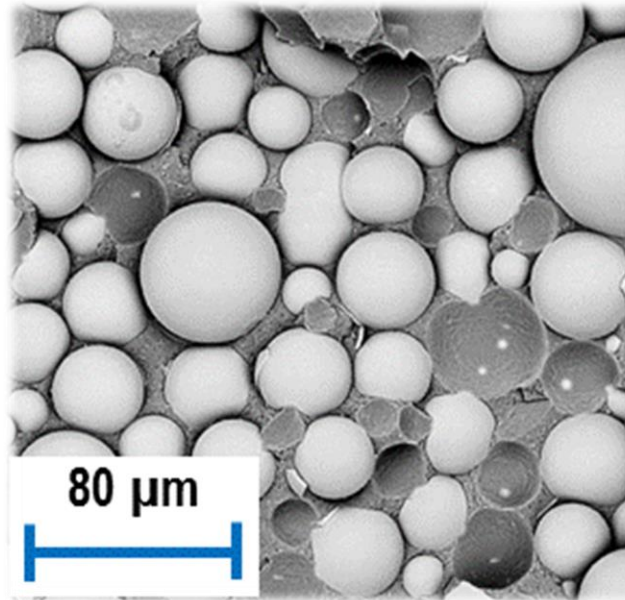
THERMOPLASTICS WEIGHT REDUCTION TECHNOLOGIES



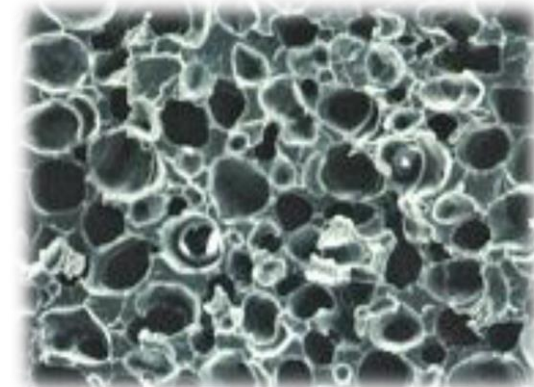
DESIGN APPROACH Thin Walling



MATERIAL APPROACH 3M™ GLASS BUBBLES



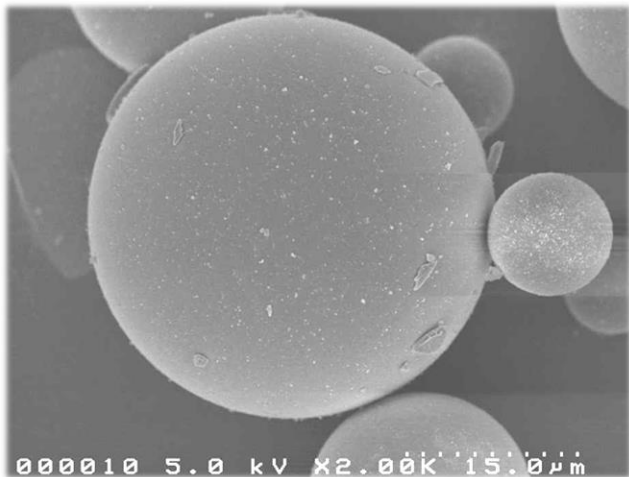
PROCESS APPROACH Foaming



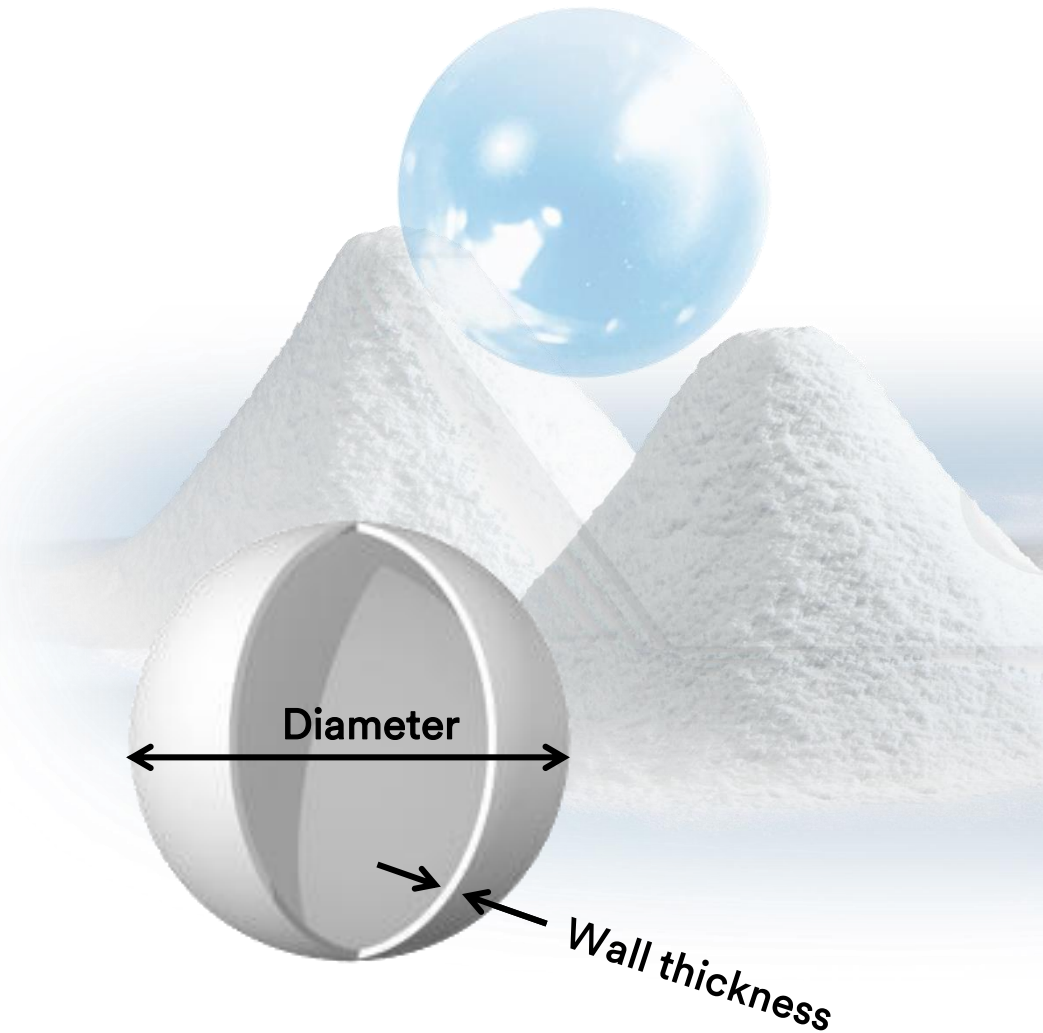
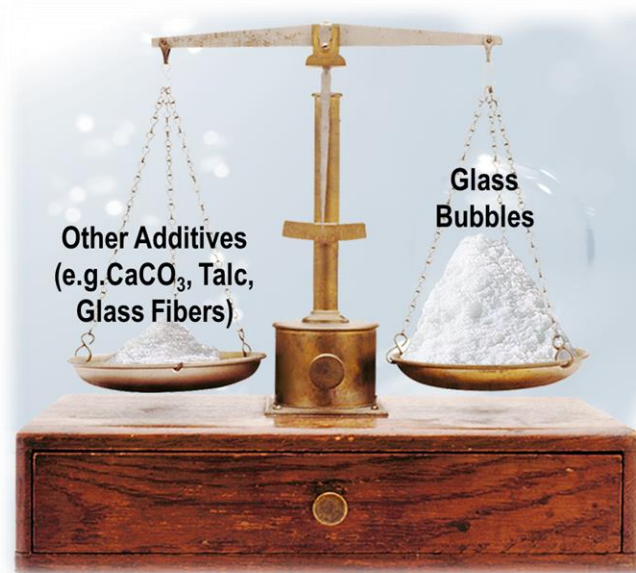
3M™ Glass Bubbles

Property	Value
Shape	Hollow; thin walled; single-cellular spheres
Composition	Borosilicate glass, chemical and water resistant
Color	White
Hardness	Mohs Scale 5
Softening temperature	600° C
Density	0.12 – 0.6 g/cm ³
Isostatic collapse strength	1.7 – 190 MPa (250 – 28000 psi)
Average particle diameter	16 – 65 µm

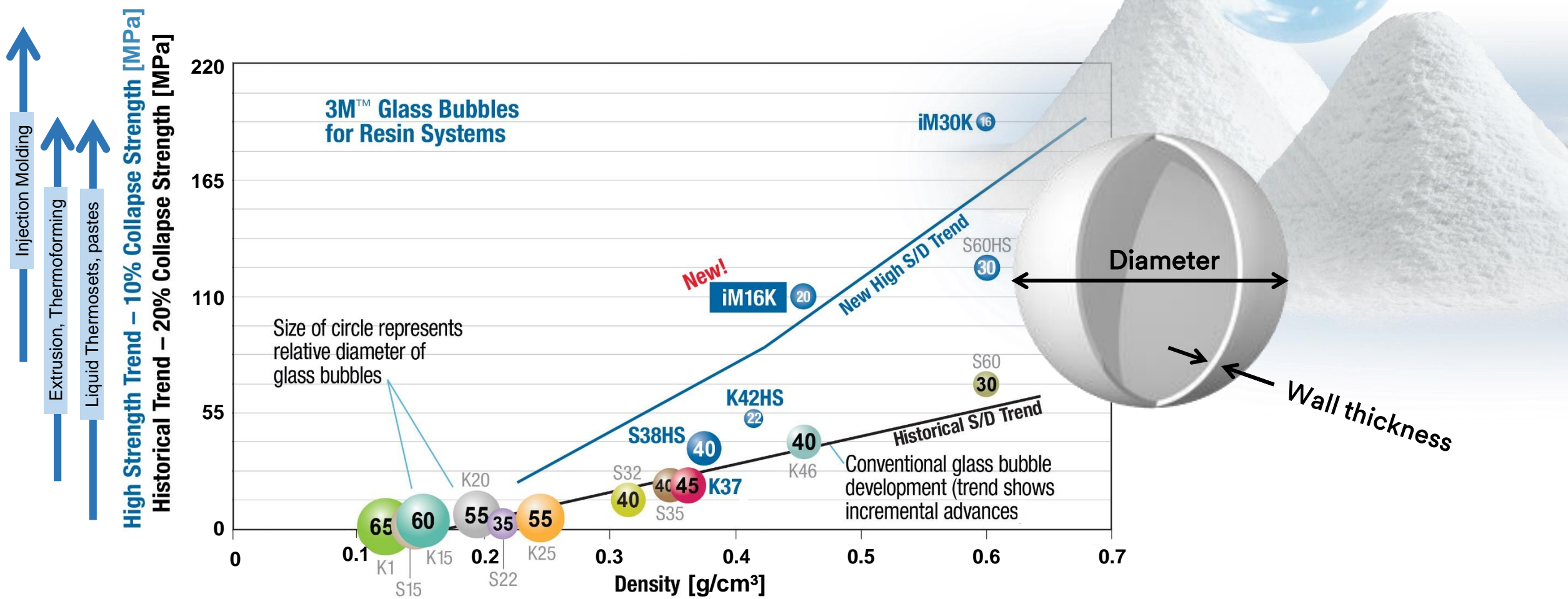
The named properties are not for specification purpose.



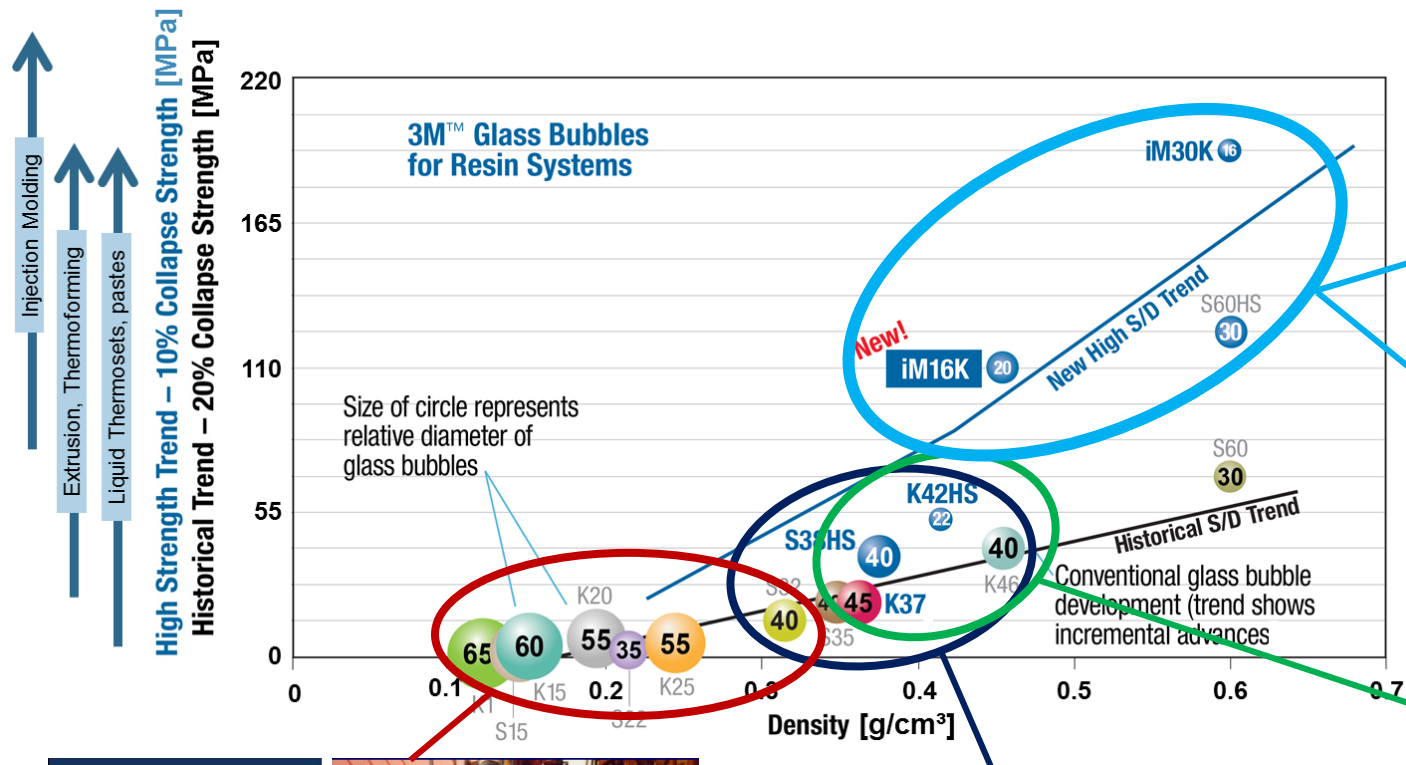
Glass Bubble as manufactured



3M™ Glass Bubbles Isostatic Collapse Strength



3M™ Glass Bubbles Applications in Polymers



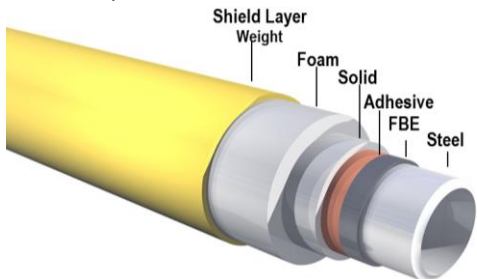
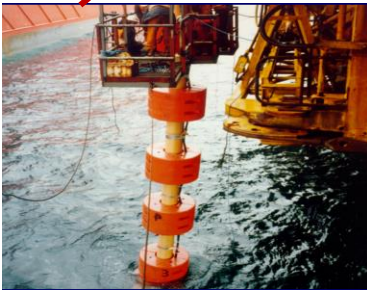
Lightweight extruded thermoplastics for aerospace



Lightweight injection molded thermoplastics for automotive



Buoyancy elements



Pipeline thermal insulation



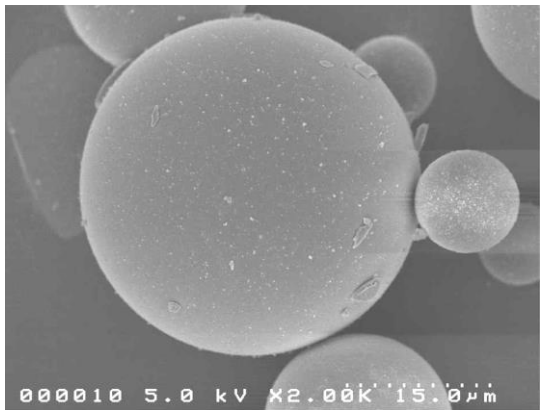
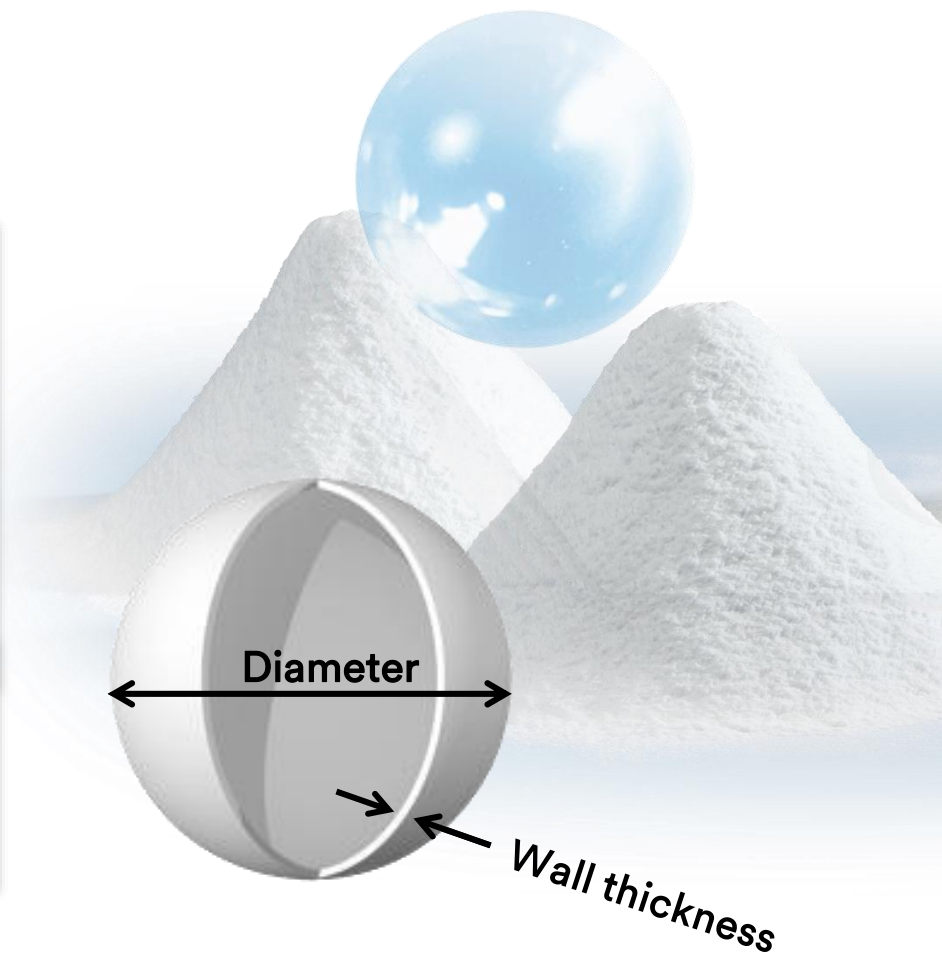
Lightweight SMC

Properties of 3M™ Glass Bubbles

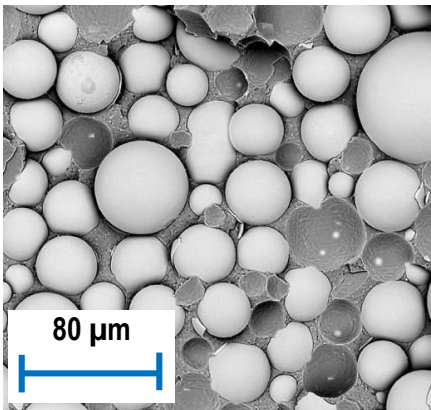
Two Glass Bubble Types for Thermoplastic Applications

Property	Value	
Shape	Hollow; thin walled; single-cell spheres	
Composition	Borosilicate glass, chemical and water resistant	
Color	White	
Hardness	Mohs Scale 5	
Softening temperature	600° C	
	iM16K	iM30K
Density	0.46 g/cm ³	0.60 g/cm ³
Isostatic collapse strength	110 MPa / 16000 psi	190 MPa / 28000 psi
Average particle diameter	20 µm	16 µm

The named properties are not for specification purpose.



Glass Bubble as manufactured

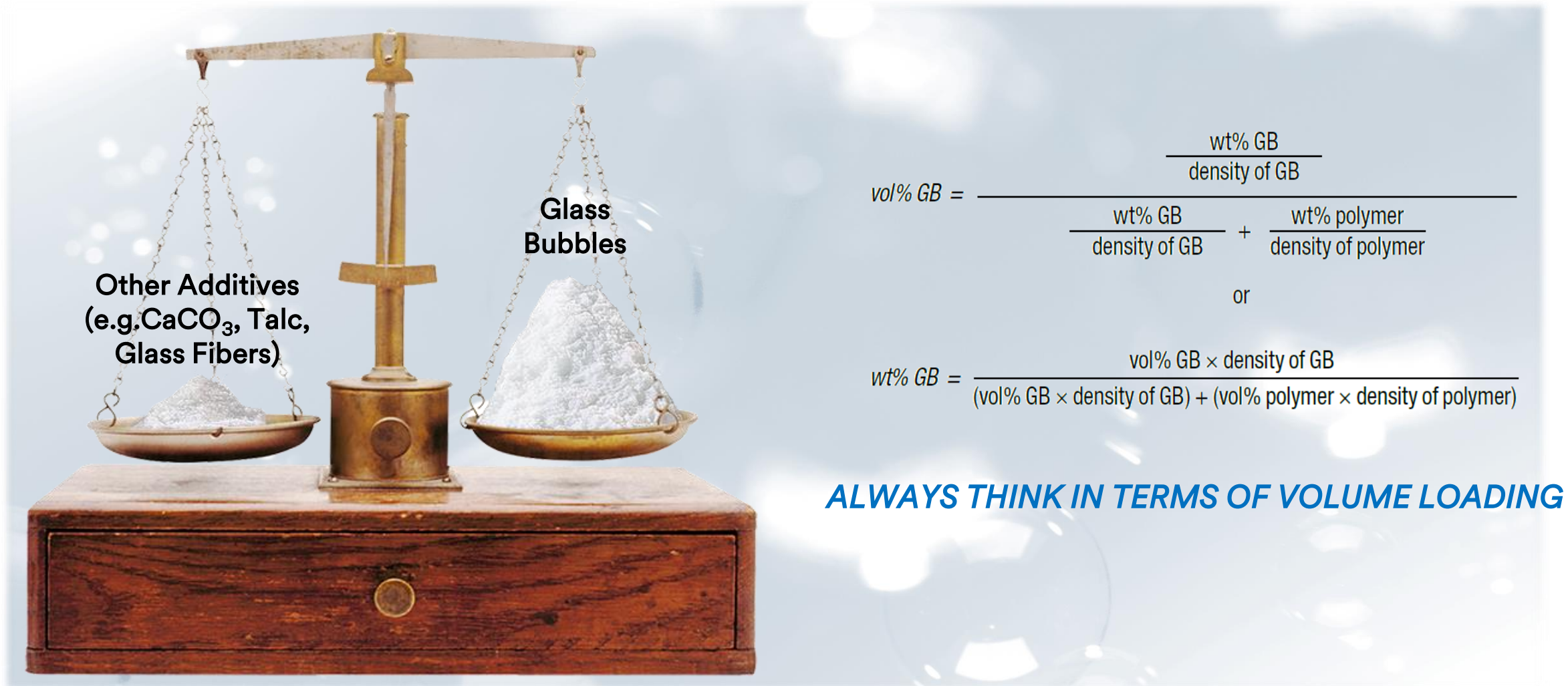


Glass Bubbles Masterbatch (PP)



3M™ Glass Bubbles Formulating

Formulating with 3M™ Glass Bubbles



$$\text{vol\% GB} = \frac{\frac{\text{wt\% GB}}{\text{density of GB}}}{\frac{\text{wt\% GB}}{\text{density of GB}} + \frac{\text{wt\% polymer}}{\text{density of polymer}}}$$

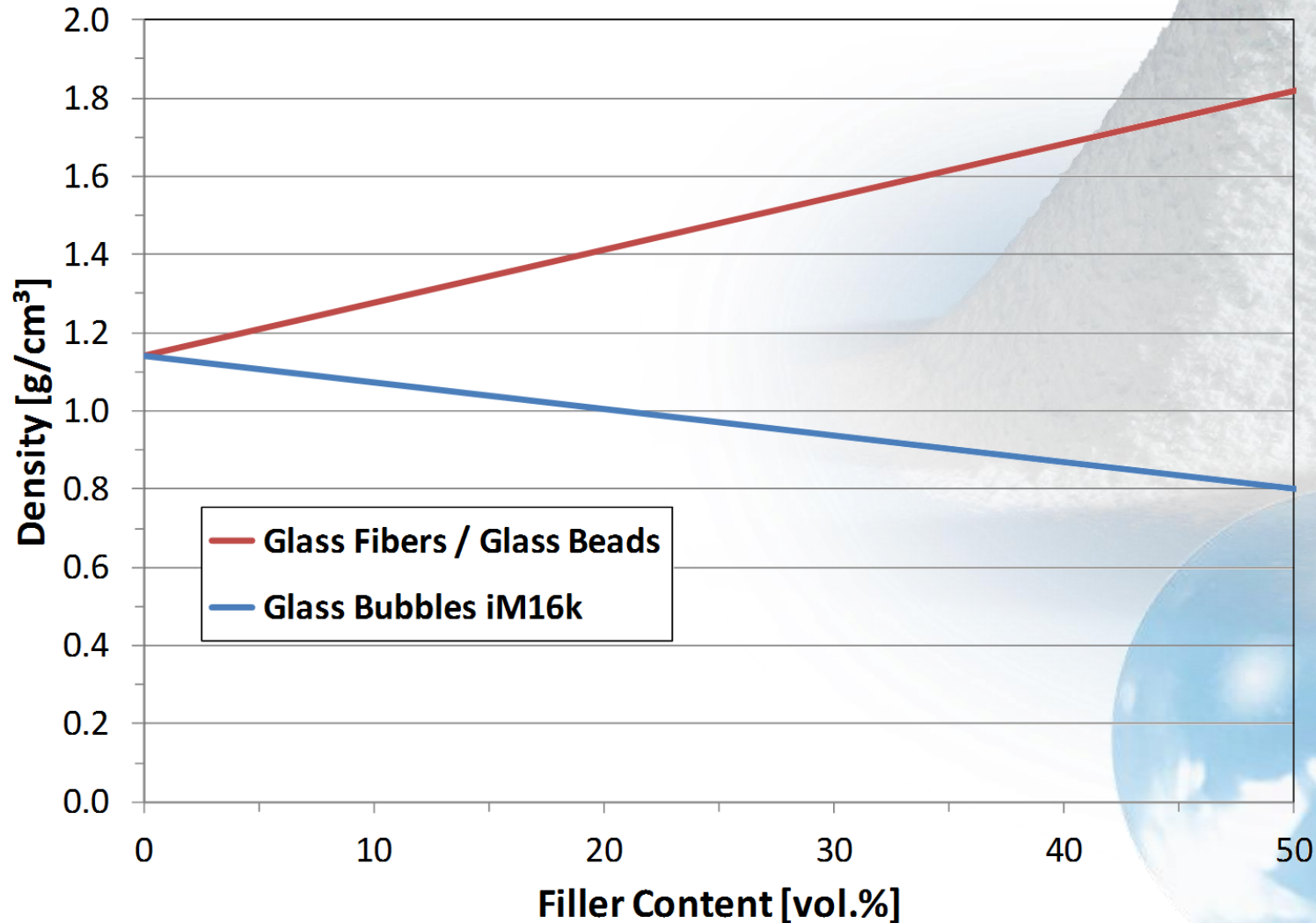
or

$$\text{wt\% GB} = \frac{\text{vol\% GB} \times \text{density of GB}}{(\text{vol\% GB} \times \text{density of GB}) + (\text{vol\% polymer} \times \text{density of polymer})}$$

ALWAYS THINK IN TERMS OF VOLUME LOADING

Formulating with 3M™ Glass Bubbles

Density of PA Compound with Various Glass Fillers

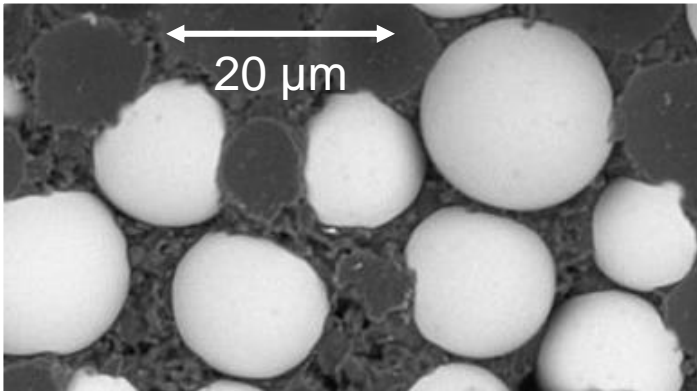


Glass Bubbles decrease the compound density whereas common fillers (e.g. minerals, glass fibers, glass beads) increase density

Formulating with 3M™ Glass Bubbles

Comparison of 3M™ Glass Bubbles to Typical Fillers used in Thermoplastic Compounds

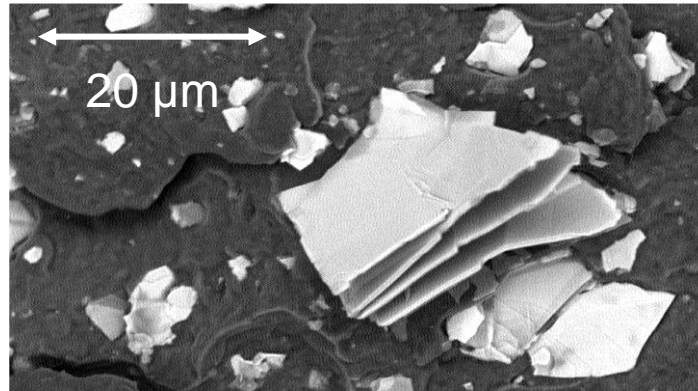
Hollow Glass Microspheres



0.46 - 0.6 g/cm³

1:1

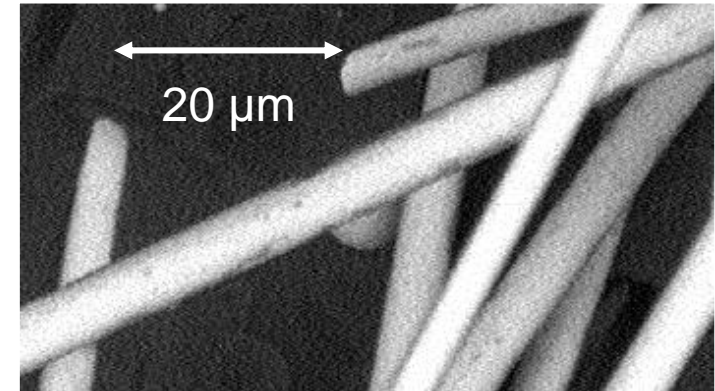
Talc



2.8 g/cm³

20:1

Glass Fibers



2.5 g/cm³

30–50:1

Low



Aspect Ratio

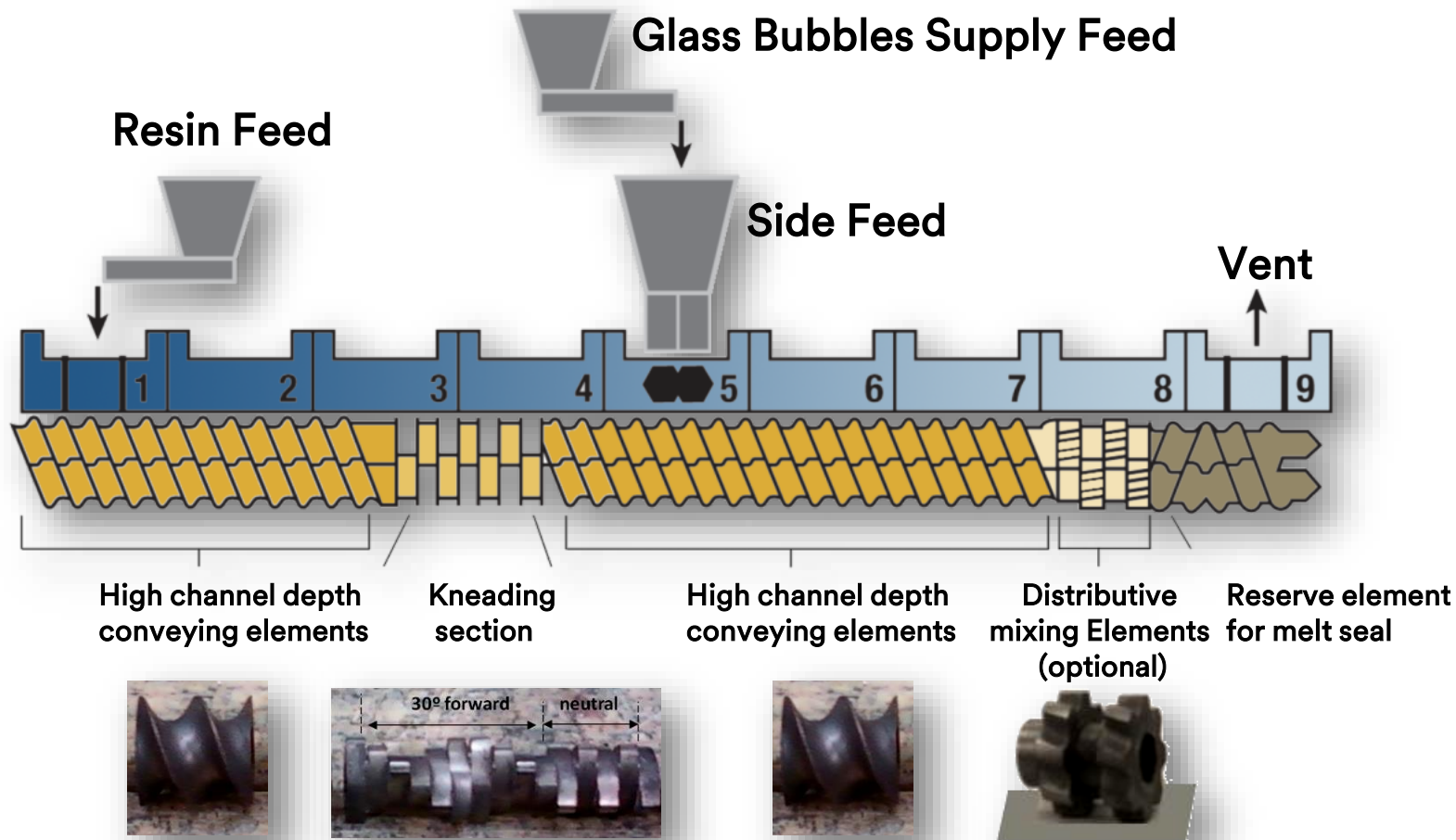
High



3M™ Glass Bubbles Processing

Processing of 3M™ Glass Bubbles Compounds

Compounding via Twin Screw Extruder

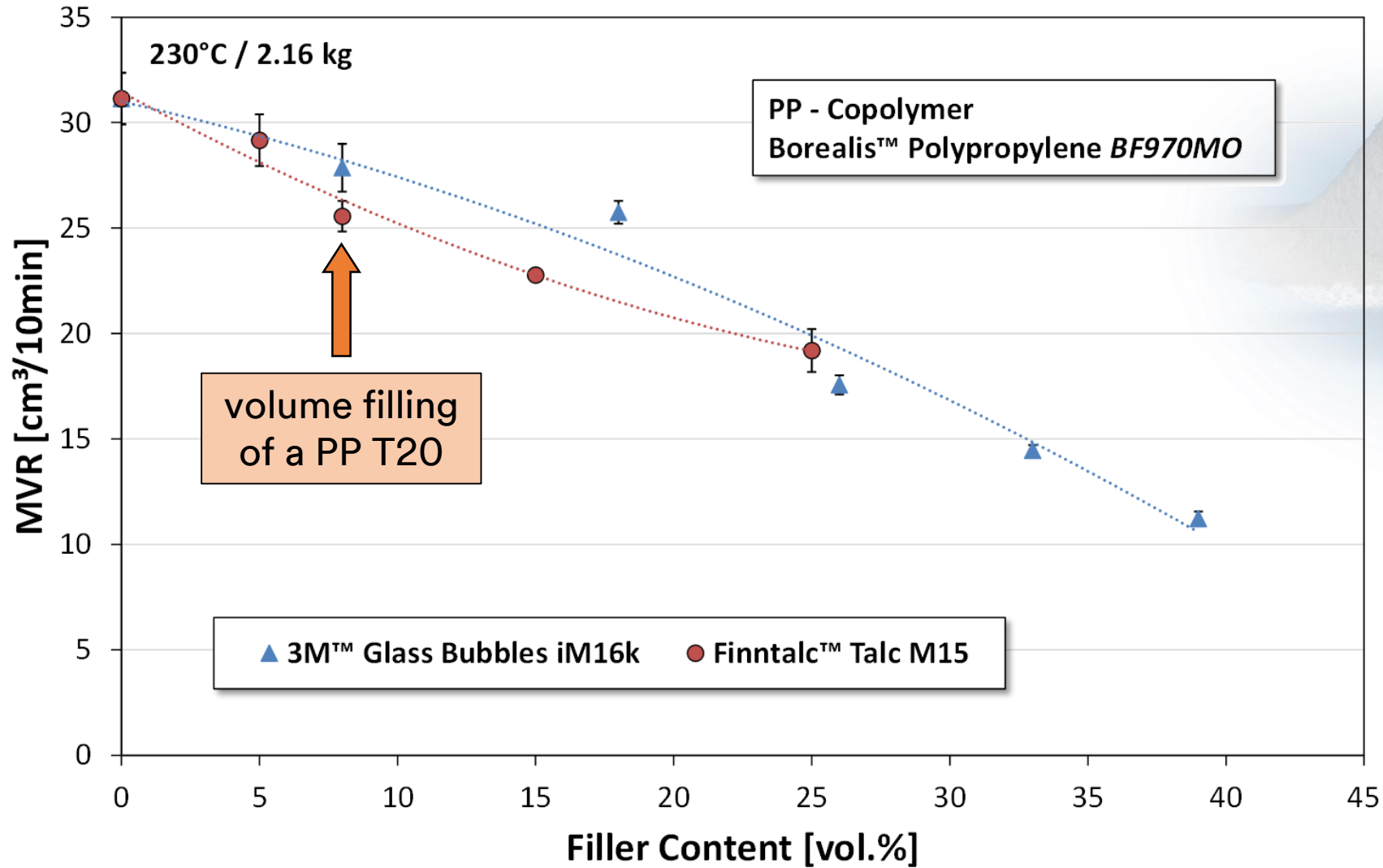


- Add glass bubbles downstream into fully molten polymer to minimize breakage
- After addition use high channel depth conveying elements
- Feeding into kneading block or conveying element with low channel depth will increase breakage

Glass Bubble compounds can be molded with any injection molding machine without modification

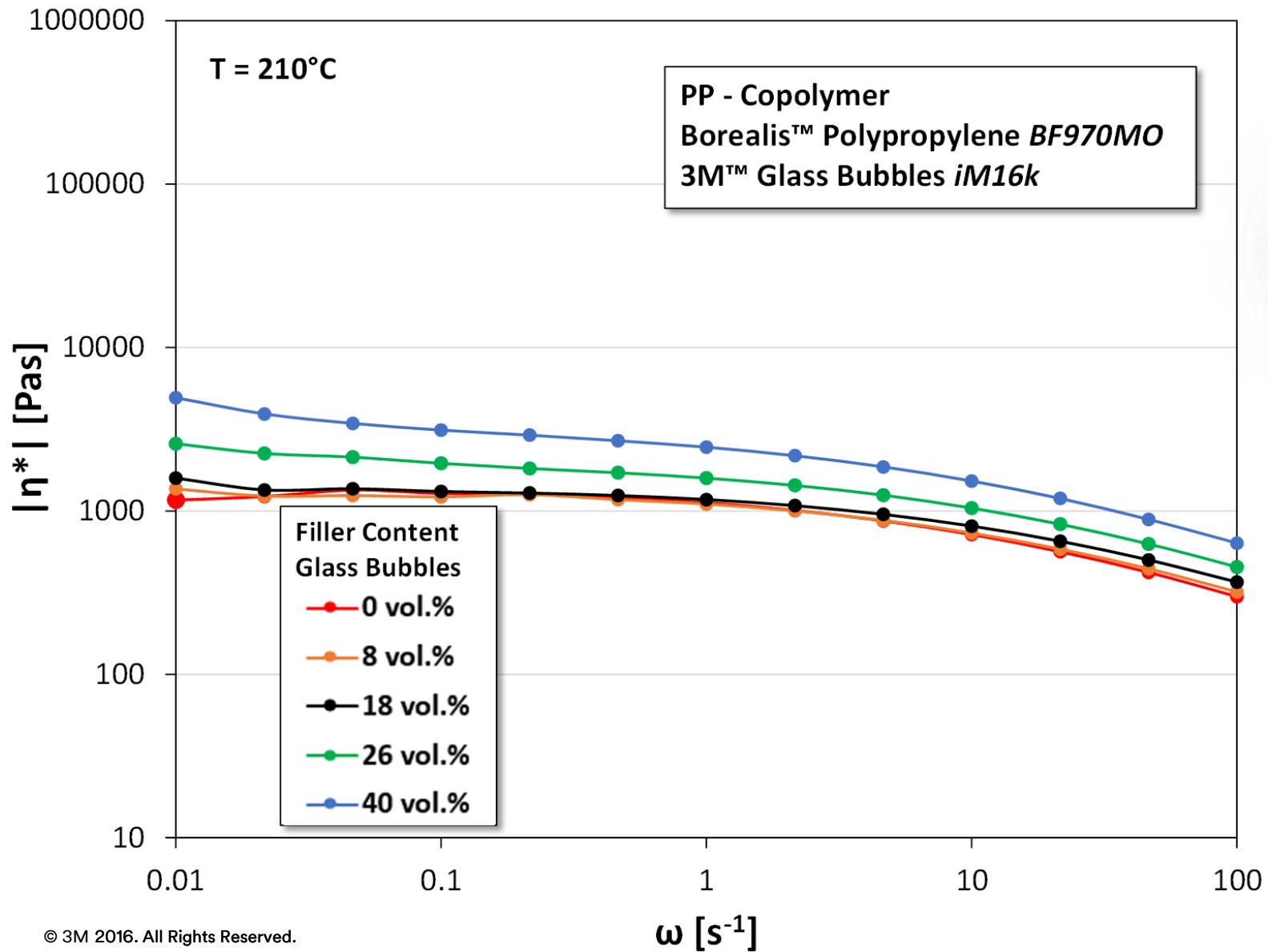
Rheology

Example PP Copolymer



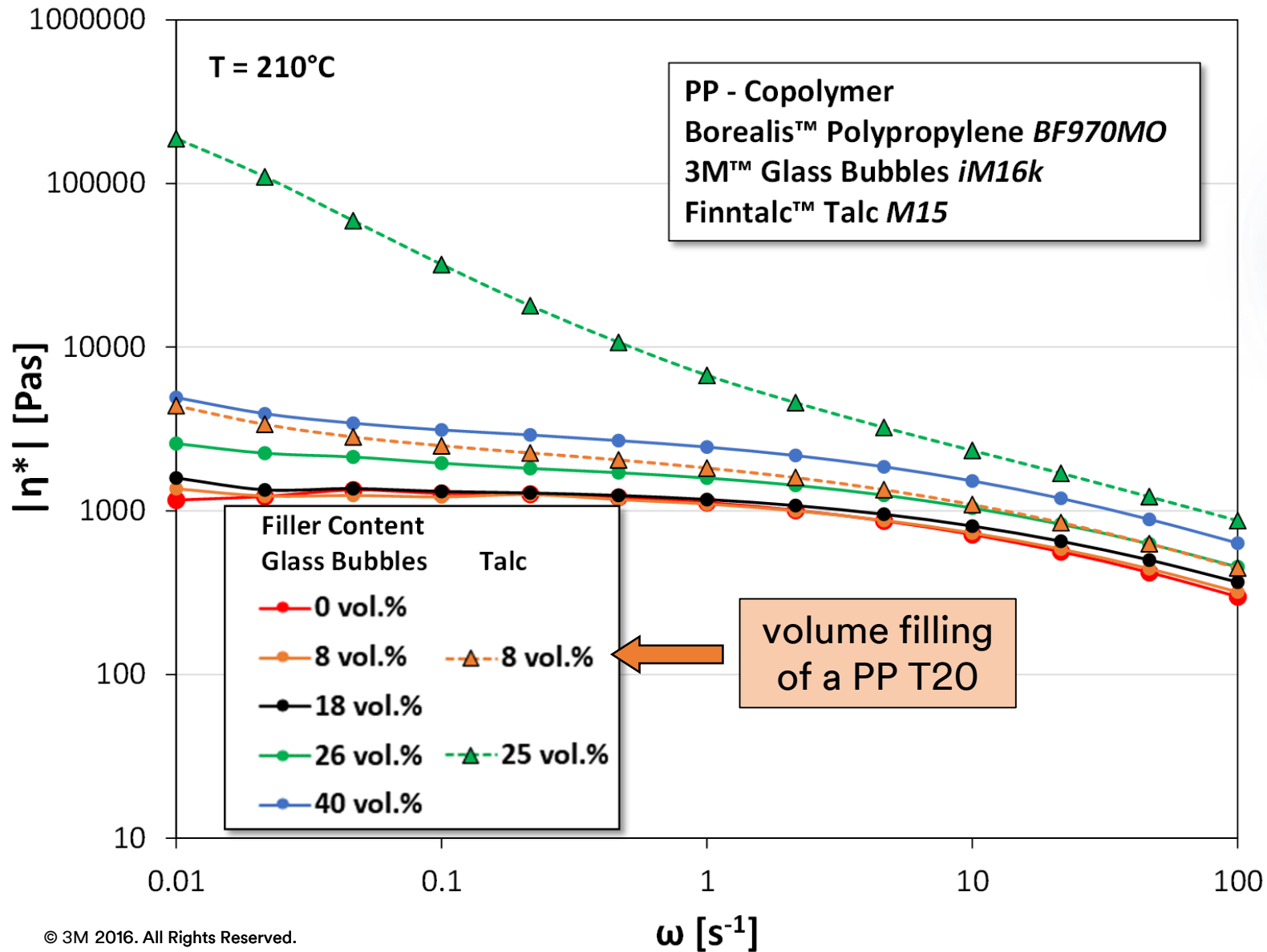
Rheology

Example PP Copolymer



Rheology

Example PP Copolymer





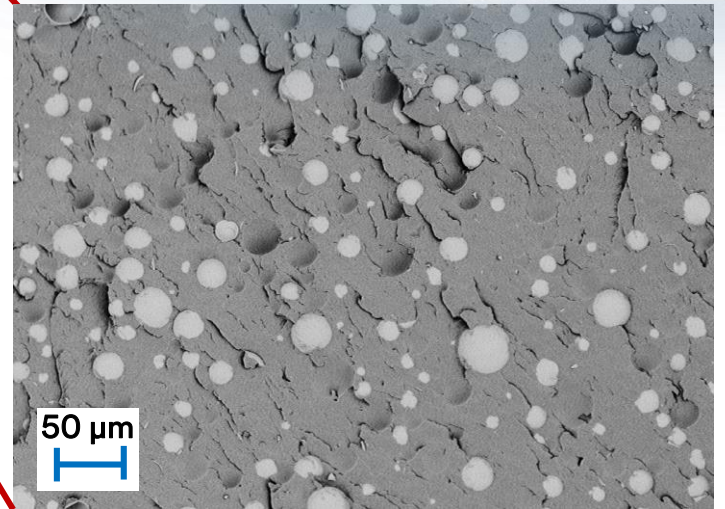
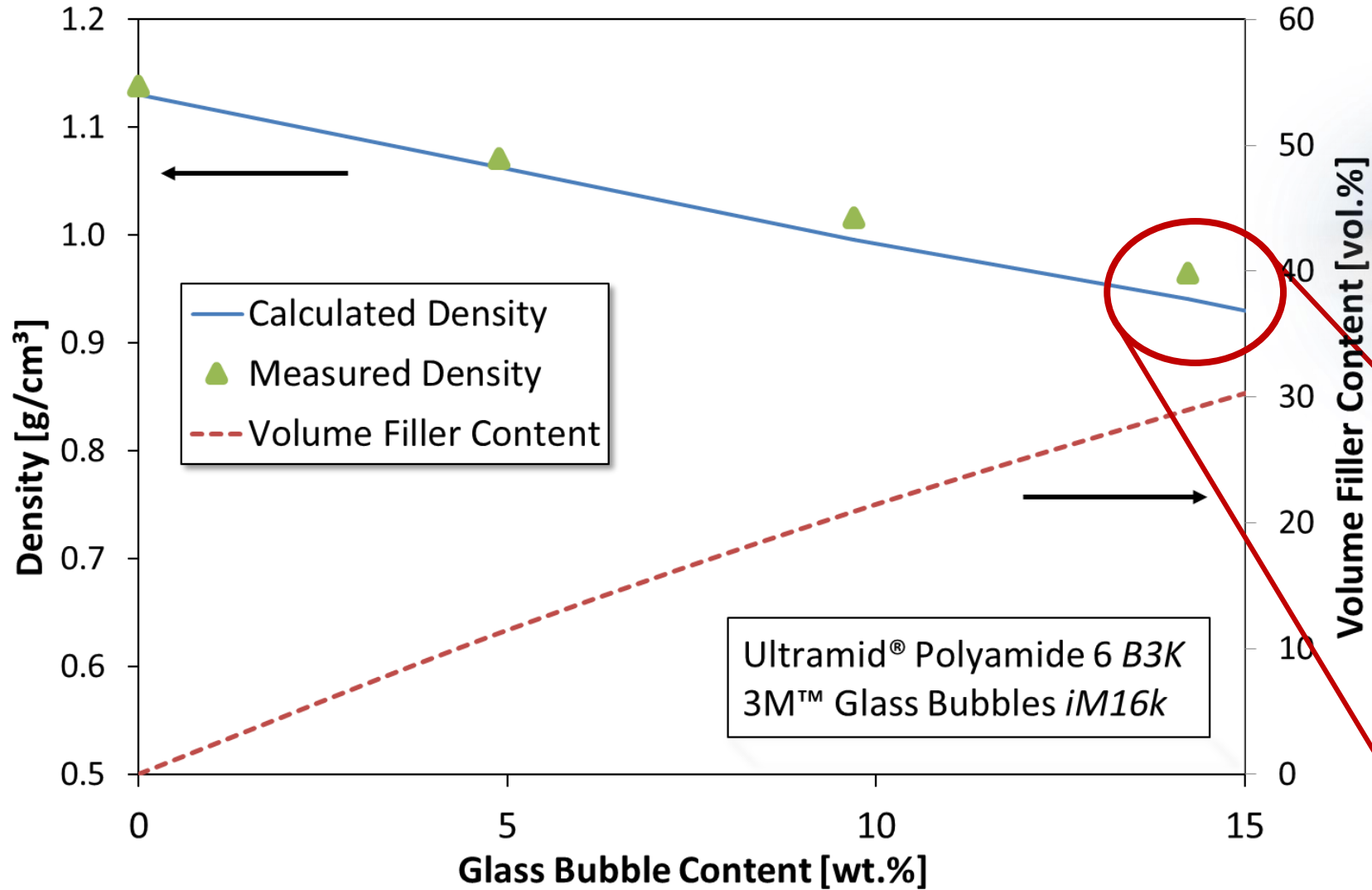
3M™ Glass Bubbles

Properties of Thermoplastic Compounds

(Example PA6)

Density

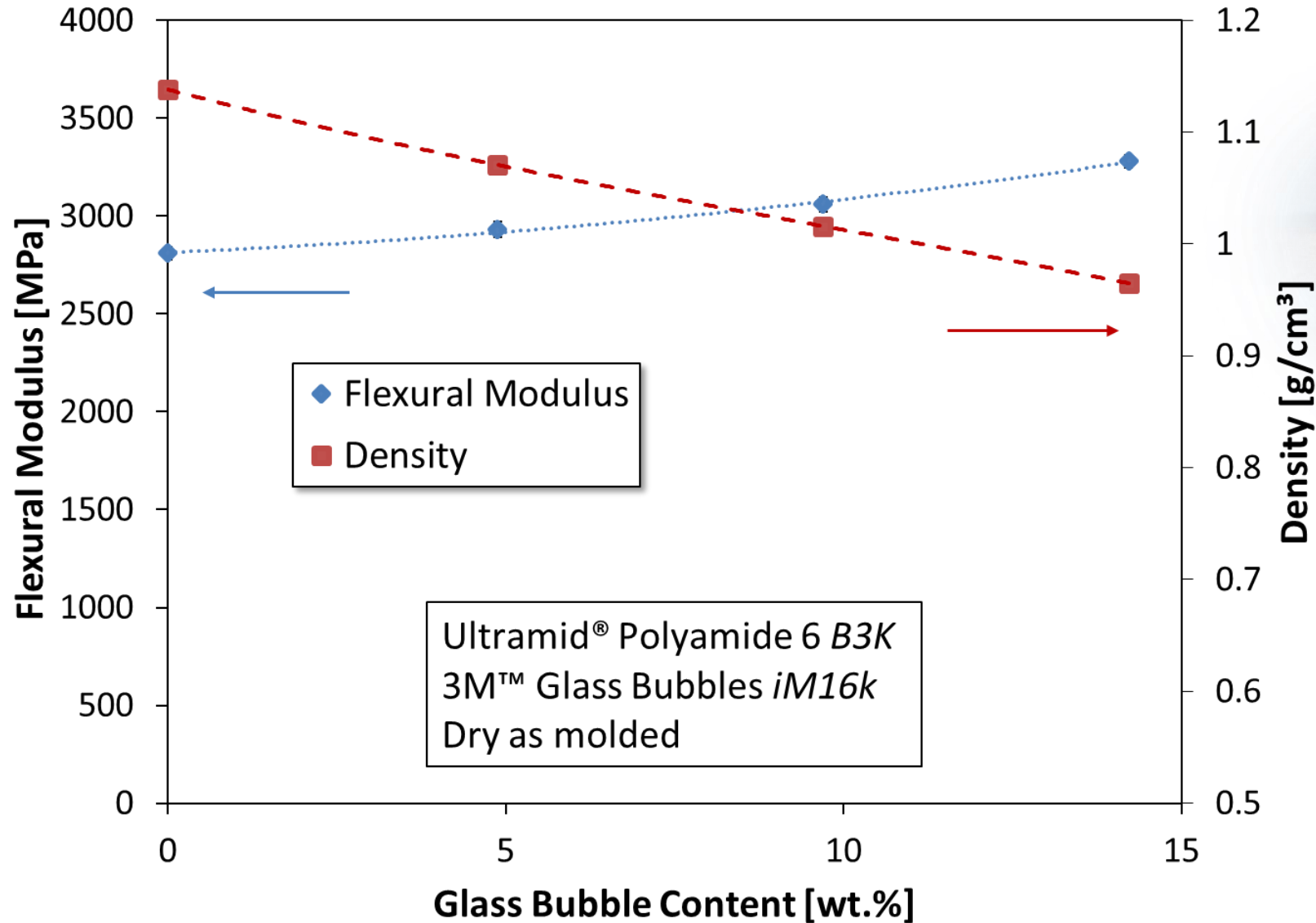
Example PA6



PA6 with 14 wt.% (\pm 29 vol.%) iM16k

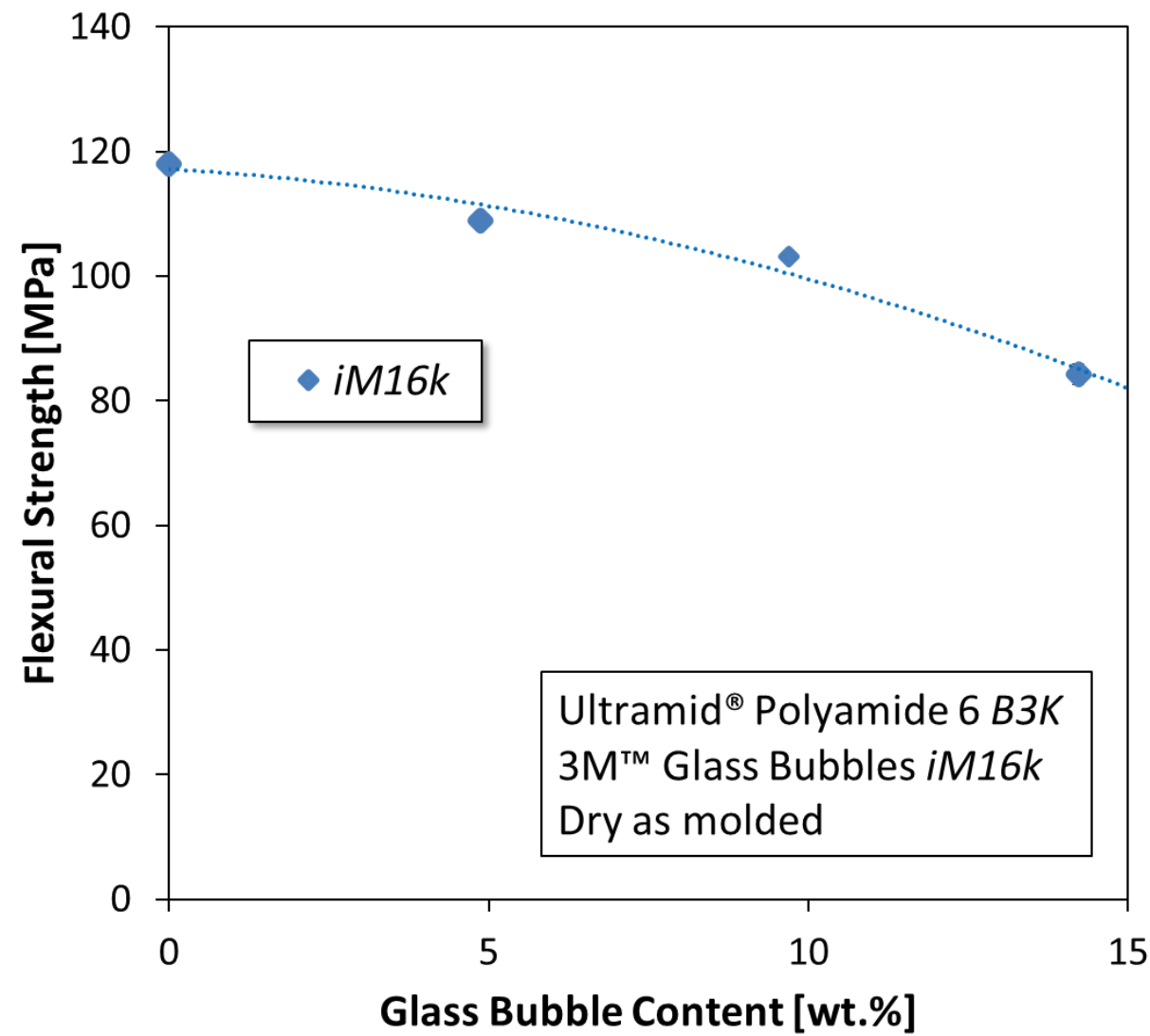
Mechanical Properties

Example PA6



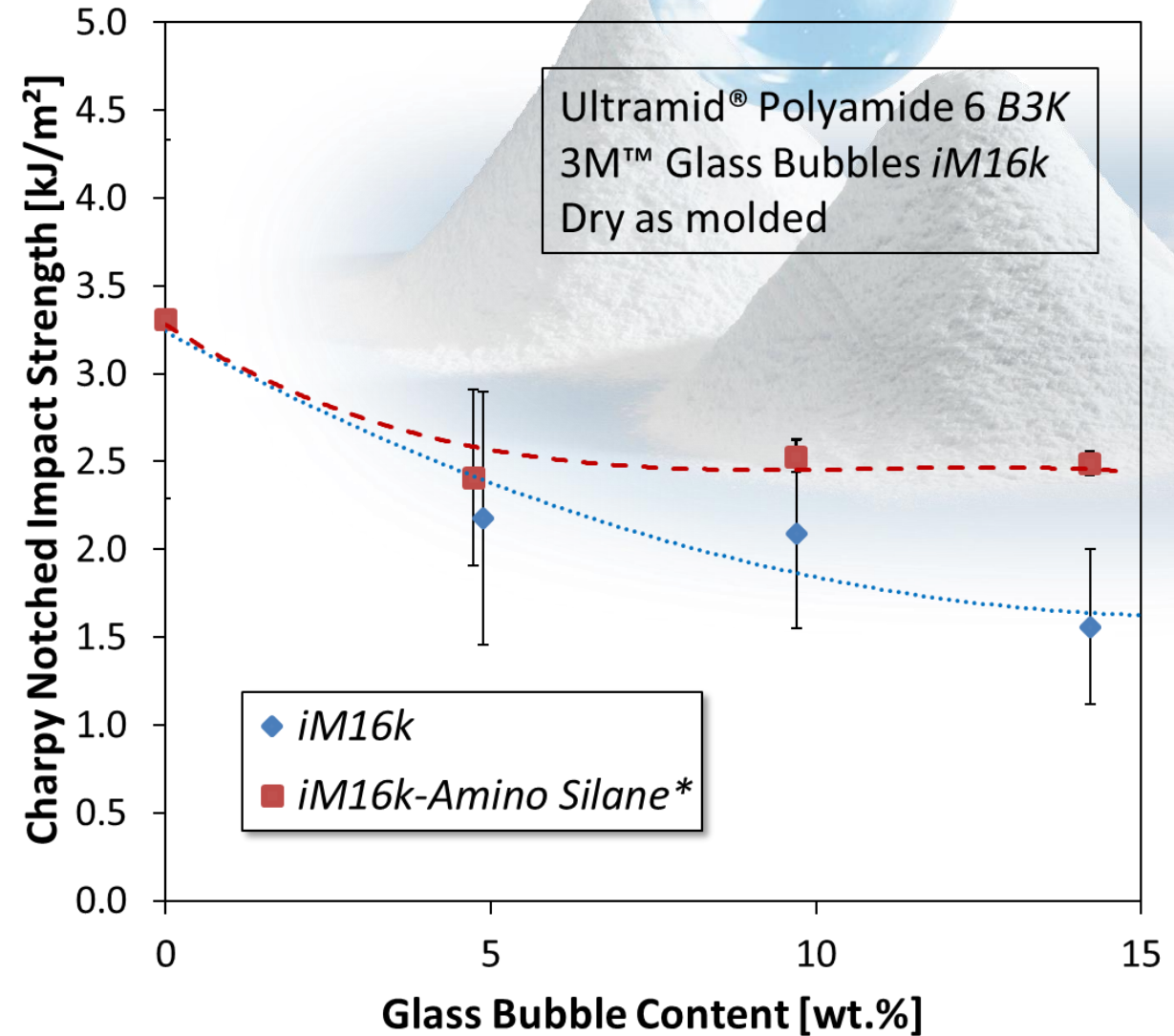
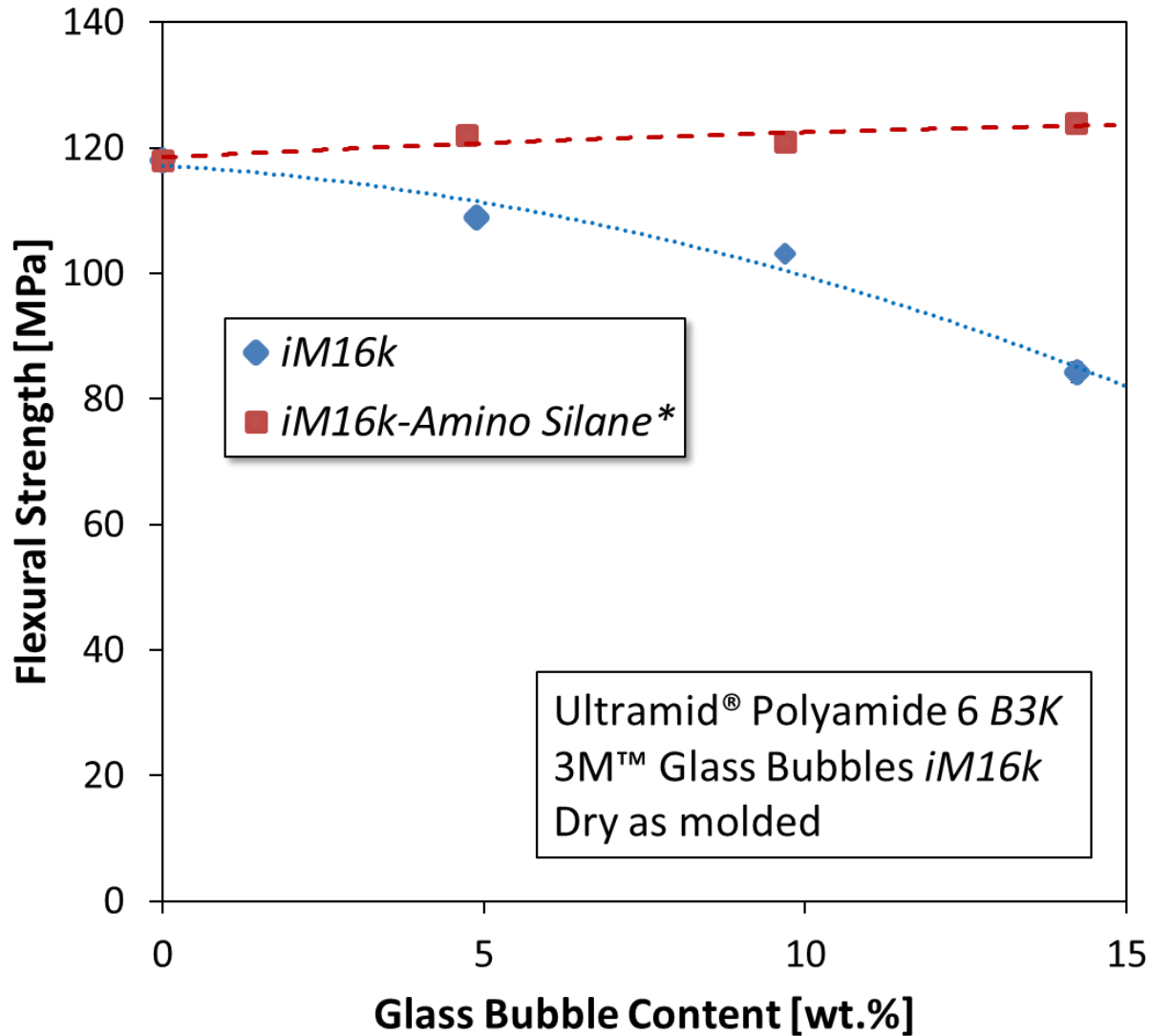
Mechanical Properties

Example PA6

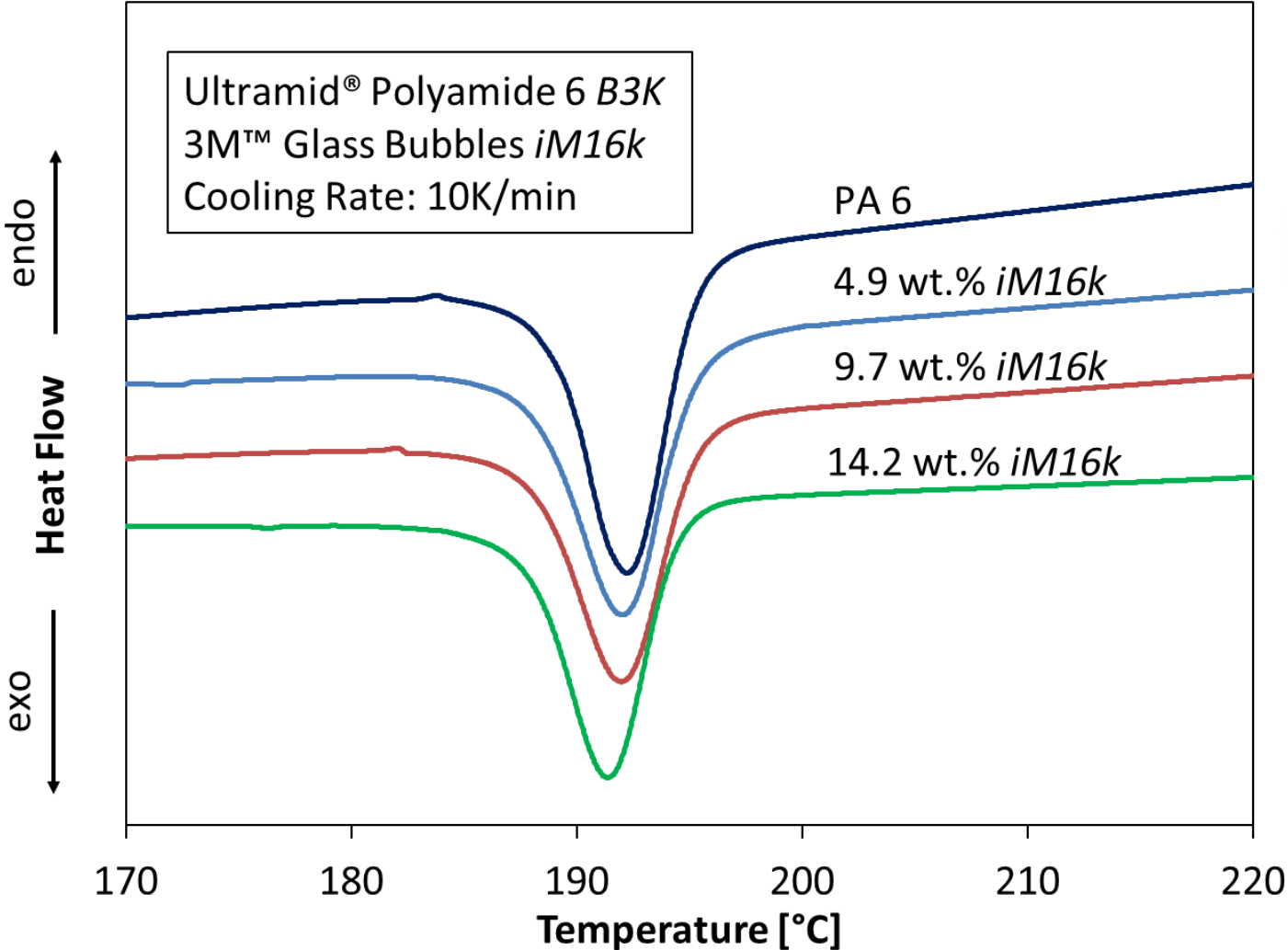


Mechanical Properties

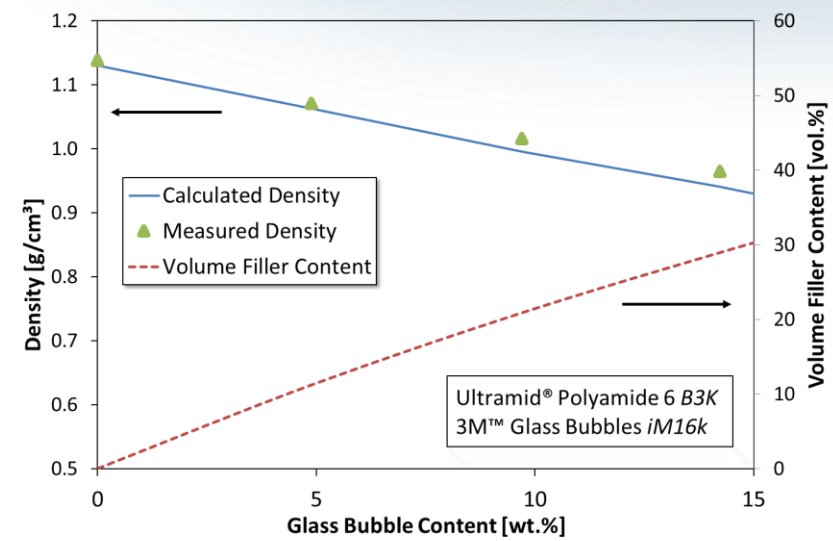
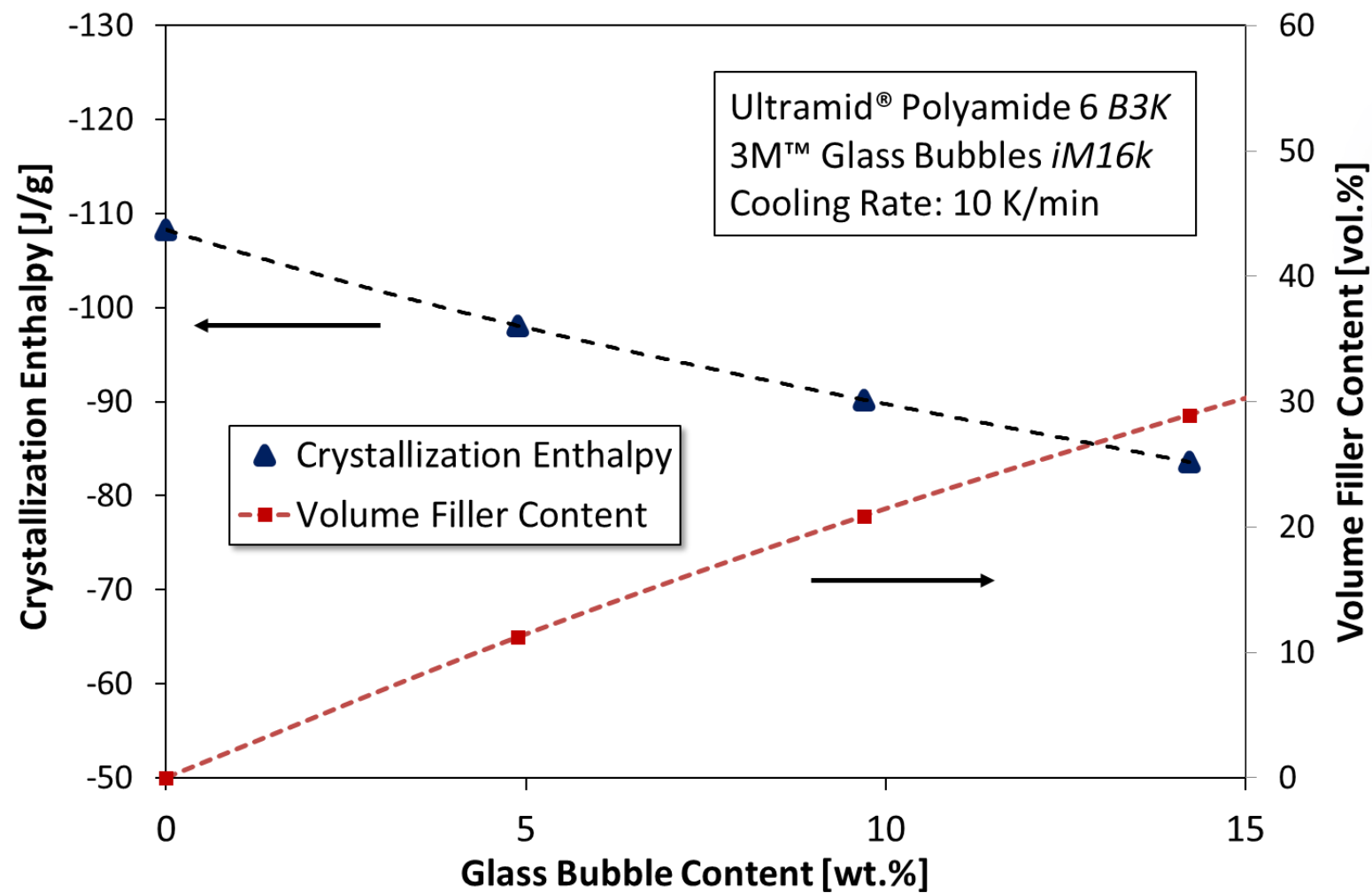
Example PA6



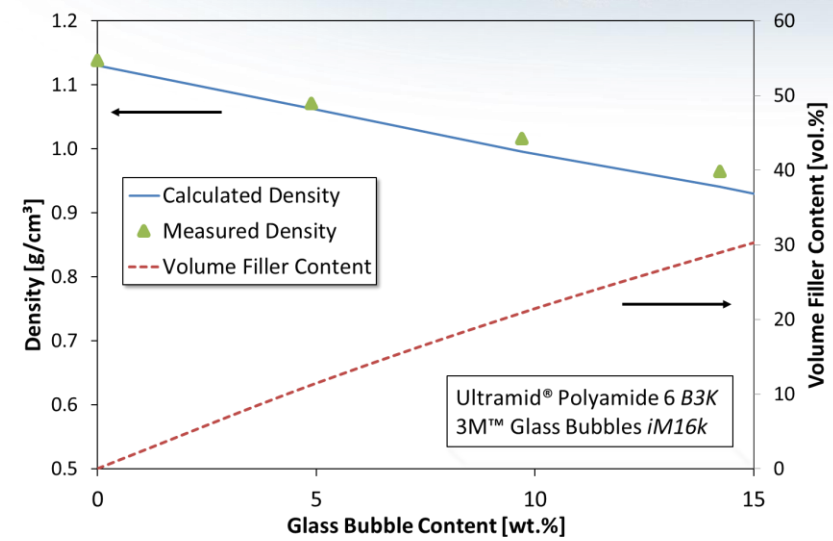
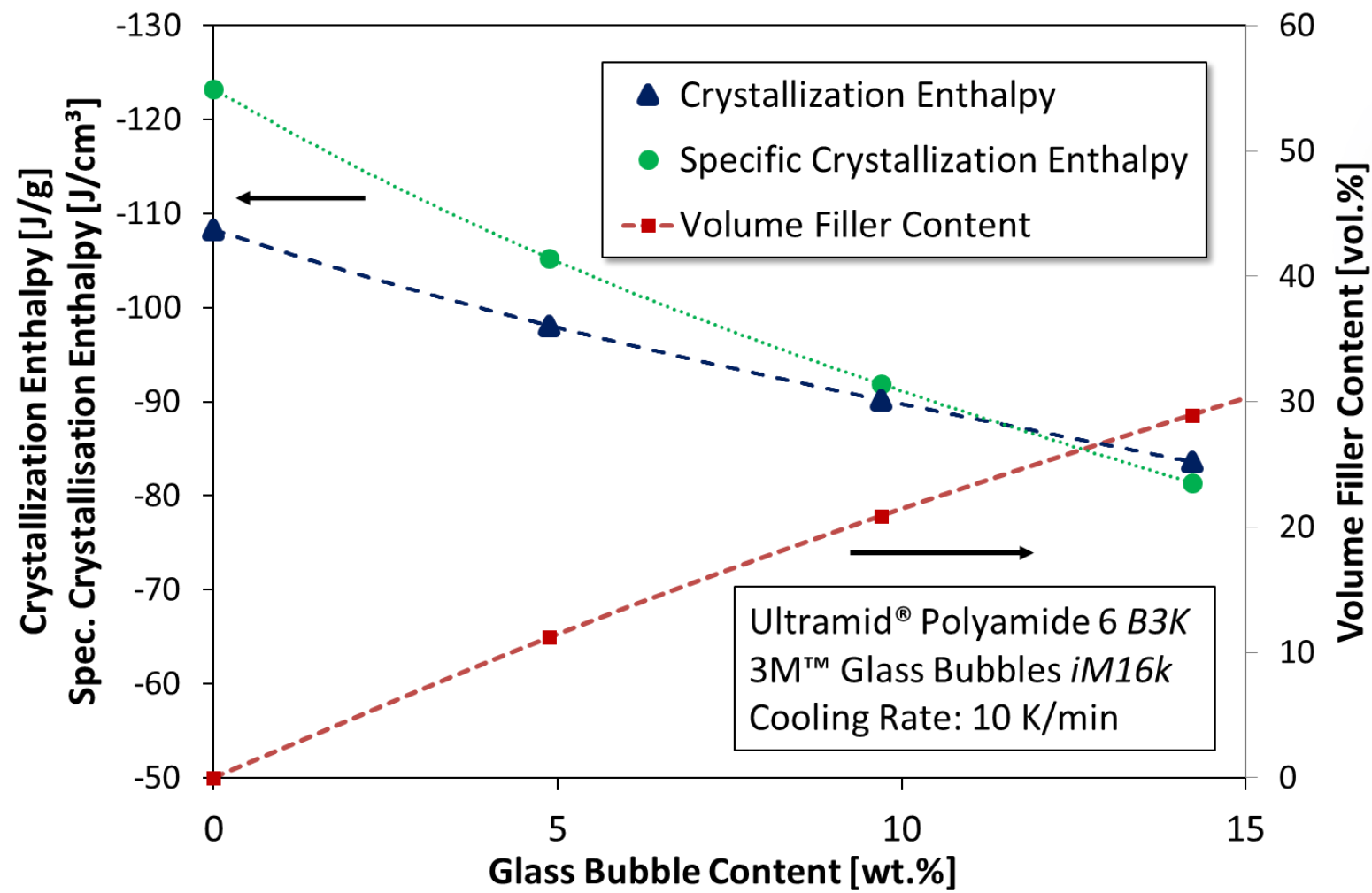
Thermal Properties



Thermal Properties

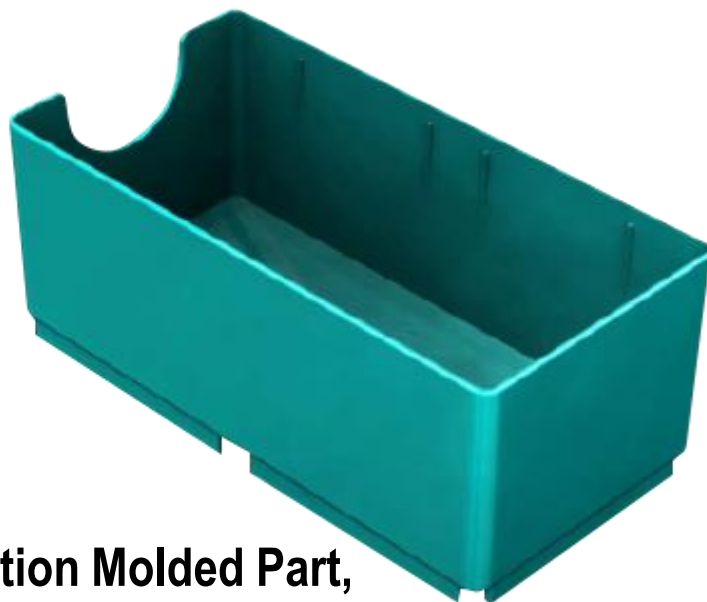


Thermal Properties



Cycle Time Reduction with 3M™ Glass Bubbles

Injection Molding Cycle Time Reduction for PA6 containing iM16K



**Injection Molded Part,
Dimensions: 60 x 60 x 2 mm**



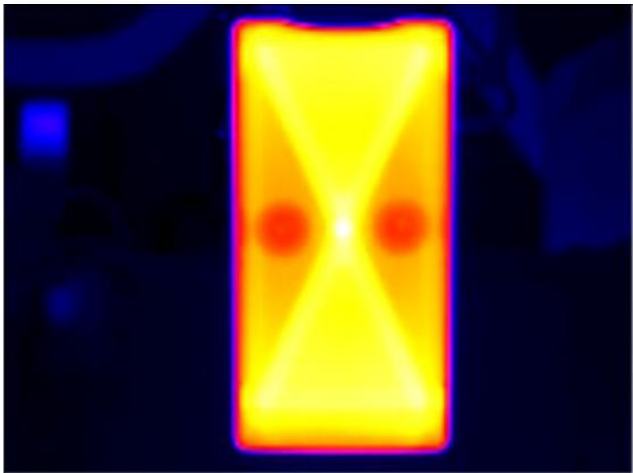
**Experimental Setup:
Ejection Temperature measured by IR**

Study at SKZ Institute, Germany

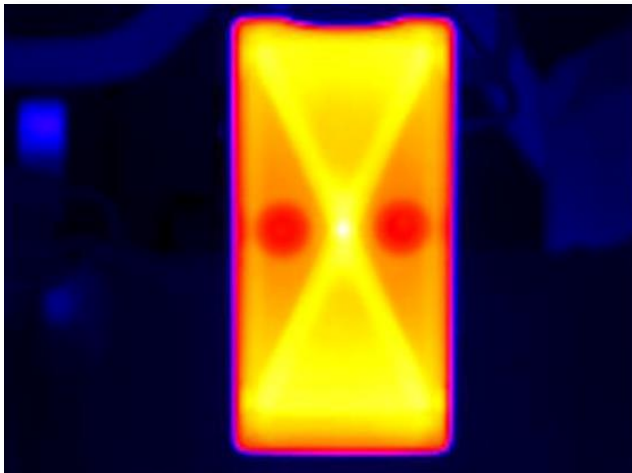
Cycle Time Reduction with 3M™ Glass Bubbles

Ejection temperature determined by IR camera and thermographic software of SKZ

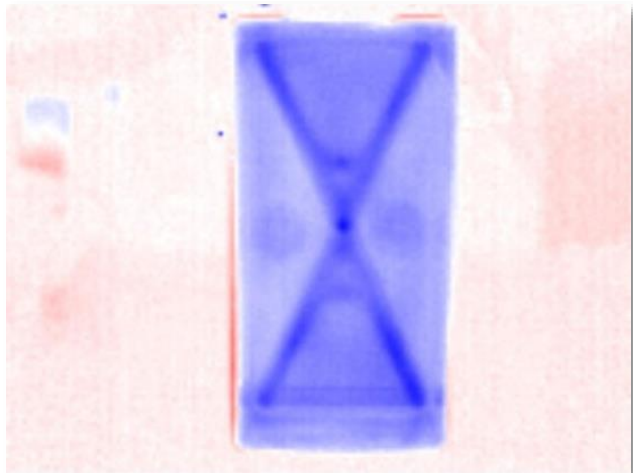
PA 6 Reference tc = 17s



PA 6 GB 7wt.% (16vol.%) tc = 17s



Temperature difference



104.3 95.2 86.0 76.9 67.7 58.5 49.4 40.2 31.1



Temperatur in ° C



hotter

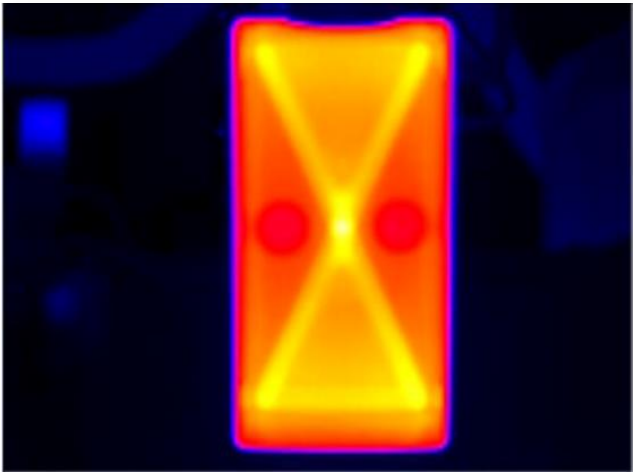
equal

cooler

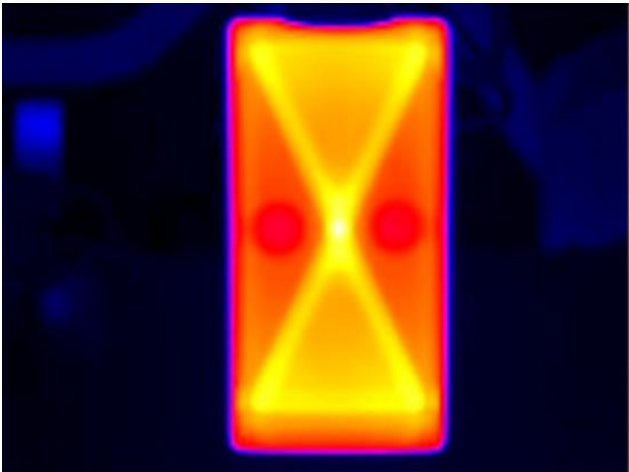
Cycle Time Reduction with 3M™ Glass Bubbles

Ejection temperature determined by IR camera and thermographic software of SKZ

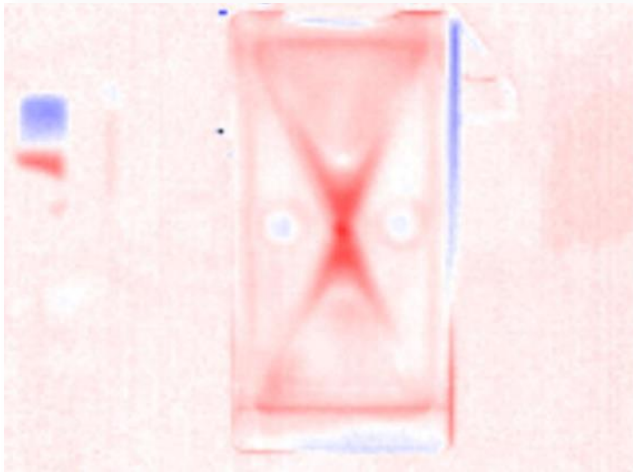
PA 6 Reference tc = 17s



PA 6 GB 7wt.% (16vol.%) tc = 11.5s



Temperature difference



114.6 104.4 94.1 83.9 73.6 63.3 43.1 42.8 32.6

Temperatur in ° C



hotter equal cooler

Cycle Time Reduction with 3M™ Glass Bubbles

Injection Molding Cycle Time Reduction for PA6 containing iM16K



Injection Molded Part,
Dimensions: 60 x 60 x 2 mm

Material	Cooling Time [s]	Total Cycle Time [s]	Total Cycle Time Reduction [%]
PA 6	17	40.2	–
PA 6 GB 7 wt% (16vol.%)	11.5	35.2	12



Experimental Setup:
Ejection Temperature
measured by IR

Study at SKZ Institute, Germany



3M™ Glass Bubbles

**Case
Studies**

Weight Reduction in Automotive Plastic Parts

Interior

- Technology: PP – Mineral – 3M™ Glass Bubbles
- Reduced weight 10%
- Target Costs +/- 0%



Door trim (center trim)



Door scuff



Wheel house trim

Weight Reduction in Automotive Plastic Parts

Engine Cover

- Technology: PA6 – Glass Fibers – 3M™ Glass Bubbles
- Reduced weight 14%
- Process Time Saving 5%
- Target Costs +/- 0%



BBP KUNSTSTOFFWERK MARBACH BAIER GMBH



3M™ Glass Bubbles Plant Tilloy, France

3M Science.
Applied to Life.™



**Industrial Park Werk GENDORF, Germany
with 3M™ Specialty Additives Laboratory**

Thank You

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