Plastic Materials for Thermoforming

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Rheology Challenge with Thermoforming

- Operating temperature range
- Outdoor exposure
- Chemical exposure
- Loads / impact
- Fatigue / vibration / cyclic stress
- Electrical properties (radomes)
- Optical requirements (transparent, light diffusing)
- Appearance (color, texture, gloss)
- Flammability requirements
- Certifications (FDA, UL, etc.)

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Rheology Challenge with Thermoforming

- Shallow draw vs. deep draw
- Requirement for pre-drying
- Forming temperature
- Tolerance for regrind
- Processing temperature window
- Shrinkage
- Ease of painting / bonding with adhesives
- Tooling requirements

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Rheology Challenge with Thermoforming

- The material must have sufficient “rubbery” strength to support its own weight during forming
- The material must flow to achieve the desired shape

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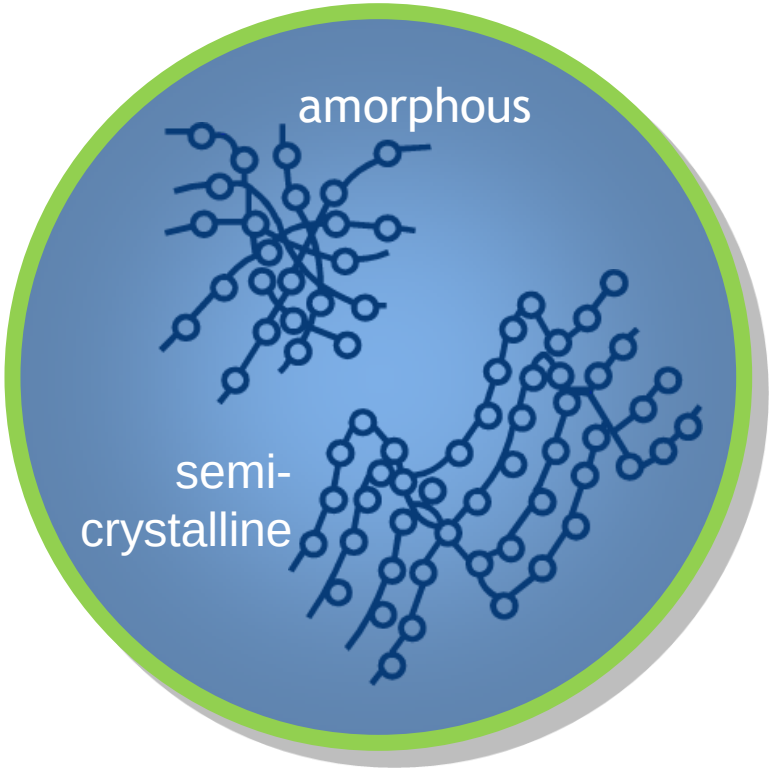
Structure of Thermoplastic Molecules

Amorphous thermoplastics

- Molecules lacking a crystalline structure

Semi-crystalline thermoplastics

- More orderly, geometric molecular structures



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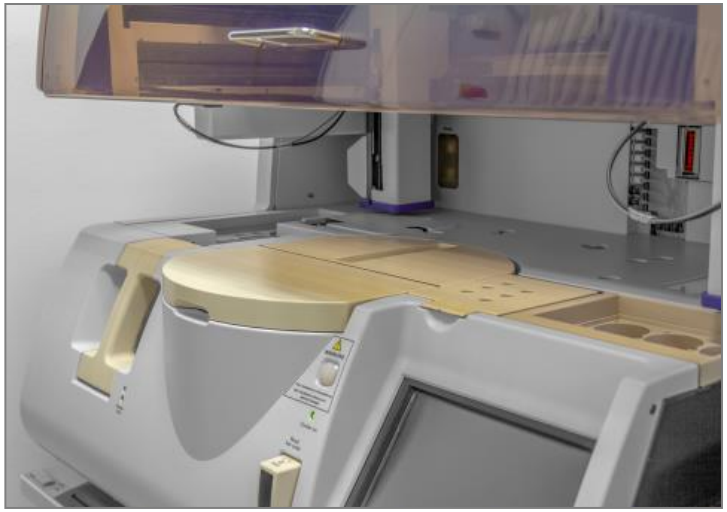
Amorphous Plastics vs. Semicrystalline Plastics

Amorphous thermoplastics

- Easier to thermoform
- Examples: ABS, HIPS, Polycarbonate



Semi-crystalline thermoplastics

- Difficult to thermoform
- Examples: HDPE, PP

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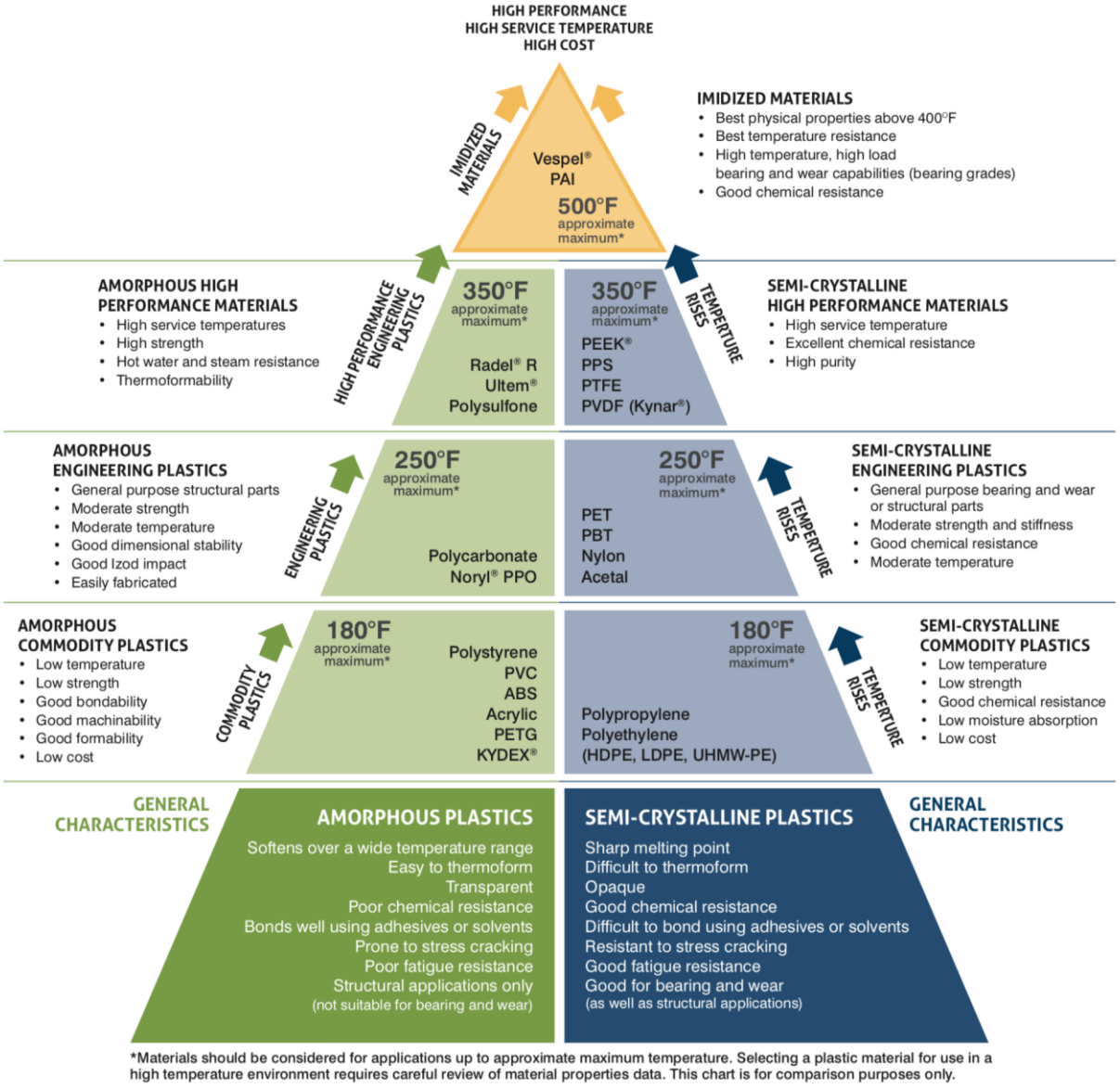
Thermoplastic Triangle



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HDPE

- Semicrystalline, difficult to thermoform
- Inexpensive
- Good chemical resistance
- Difficult to glue or paint
- HMW (high molecular weight) blow molding grades can be thermoformed
- HMW grades have good cold temperature toughness

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Polypropylene

- Semicrystalline, difficult to thermoform
- Inexpensive
- Good chemical resistance
- Difficult to glue or paint
- Available in homopolymer (moderately stiff) and copolymer (flexible and tough) grades
- Can be decorated with transfer paper

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HIPS (High Impact Polystyrene)

- Inexpensive
- Easy to thermoform
- Easy to screen print, glue, and paint
- Low strength, stiffness
- Limited operating temperature range
- Moderate impact strength

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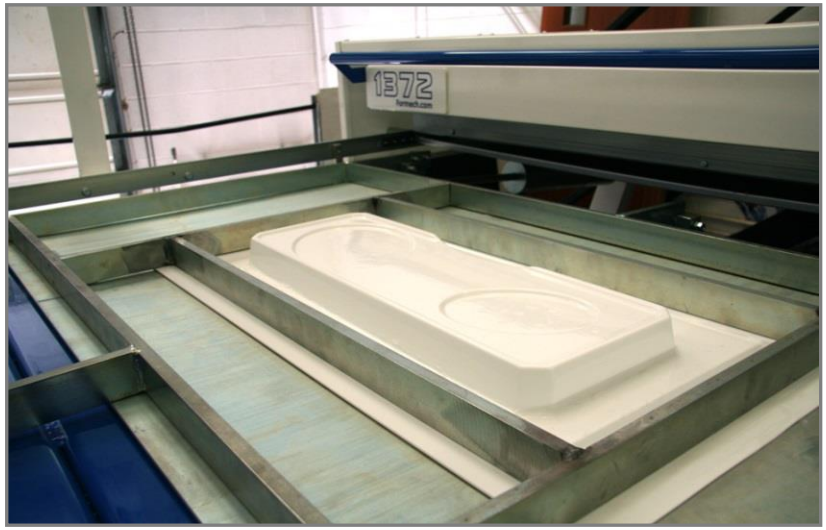
ABS

- Inexpensive
- Easy to thermoform
- Easy to screen print, glue and paint
- Moderate strength and stiffness
- Limited operating temperature range
- Higher impact strength than HIPS but lower than KYDEX® Thermoplastics



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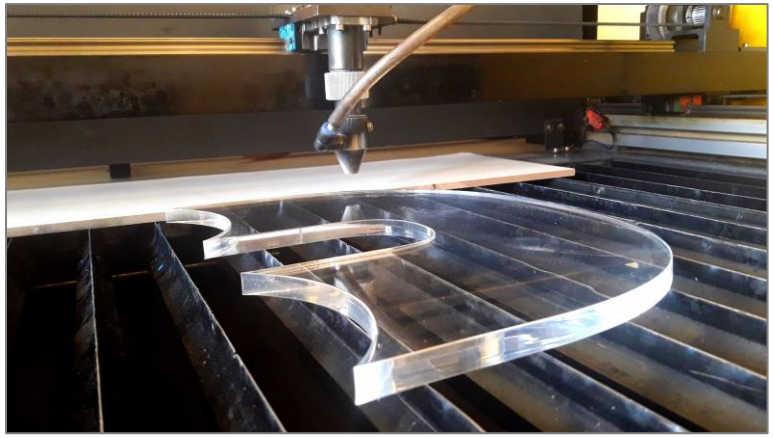
Acrylic – Transparent, brittle

- Optically transparent
- Good UV stability
- LED Light diffusing grades available
- Available in many different colors
- Somewhat brittle



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PETG

- Optically clear
- Poor UV stability
- Great for deep draw parts
- Tougher than acrylic but not as tough as polycarbonate
- Not good for elevated temperature applications
- Generally does not require drying prior to thermoforming

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Polycarbonate – Transparent, tough, prone to ESC

- Optically clear grades available
- LED light diffusing grades available
- Many different colors available
- Higher impact strength and higher operating temperature than acrylic or PETG
- Outdoor grades available
- Prone to environmental stress cracking
- Must be dried prior to thermoforming
- Degrades when exposed to steam

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KYDEX® Thermoplastics

- Typically PVC / acrylic alloys
- Very good thermoforming characteristics
- Tougher than HIPS or ABS
- Available in virtually any color and in many different textures. Low minimums for custom colors.
- Extremely good flammability characteristics (UL grades, aircraft grades, etc.)
- New polycarbonate based grades have higher service temperatures

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Polysulfone

- Higher service temperature than polycarbonate
- Transparent yellow appearance
- Stands up well to steam
- Less expansive than Ultem® or Radel® R

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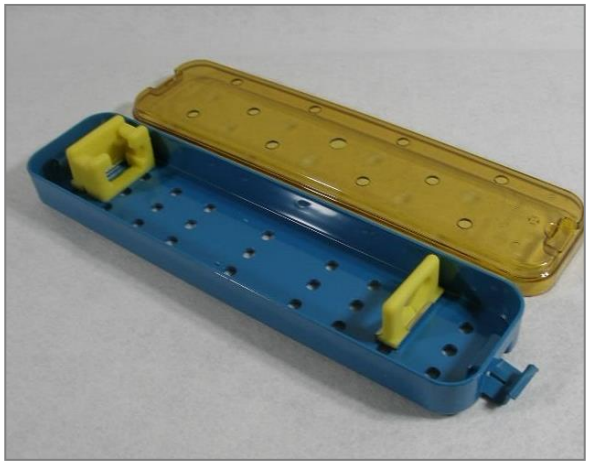
Ultem® PEI

- Higher service temperature than polysulfone
- Very strong and stiff
- Transparent amber appearance
- Stands up well to steam including medical autoclave
- Outstanding electrical properties
- Somewhat brittle



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Radel® R PPSU

- Extremely high service temperature
- Tougher and more durable than polysulfone or Ultem®
- Transparent amber color
- Stands up well to steam including medical autoclave

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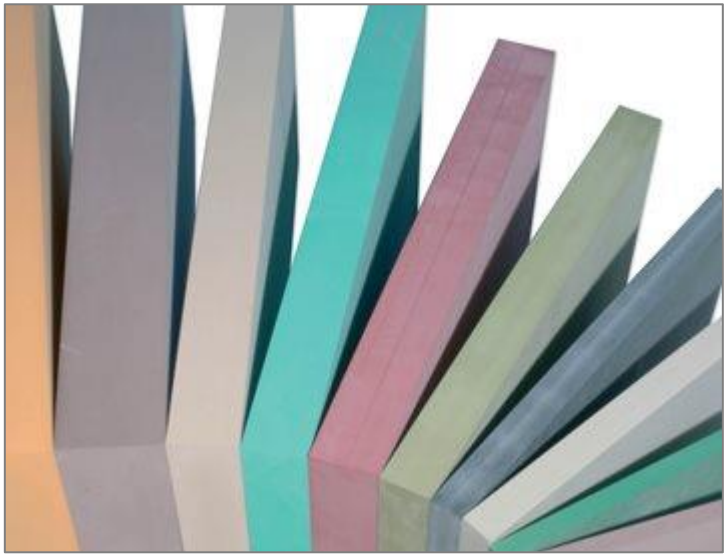
Tooling and Fixturing Materials

- Rigid polyurethane boards
- Some are foam, some are solid
- Grades available that are good for low volume thermoforming tooling and trim fixtures



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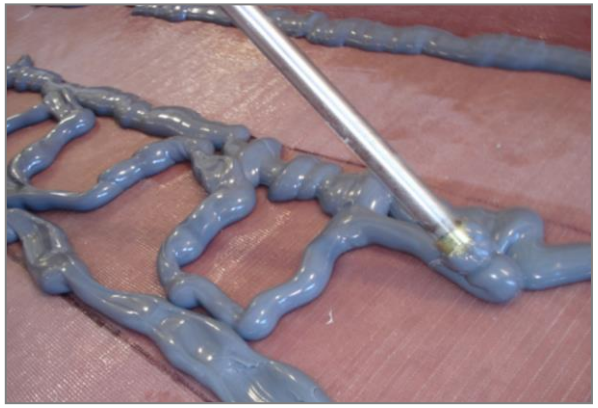
Plexus® Methacrylate Adhesives

- Bonds dissimilar materials
- Gap filling properties
- Can be sanded and painted
- Not greasy
- Available with a wide range of working times



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Plexus® MA 420 FS Adhesive

- Working time of 1 to 2 minutes
- 75% of ultimate strength in 5 to 6 minutes
- Can often be replace mechanical fasteners
- Requires very little surface preparation

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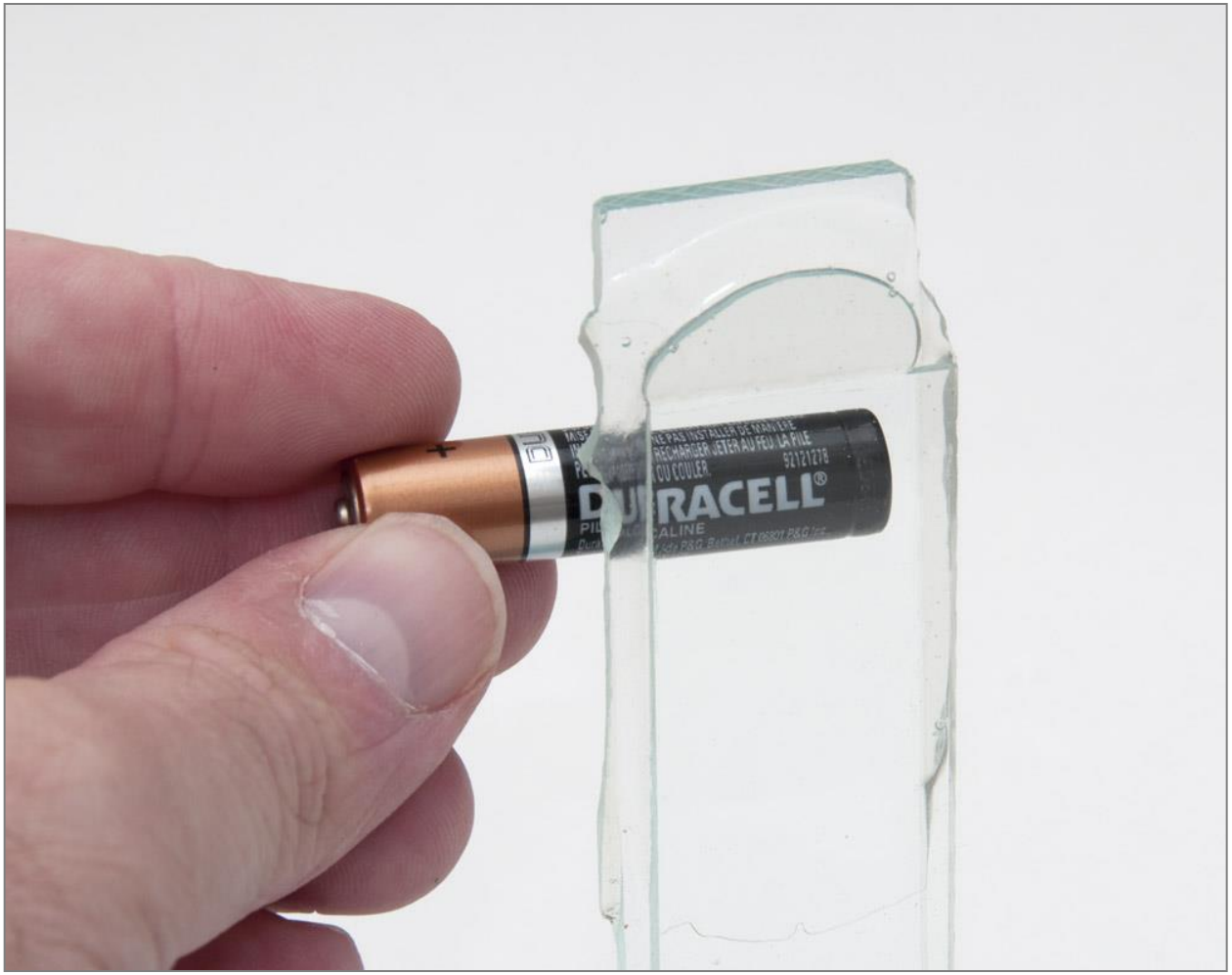
Plexus® MA 685 Optically Clear Adhesive



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