THERMOPLASTIC ELASTOMERS • STRUCTURAL • WEAR
CONDUCTIVE • COLOR • FLAME RETARDANT

New Medical Plastic Technologies

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ISO 9001

Independent Specialty Compounder

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- **Compounder** → We blend thermoplastic resins with fillers, additives, and modifiers
- **Specialty** → We create engineered formulations
- **Independent** → We are unbiased in our selection of raw materials

Agenda

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- Define Compounding
- Plastic Resin Selection Process
- Compounds for Healthcare

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Defining Compounding

Compounding Process

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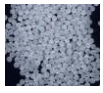
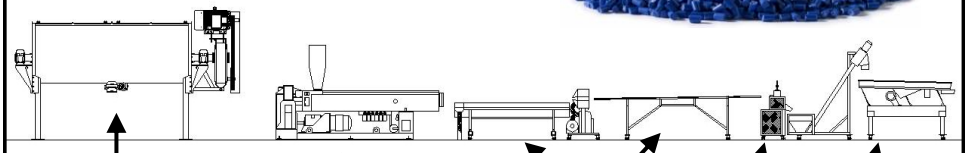
Raw Materials → Finished Product



Compounding Objectives

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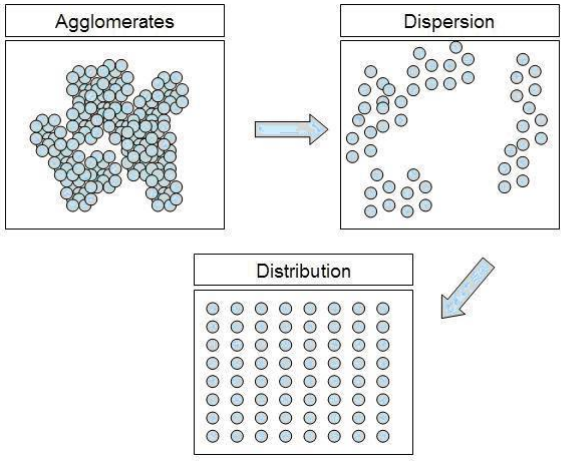
- **Mixing**
  - Dispersive
  - Distributive



Compounding Extruders

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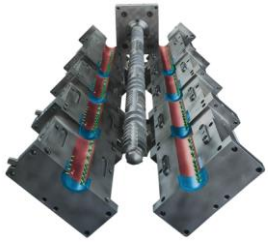

Single Screw | Twin Screw | Co-Kneader

Putting Compounding Into Perspective

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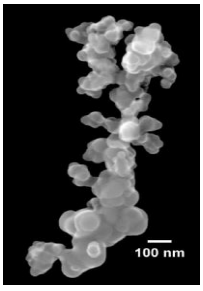

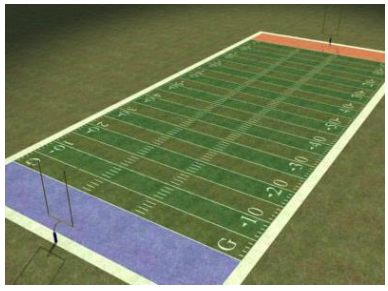

- Conductive carbon black surface area = 130 m^2/gram
- 34 grams carbon black = surface area of football field (4460m^2)
- Dispersing a 20% carbon black compound is similar to evenly coating a football field with 136 grams of plastic!

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Resin Selection

The Dilemma

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- 60 Thermoplastic Resins + 100 Additives = 1000's of Potential Compounds

Which **ONE** Do I Choose For My Application???

Plastic Selection Process

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

Step 1: Use Resin Morphology

Step 2: Use Thermal & Cost Requirements

Step 3: Fine Tune & Special Features

Plastic Selection Process

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

— Step 1: Use Resin Morphology —

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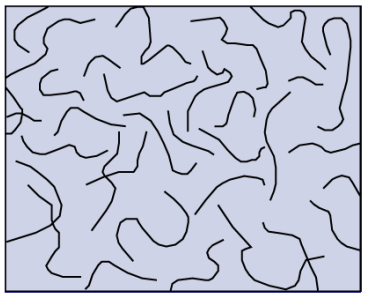
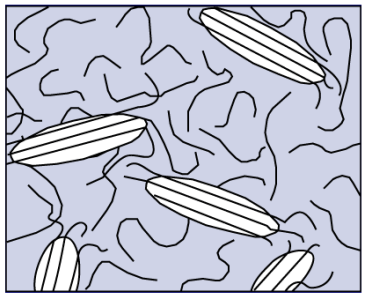
Morphology

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

The form and structure the molecules of a polymer take upon solidification



Amorphous



Semi-Crystalline

Morphology

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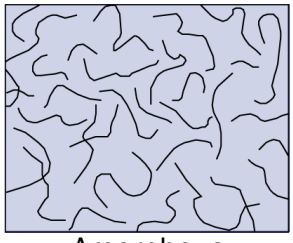
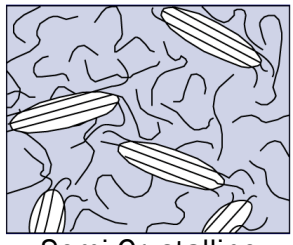


Amorphous



Semi-Crystalline

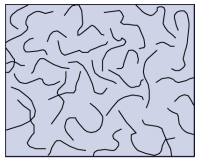
Compare

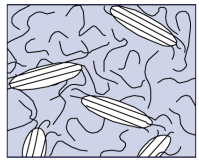
- **Molecular Packing (Shrinkage)**
- **Resistance to Molecular Disentanglement (Chemical/Abrasion Resistance)**
- **Light Refraction (Opacity)**
- **Melting Characteristics (Flow)**

Morphology Characteristics

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

	Amorphous	Semi-Crystalline
Low Shrinkage	✠	
Low Warpage	✠	
Tight Tolerances	✠	
Transparency	✠	
Mold Flow Ease		✠
Chemical Resistance		✠
Wear Resistance		✠





Morphology Characteristics

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	Amorphous	Semi-Crystalline
Low Shrinkage	✠	
Low Warpage	✠	
Tight Tolerances	✠	
Transparency	✠	
Mold Flow Ease		✠
Chemical Resistance		✠
Wear Resistance		✠

- Lens?
- Fuel Float?
- Lamp Housing?
- Tool Housing?
- Pulley?
- Precision Printer Chassis?
- Intake Manifold?
- Grease Fitting?
- Laptop Cover?

Morphology Of Thermoplastics

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Amorphous	Semi-Crystalline
Polyetherimide (PEI)	Polyetheretherketone (PEEK)
Polyethersulfone (PES)	Polyphenylene Sulfide (PPS)
Polysulfone (PSU)	Polyphthalamide (PPA)
Amorphous Nylon	Polyamide (PA/Nylons)
Polycarbonate (PC)	Polyethylene Terephthalate (PET)
Acrylonitrile Butadiene Styrene (ABS)	Polybutylene Terephthalate (PBT)
Styrene Acrylonitrile (SAN)	Acetal (POM)
Polystyrene (PS)	Polylactic Acid (PLA)
High Impact Polystyrene (HIPS)	Polypropylene (PP)
Acrylic (PMMA)	Polyethylene (HDPE, LDPE, LLDPE)

Plastic Selection Process

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

Step 1: Use Resin Morphology

Step 2: Use Thermal & Cost Requirements

Step 3: Fine Tune & Special Features

Morphology Vs Thermal/Cost

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

Amorphous	Semi-Crystalline
Polyetherimide (PEI)	Polyetheretherketone (PEEK)
Polyethersulfone (PES)	Polyphenylene Sulfide (PPS)
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Polystyrene (PS)	Polylactic Acid (PLA)
High Impact Polystyrene (HIPS)	Polypropylene (PP)
Acrylic (PMMA)	Polyethylene (HDPE, LDPE, LLDPE)

Thermal & Cost Increases

Commodity (<$1.50) • Engineered ($1.50-$4.00) • High Performance (>$4.00)

Plastic Selection Process

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

Step 1: Use Resin Morphology

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Plastic Selection Process

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

Compare:

- **PC**
  - Impact
- **Nylon**
  - Strength, fuel resistance
- **Acetal**
  - Wear and friction

Vs.:

- **PMMA**
  - Cost, UV
- **PP**
  - Cost, stable properties
- **Nylon**
  - Wear and friction + mechanical properties

PEI Replacement

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- **Topic of the day: PEI Replacement**
  - Tight supply
  - Long lead times
  - One supplier

- **Several alternatives, none are one-to-one replacements**

PEI Replacement

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- **Which resin depends on:**
  - Temperature performance
  - Mechanical properties
  - Chemical resistance

PEI Replacement

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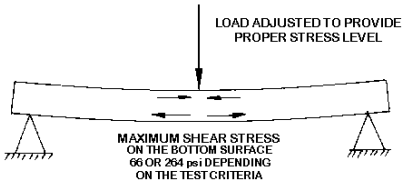
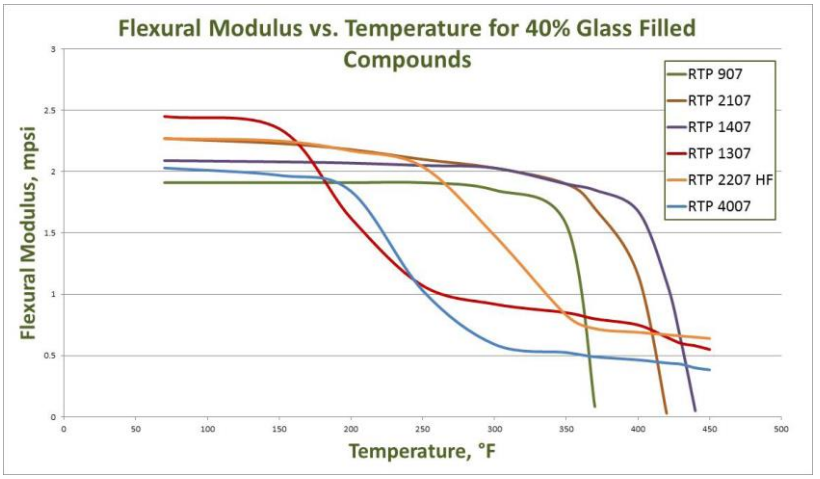
Temperature Properties

HDT @ 264psi	Unfilled	30 glass
Amorphous		
PEI	392 F	405 F
PPSU	405	415
PES	398	420
PSU	345	365
Semicrystalline		
PPS	N/A	510
PPA	280	500
PEEK	313	600



HDT can be improved through compounding fillers.
Also need to understand peak and continuous temperatures to select the right product.

Mechanical Properties



PEI Replacement
YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

Chemical resistance

- PEI has good chemical resistance for an amorphous resin
- Semi-crystalline generally offers improvement
- Need to consider:
  - Chemical type and concentration
  - Frequency of contact
  - Duration of contact
  - Temperature during contact

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Compounds for Healthcare

Application Requirements

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- **Environmental requirements**
  - *What conditions must the material survive?*
  - *What must survive around the material?*
- **Property requirements**
  - *What other properties does the material bring to the table?*

"Typical" vs. "Medical"

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Environmental Requirements

Environmental Exposure

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- **Typical requirements, resistance to:**
  - Chemicals
  - Temperature
  - Humidity
- **Medical requirements**
  - Sterilization
  - Tissue/Fluid contact
  - Drug flow path

Sterilization

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- **Radiation**
  - Gamma
  - E-beam
- **Damages polymers via chain scission or crosslinking**
- **Cumulative damage**

Sterilization

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- **Radiation resistant**
  - ABS
  - Sulfones (PSUL, PES, PPSU)
  - PC
    - Typically yellows with radiation exposure
    - Maintains mechanical properties
  - Polypropylene
    - Requires stabilization to survive multiple exposures
- **Not resistant**
  - Polyethylene
  - POM (Acetal)

Sterilization

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- **Ethylene Oxide (EtO)**
  - Toxic gas
  - Polymers require chemical resistance
  - Most polymers OK for use with EtO
  - Some ABS grades exhibit stress cracking

Sterilization

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- **Steam (Autoclave)**
- **Commonly used in healthcare facilities**
- **Temps from 120ºC to 135ºC with humidity exposure**
- **Exposure time from 3 to 15 minutes**
- **Stress relaxation (annealing) can occur**

Sterilization

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

Resistance to autoclave

- **Best**
  - PEEK
  - PPSU
- **Good**
  - PP
  - PA
  - PSUL
  - PC

Not recommended for autoclave

- Styrenics
  - ABS
  - Polystyrene
- Polyesters
  - PBT
  - PET

- **Materials with poor resistance to heat/humidity**

Internal Fluid/Tissue Contact

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- **Suitability often determined by biocompatibility testing**
  - ISO 10993
  - USP Class VI
- **Testing best performed on part, not just material**
- **Specialty medical compounder material selection:**
  - Biocompatible resins
  - FDA compliant additives

Formulating for Body Contact

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- **Resins**
  - ISO 10993
  - USP Class VI
- **Fillers/additives**
  - FDA Compliant
  - Have history of passing previous bio tests
- **"No Subs" formulation**

Drug Flow Path

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- **Biocompatibility**
- **Chemical resistance of polymer**
  - Resist degradation from drug exposure
- **Drug potency**
  - Extractables
  - Material-drug interaction

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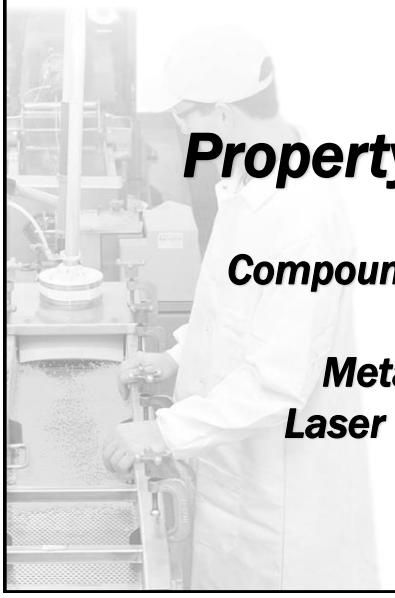

Property Requirements

Compounding in Performance
Focus:
Metal Replacement
Laser Direct Structuring

Metal Replacement

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- **Generally focused on fiber reinforced compounds**

- ***Questions to ask:***
  - Might the metal part be overspecified?
  - Are there secondary operations that can be eliminated with a switch to plastic?
  - Could performance be enhanced with a switch to plastic?

Surgical Head Restraint

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

Application: Surgical Head Restraint System

Problem: MR/CT scans unrecognizable due to magnetic material.

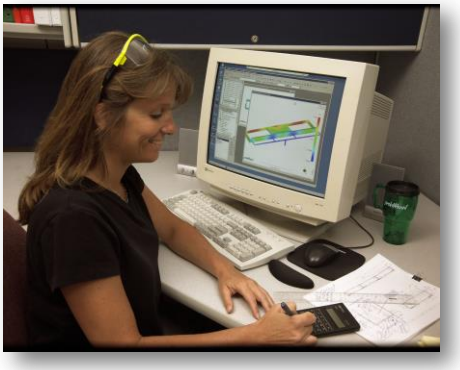
Material: Titanium

Solution: PEEK reinforced with carbon fiber.

Metal Replacement

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- **Items to note:**
  - Consult with plastics experts on proper plastic design principles.
  - Consider mold design and gating as carefully as part design and material selection.



Orientation Effects

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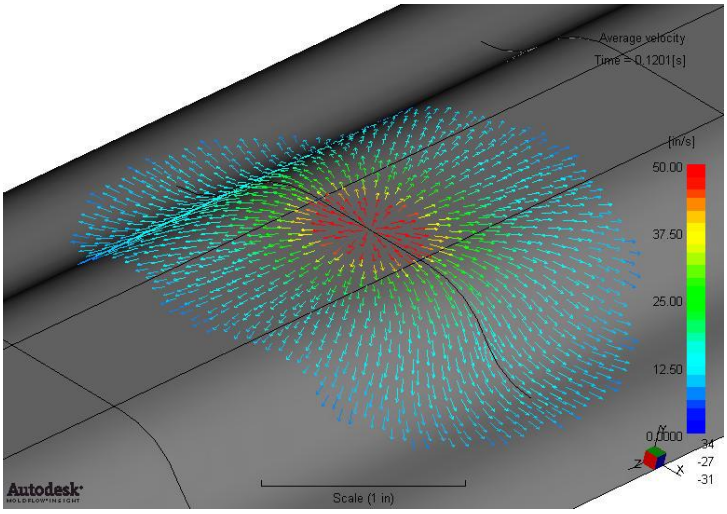

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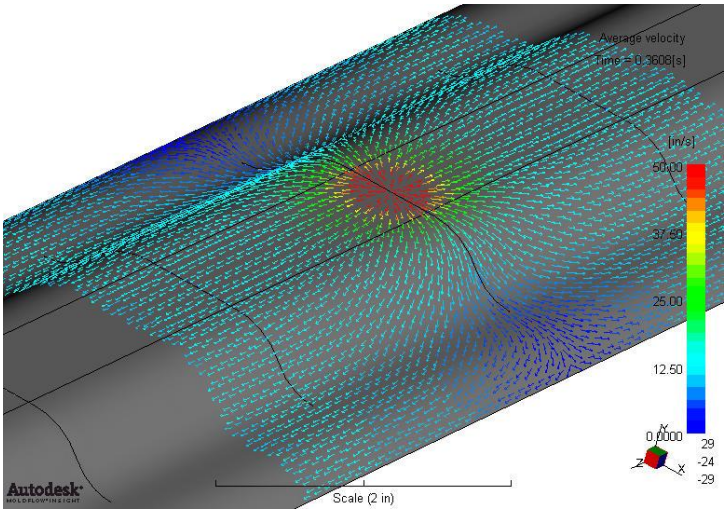

Surgery Drill Guide

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

Application:

Surgery Drill Guide

Problem:

Needed a disposable product at a disposable price.

Material:

Metal

Solution:

Glass fiber reinforced PC

Conductivity

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- **Covering three main areas:**
  - Static dissipation
  - Conducting current
  - EMI/RFI shielding

Selective Plating Laser Direct Structuring

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

Advantages

- Specialized formulations
- Limited number of platers/lasers
- Standard single shot tooling
- Great design flexibility

LPKF®
Laser & Electronics

LDS Process

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Additive Process

Selective metallization of thermoplastic injection molded parts by Laser Direct Structuring

3 Step Process

1. Injection molding
2. Laser activation
3. Selective metallization

Overview of LDS Technology

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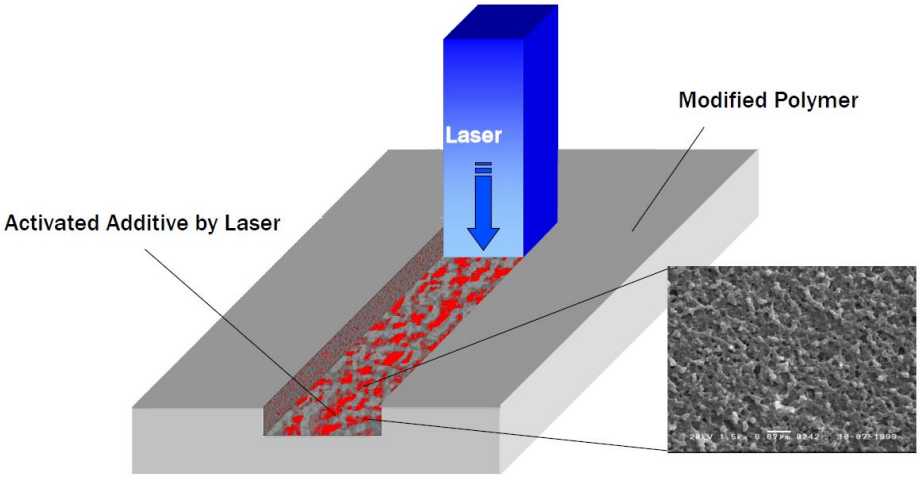
Generation of a micro-etched surface



Applications

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- Connectors
- Sensors
- Antennas for handheld devices
  - Phones
  - Cameras
  - GPS
- Security Covers
- Various components for part consolidation

Materials Available

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- PC
- ABS
- PC/ABS
- Nylon 6/6 with glass and mineral
- LCP with glass and mineral
- PPA with glass and mineral
- PEI with glass and mineral