PolymerPlus LLC

Multilayered services and products

PolymerPlus Coextrusion Line

Technologies
- Gradient Refractive Index Optics
- Multilayered Dielectric Films
- Fiber/Filter Media
- Gradient Films
- Reflective Films
- Barrier Films
- Thermoforming
- Lamination
- Mechanical Improvement

Micro- and Nanolayer Coextrusion

MULTIPLIER

2 Layers → 4 Layers → Up to 4096 Layers

Continuous layer multiplication, towards thousands of Layers and unique properties
Gradient Refractive Index (GRIN) Optics

- Key technology breakthrough for lightweight, high resolution optics: large scale processing of nanolayered polymer films with a single, compositionally dependent refractive index
- Enabling large GRIN optics (50 mm +)
- Through a series of stacking and thermoforming steps, PolymerPlus can create optics with a wide variety of refractive index distributions.
- On site manufacturing and metrology processes

<table>
<thead>
<tr>
<th>GRIN Advantages</th>
<th>GRIN Optics Prototypes</th>
<th>Refractive Index Profiles of GRIN Sheets</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Chromatic aberration correction</td>
<td>Night Vision Goggle eyepiece</td>
<td>High n</td>
</tr>
<tr>
<td>• Spherical aberration correction</td>
<td></td>
<td>Low n</td>
</tr>
<tr>
<td>• Lightweight optics</td>
<td>Glass</td>
<td></td>
</tr>
<tr>
<td>• Compact optical systems</td>
<td>GRIN offers compact optical design</td>
<td></td>
</tr>
<tr>
<td>• Improved light collection</td>
<td>• GRIN System: 2 GRIN + 1 glass lens</td>
<td></td>
</tr>
</tbody>
</table>

GRIN Manufacturing Process

1. Nanolayered Films
2. Film Stack
3. GRIN Sheet
4. GRIN Lens

- GRIN offers a 3.5x volume reduction and a 7.5x weight reduction over current commercial product

PVS 14 Eyepiece

- 24% weight reduction using GRIN lenses

- Design flexibility
- Custom refractive index profile possible
### Multilayered Dielectric Films
- High energy density multilayered films – up to 13 J/cc
- Combination of high dielectric constant and high breakdown strength polymers
- High temperature usage (140 °C)
- Compact capacitors - Up to 50% size reduction, weight reduction
- Film production via continuous coextrusion process

### Fiber Filter Media
- Multilayered films with thousands of layers
- Micro- and nano-scale fibers by melt processing
- Solvent-free processing
- Composite fibers and media

### Reflective Films
- Structural colors through layered interference
- No pigments required
- Tunable colors in visible wavelength range

### Gradient Films
- Up to 10X gradient in film thickness and custom gradient distributions
- Applications in optical filters & controlled transport or diffusion

### Mechanical Improvement
- Improved mechanical properties via layering
- Stronger, tougher and thinner films using thermoplastics
- Oriented blends via layering
- Compatibilizing dissimilar materials
- Improving layer adhesion

### Barrier Films
- Improved film barrier properties by controlled crystallization
- Up to 100 times improvement in the barrier properties

### Lamination
- Vacuum thermoformer lamination of various substrates
- Substrates - glass, carbon fiber, metal, wood, etc.

### Thermoforming
- Composite polymer sheets & parts
Research & Development Services

General Polymer Science
- Structure-property analysis, crystallization and thermal analysis
- Polymer interactions, miscibility, interphase materials, blends

Polymer Processing Capabilities:
- Micro- and nanolayer film processing, single screw/twin screw blending, compression molding, thermoforming

Material Testing
- Mechanical: tensile/flexural, failure, impact testing
- Transport: O₂ and H₂O permeation, controlled release
- Thermal: DSC and TGA
- Electrical: energy storage, breakdown, hysteresis
- Optical microscopy, atomic force microscopy, scanning electron microscopy

Optical Characterization: Transmission / reflectance, dispersion, interferometry and profilometry, refractive index, birefringence measurements

Scale-up and Commercialization of R&D work
- Transition R&D technology to commercial application
- Prototype fabrication
- Scale-up and supply chain development

Multilayered Films Examples

Individually Layers = 8μm

Various Film Structure Possibilities

Polymer A
Polymer B
Polymer A
Tie
Polymer B
Tie
Polymer A
Skin Layer
Polymer A
Polymer B
Polymer C
Skin Layer

Development Models

Contract Research Services
Lab Scale Coextrusion Trials
Joint Development Projects
Pilot Scale Coextrusion Trials
Material Testing & Characterization

www.polymerplus.net
info@polymerplus.net
216-264-4818