

## Crystal orientation on a substrate : a new route towards toughness?

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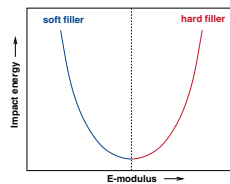
providing details and we will investigate your claim.

## /Introduction

Most semi-crystalline polymers are ductile, but start to behave brittle under severe conditions: high deformation rate and low temperature. It is known that the impact toughness of semi-crystalline polymers can both be increased by addition of rubber particles as well as certain hard filler particles.

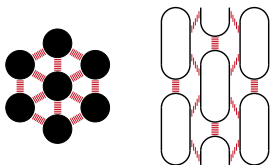
Advantage of system with **hard filler** compared to **rubber filler**:

- Increased stiffness
- No influence  $T_g$  rubber phase



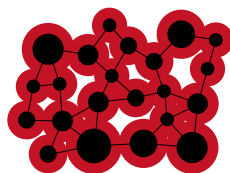
## Toughening mechanism

Recently a toughening mechanism for these heterogeneous semi-crystalline polymer systems was postulated by A.S. Argon (MIT) [1-3]. It is based on the idea that an **interface** is formed around the inclusions (rubber or hard filler), which consists of preferentially **oriented crystalline lamellae**, having a reduced plastic shear resistance in the crystal planes parallel to the filler surface.



Upon cavitation or debonding of particles  
→ large shear deformation of ligaments between particles

If oriented lamellae bridge between particles  
→ low shear resistance behaviour percolates throughout structure and toughness is enhanced.



## Objective

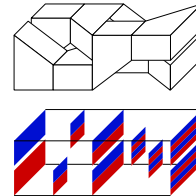
The goal is to verify this toughening mechanism. The first step is to find the existence and mechanical behaviour of this anisotropic crystal oriented layer.

## /Materials and Methods

Using a multiflux static mixer sub-micron multi layer systems can be made consisting of alternating layers of a semi-crystalline polymer (HDPE) and a substrate polymer (SEBS & SBS):

## /References:

- [1] MURATOGLU, O.K., ARGON, A.S., COHEN, R.E. AND WEINBERG, M. *Polymer*, vol. 36, p921-930, 1995.
- [2] BARTCZAK, Z., ARGON, A.S., COHEN, R.E. AND WEINBERG, M. *Polymer*, vol. 40, p2331-2346, 1999.
- [3] BARTCZAK, Z., ARGON, A.S., COHEN, R.E. AND WEINBERG, M. *Polymer*, vol. 40, p2347-2365, 1999.

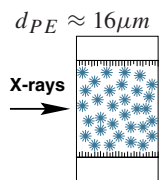
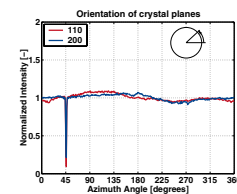
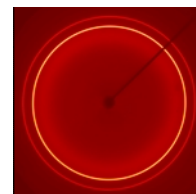


5 to 10 mixing elements  
↓  
64 to 2048 layers  
↓  
Layer thickness: 16  $\mu\text{m}$  to 0.2  $\mu\text{m}$

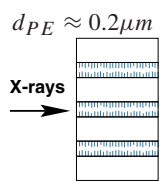
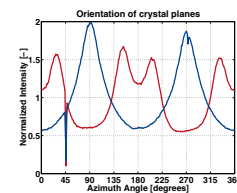
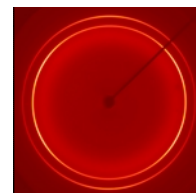
The crystal orientation was investigated by X-ray diffraction and Transmission Electron Microscopy.

## /Results

Wide Angle X-ray Diffraction patterns:

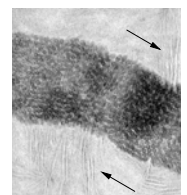


- Thick HDPE layers show no crystal orientation  
→ isotropic spherulites



- Thin HDPE layers show orientation of the 200 ( $\parallel$  to surface) and 110 ( $\pm 30^\circ$  to 200) crystal planes  
→ lamellae  $\perp$  to surface

TEM confirms lamellae orientation in HDPE near the substrate.



**Conclusion:** So far the results support the postulated toughening mechanism.

## /Future Work

- Determine thickness of crystal oriented layer more accurate
- Exploitation towards other materials
- Determine mechanical behaviour of anisotropic crystalline layer