Nucleation induced by elongational flow

Nucleation Induced by Elongational Flow

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Introduction

Crystallization of semi-crystalline polymers can be enhanced strongly by chain orientation during melt flow. Elongational components may cause extraordinary large molecular orientations, specially for molecules from the high end-tail molecular-weight distribution. They act as nuclei during crystallization, since relaxation time of these molecules is very large.

Objectives

- determine the influence of deformation history on crystallization kinetics
- develop/extend crystallization models that incorporate the influence of deformation history

Cross Slot Flow Cell

A stagnation flow with a strong elongational component is created by moving a ring with two cams, using a motor. Temperature history in the flow cell is controlled by three oil-baths.

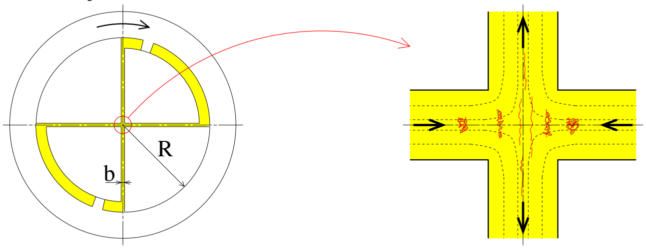

Figure 1: *Left: Cross slot flow cell (R = 50 [mm]; b = 2 [mm]). Right: Enlarged detail around the stagnation point. Red lines illustrate the stretching of polymer chains in the hyperbolic flow field.*

Material and Methods

Wide Angle X-ray Diffraction (WAXD) measurements were performed at the micro-focus beam line of the ESRF (Grenoble, France) on iPP (DSM StamylanP 13E10; M_w = 501 [kg/mol] and M_w/M_n = 6.0 [-]) at the stagnation point of the cross slot, using a beam size of about 10 [μm].

Experimental Conditions

- annealing for 60 minutes at 220 [^{o}C] to erase crystal and flow memory
- cooling to 148.4 [^{o}C]
- creating flow ($\dot{\gamma} \approx 0.08$ [s^{-1}])
- following isothermal crystallization by WAXD

Results

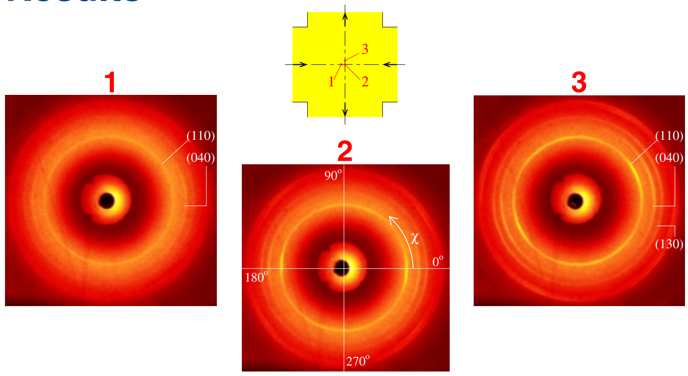

Figure 2: *2D WAXD patterns around the stagnation point.*

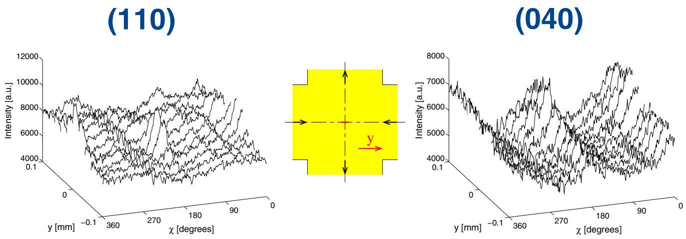

Figure 3: *WAXD intensity vs orientation angle and distance from the stagnation point on inflow center line.*

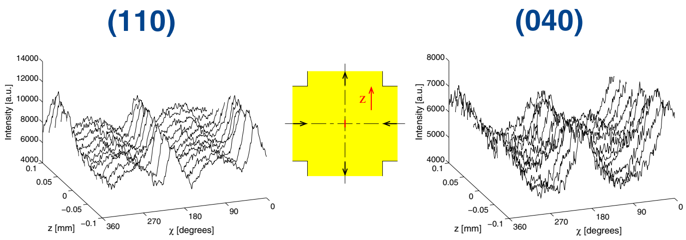

Figure 4: *WAXD intensity vs orientation angle and distance from the stagnation point on outflow center line.*

Conclusions

- Close to the stagnation point orientation is found in both (110) and (040) reflections, parallel to outflow direction.
- The area in which this structure can be found is about 80 [μm] in inflow and at least 0.2 [mm] in outflow direction.
- This area correlates with the first normal stress difference.

Acknowledgement

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