Spatio-temporal dynamics of long chain branched polyethylenes during extrusion flow

Overview
Extrusion is one of the most common means of plastics processing, accounting for ca. 35% out of worldwide annual production of approx. 280 x 106 tons (Source: Plastics Europe, 2014). This makes it the most important single polymer processing operation for the industry and can be found in a variety of forms in many manufacturing operations. A major throughput limiting factor of extrusion operations is the onset of instabilities during extrusion. These instabilities represent surface and volume distortions of the extrudate that can significantly affect the mechanical performance and appearance of the final products. But the most fascinating feature of extrusion instabilities is their dependence on the melts’ molecular properties. Understanding the functional, i.e. dependence in the most general sense, between the characteristics of the flow transition sequences and the materials’ molecular properties is of paramount importance for understanding how to tune the materials’ molecular design to a desired processing flow behavior.

Project summary
The master project’s main task is to set up a new ex-situ inline optical visualization setup for monitoring and analysis of the onset and development of polymer melt extrusion instabilities. This includes: (i) integrating the visualization setup in the extrusion system for optimal visualization quality, (ii) set up remote acquisition and data processing and (iii) apply spatio-temporal imaging. The test materials are provided by Basell Polyolefine GmbH, Frankfurt, Germany, and include several branched architectures of varying molecular properties (low density polyethylenes). The final goal is to determine the spatio-temporal dynamics during the transitions sequences using controlled dynamical history experimental protocols for the various branched molecular architectures and interpret the data in the framework of basic stability theories.

(a) Schematic overview of the experimental setup. (b) Several of the instabilities observed during the extrusion flow of polymer melts: selected distinct patterns observed for a linear low density polyethylene (LLDPE), low density polyethylene (LDPE), high density polyethylene (HDPE) and a medium density polyethylene (MDPE).