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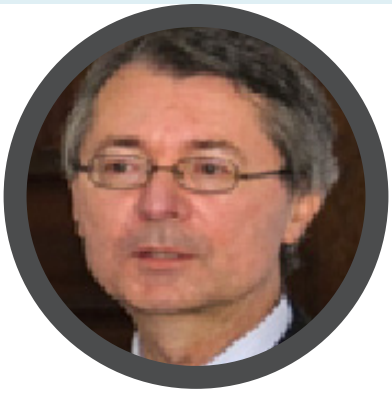
NANO-SCALE THERMODYNAMIC PROPERTIES OF POLYMERS DOMINATING THEIR SOLIDIFICATION BEHAVIOUR DURING PROCESSING



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Phase transitions, like crystallization, are severely dependent on the so-called nucleation process, which describes the first occurrence of entities of the new phase as primary spots for some further growth process. These processes are usually strong functions of the processing conditions, as there are (local) temperature, pressure and even the deformation history as important in shear induced crystallization during processing. For a better understanding of nucleation processes, which usually start at a nanoscopic scale, it turns out, that the introduction of additional thermodynamic properties is of big importance. Already in the early 19th century a quite general description of basic geometric properties of systems with interfaces has been found. This includes the four so-called Minkowski functionals, which are: volume, interfacial area, mean curvature integral over the interfacial area, and the Euler-Poincaré characteristics. The latter two quantities, which become of importance on small scales, have been ignored so far in natural and technical sciences, however. In equilibrium thermodynamics the simple assumption of linear coefficients for the work differential in terms of the differential change of the four Minkowski functionals leads (in addition to pressure and interfacial tension) to two novel energetic properties: edge force and item energy. They dominate the behaviour at structural scales in the nanometer range. The classical Young-Laplace equation stating the proportionality of the pressure jump across an interface and the mean curvature of the interface (with twice the interfacial tension as proportionality constant) can be easily extended using a second term proportional to the Gaussian curvature of the interface, with the edge force as proportionality constant. As an important consequence, one has in polymer melts already at temperatures above the thermodynamic melting temperature stable clusters, which, however, are unable to grow. A simple relationship is obtained for the temperature of homogenous nucleation in terms of the edge force.

Biography

Gerhard Eder is Professor at the Institute of Polymer Science, Johannes Kepler University Linz, Austria. He got his Diploma in Mathematics and Physics in 1982 and 1983 and finished his PhD in 1989 with a thesis in Rheology of Polymer Melts. In 1989/90 he was research scientist at the Philips Natuurkundig Laboratorium in Eindhoven, The Netherlands. Since 1997, he is an Associate Professor at Johannes Kepler University. In 2002 he was Visiting Professor in Yamagata University, Japan. He gave more than 20 invited lectures at international conferences. In 2013, he received the Hermann Mark Medal for his work on polymer characterization. His research interests have their focus on Structure Development of Polymers as Present in Usual Processing, a research field situated between and strongly interacting with the classical transport phenomena: Heat Transfer, Flow Dynamics and Mass Diffusion. Recently his interest widened towards Thermodynamics of Phase Transitions and Kinetic Modelling.

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