Theory and simulation of texture formation in mesophase carbon fibers

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Abstract

Carbonaceous mesophase precursors are spun into high-performance commercial carbon fibers using the standard melt spinning process. The spinning process produces a wide range of cross-sectional fiber textures whose origins are not currently well understood. The planar polar (PP) and planar radial (PR) textures are two frequently observed textures. This paper presents theory and simulations of the elasticity-driven formation process of the PP texture using the classical Landau–de Gennes mesoscopic theory for discotic liquid crystals, including defect nucleation, defect migration, and overall texture geometry. The main characteristic of the real PP texture is the presence of a pair of defects equidistant from the fiber axis. In this research it is analytically and numerically found that, under elastic isotropy, the ratio of the equilibrium defect–defect separation distance to the fiber diameter is always equal to $1/\sqrt[4]{5}$. The computed PP and PR textures phase diagram, given in terms of temperature and fiber radius, is used to establish the processing conditions and geometric factors that lead to the selection of these two textures.

Keywords: A. Carbon fibers, Mesophase pitch; C. Modeling