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Laser-Interferometric Creep Rate Spectroscopy of Polymers

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Abstract Laser-interferometric creep rate meter (LICRM) and creep rate spectroscopy (CRS), as an original high-resolution method for discrete relaxation spectrometry and thermal analysis, were developed in the authors' Materials Dynamics Laboratory at Ioffe Physical-Technical Institute of the Russian Academy of Sciences (Saint-Petersburg). In the last few decades they have been successfully applied to solving various problems of polymer physics and materials science, especially being combined with DSC, structural, and other techniques. CRS involves measuring ultra-precisely a creep rate at small tensile or compressive stress, typically much lower than the yield stress, as a function of temperature, over the range from 100 to 800 K. LICRM setup allows one to register precisely creep rates on the basis of deformation increment of 150–300 nm. The survey describes this method and summarizes the results of numerous studies performed with the LICRM setup and CRS technique for different bulk polymeric materials, films, or thin fibers. This approach provided new experimental possibilities superior in resolution and sensitivity compared to the conventional relaxation spectrometry techniques. Among such possibilities are discrete analysis of dynamics; creep on submicro-, micro- and meso-scales; revealing relations between stepwise microplasticity and morphology; kinetic information on creep at any temperature and deformation; polymer dynamics at interfaces; analysis of microplasticity, relaxations, and phase transitions in brittle materials; using creep rate spectra for non-destructive prediction of temperature anomalies in mechanical behavior of materials, etc. Considerable attention has been paid to combined CRS/DSC analysis of the peculiarities of segmental dynamics, nanoscale dynamic, and compositional heterogeneity in different kinds of complex polymer systems and nanocomposites.

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