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ANISOTROPIC THERMAL DIFFUSIVITY OF THIN POLYMER FILMS: DETERMINATION WITH A LASER SCANNING MICROSCOPE

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The heat conductivity of polymer materials is known to be anisotropic if a preferential direction exists for the orientation of the polymer chains, in special if polymer films are stretched. To perform measurements of the thermal diffusivity tensor components parallel to the surface of thin films a new procedure has been developed, which is based on the use of a laser scanning microscope. In a distinct surface region of the film under investigation, a thin film resistive thermometer is prepared by evaporation. The sample is locally heated by the absorption of an intensity modulated laser beam, generating a thermal wave. This thermal wave spreads over the polymer film and is detected at the thermometer. While the laser spot is scanned over the sample surface, amplitude and phase of the signal from the thermometer are recorded as a function of the spot position. The anisotropic thermal diffusivity is directly accessible from the recorded phase. The method is applied to monoaxial and biaxial stretched films of polyvinylidenefluoride (PVDF).

Keywords: Thermal diffusivity, polymers, films, anisotropy, measuring methods.

1. INTRODUCTION

Stimulated by a wide area of new applications, methods for the thermal characterization of polymer films have found growing interest in recent years. One example is the use of pyroelectric polymers in integrated detector arrays. In this kind of sensors for thermal radiation, a pyroelectric layer is mounted on the upper surface of an integrated circuit.[1,2] The propagation of heat in the pyroelectric layer is of substantial importance for the sensor performance. The heat flow perpendicular to the surface of the film to the silicon substrate is essential for the sensitivity, the heat flow parallel to the surface for the thermal crosstalk.

The heat conductivity of oriented polymers is known to be anisotropic. If a polymer is drawn, the molecular chains are oriented. This fact increases the heat conductivity in the drawing direction and therefore the thermal anisotropy.[3] The complete thermal characterization of a drawn polymer film requires the measurement of the heat conductivity perpendicular to the surface and in two directions parallel to it. To perform a measurement of the thermal diffusivity, the heat loss to the surroundings must be kept small with respect to the heat flow in the specimen. Radiation loss from the sample surfaces can not be avoided and can in particular then play a part, if the temperature is not very low. Therefore, thermal diffusivity measurements are then a nontrivial task, if the thermal diffusivity of the film is small, if the sample is a thin plate or film, if the direction of interest is parallel to the surface, and if the measurements are performed at not very low temperatures.