THERMAL DIFFUSIVITY MEASUREMENT OF POLYETHYLENE MELT BY A NEW TEMPERATURE WAVE METHOD

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Thermal diffusivity of high density polyethylene (PE) has been measured by a new a. c. Joule-heating method. The diffusivity was determined at various temperatures between room temperature and above melting point in heating and cooling processes. This method is based on the phase shift of temperature waves across film sample, so that it offers several advantages, e.g., easy measuring in polymer melts.

Keywords: high density polyethylene, temperature wave method

Introduction

Thermal diffusivity is generally used to measure than thermal conductivity in measurement period and simplicity of instruments. Some non-steady state methods have been suggested for measuring thermal diffusivity. We propose a new simple method for thermal diffusivity measurement which is based on the ac Joule heating at the front surface of polymer thin film and the observation of the temperature oscillation at the rear surface [1].

In this report, temperature dependence of thermal diffusivities for high density polyethylene was measured in the temperature range from room temperature to above melting point under stepwise heating and cooling process. Furthermore, the influence of crystallinity was also investigated.
Experimental

A commercial high density polyethylene, Showa-denko Sholex F7150, was used as sample for this measurement. Film-shaped samples were prepared from the pellets by melt hot press, and then quenched in cool water. A 50 µm thick film of sample was cut into 10 mm-10 mm and gold thin layers were sputtered on both surfaces across an area 3 mm-6 mm as shown in Fig. 1.

These layers on the front and the rear surfaces were used for a heater occurring thermal wave by Joule heating and a sensor detecting the temperature wave, respectively. Electrical resistance of the gold layers was controlled at approximately 50 Ohm. Copper lead wires were attached to both faces of the each gold layers. To avoid the deformation of shrinkage or melting, samples were mounted between two thin glass plates which were bonded in place by an epoxide resin.

The frequency of the temperature wave varies twice higher than that of applied voltage. Thermal wave was diffusing across the sample for vertical direction to the rear surface. The temperature variations on the rear surface were detected by the gold layer sensor as resistance variation which was analyzed using a NF type 5620 lock-in amplifier.

The relationship between thermal wave frequency and the phase shift of the signal at rear surface is expressed by Eq. (2)

$$\Delta \theta = \sqrt{\pi f / \alpha} \cdot d + \beta$$

Where $\Delta \theta$ is phase shift, $\alpha$ is thermal diffusivity, $f$ is frequency of thermal modification, $d$ is sample thickness and $\beta$ is instrumental constant.

Figure 2 shows typical data on relationship between the square root of $f$ and the phase shift at 30° and 180°C, which correspond to solid and melt state of