Properties and Applications of Polyurethane-Series Shape Memory Polymer

Development of materials with advance functions, such as piezoelectric or mechanochemical materials, has been flourishing in recent years, as well as their application. We are investigating applications of materials of this kind. For temperature sensors, candidate materials are bimetals and shape memory alloys; however, bimetals show only small deformations in response to temperature changes, while shape memory alloys are expensive, and low-cost materials with similar performance are highly needed.

In view of this situation, we started a development program for low-cost materials for temperature sensors intended for use in the vicinity of room temperature. The basic concept relates to sensors or mechanical actuators making use of differences between properties above and below the glass transition temperature (Tg) of polymers. Most polymers in practical applications have either the Tg distant from room temperature, or that in room temperature range but with small property charges across it.

Shape Memory Polymer(SMP) is a new smart material with a "shape memory". A large, reversible change in elastic modules across the Tg makes shape change and shape retention possible.

Significant deformation occurs in response to temperature changes. The material can change from a glassy-state to a rubbery-state across the Tg as shown in Figure1. An increase in temperature allows the material to become more flexible, therefore easily deformed or molded, and an increase in temperature hardens the plastic sustaining the new shape. This process can be repeated without material fatigue.

In addition to its shape memory properties, an shown in Figures 2,3 and 4, the SMP has unique properties in terms of moisture permeability, thermal expansion, damping, and index of refraction. These large changes in various properties are attributable to the micro-Brownian movement of the amorphous polymeric soft segments, which changes significantly when the temperature shifts above and below the Tg.

A wide range of new applications for the smart material are available. Applications include engine parts, electronic parts, medical areas, cosmetics, clothing, sporting equipment, household uses, toys, packaging and more. Some of the applications have already been developed, and more are under development and expected to be introduced soon to the marketplace.

SMP is a polyurethane-based polymer and is available in a wide range of Tg temperatures(—40℃～＋120℃) with the accuracy of 1℃ in accordance with particular application needs. Processing is similar to that of typical plastics. In addition, we not only offers pellets for various types of molding; but the polymer is also available in various forms which include solution for coating and impregnation, microbeads, UV curing polymer liquid and filaments. Furthermore, the polymer is durable, light-weight, transparent, and it can be colored.

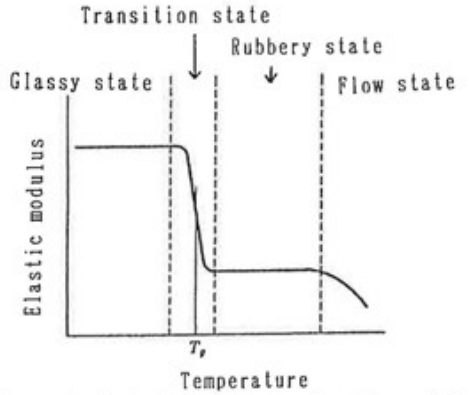

Figure 1 Relation between elastic modulus and temperature (Tg: glass-transition temperature)

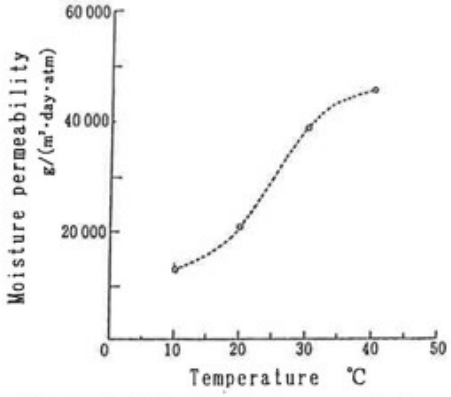

Figure 2 Relation between moisuture permeability and temperature

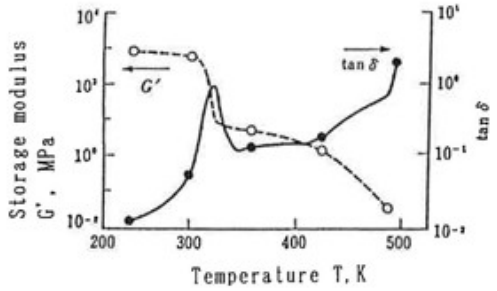

Figure 3 Relationship of storage modulus, G', and loss tangent, tan δ, with temperature

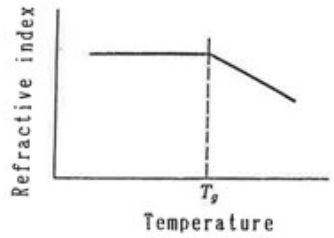

Figure 4 Relation between refractive index and temperature