



Fabrication and internal friction behaviors of novel porous CuAlMn shape memory alloy filled with polystyrene

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ABSTRACT

Polystyrene layer with adjustable thickness was introduced into a porous CuAlMn shape memory alloy, and the internal friction behaviors of the resultant materials were investigated using a multifunctional internal friction apparatus through the method of forced vibration. Two relaxational internal friction peaks accompanied by a sharp decrease of the relative dynamic modulus were found at around 95 °C and 119 °C, respectively. The two internal friction peaks have been ascribed to the relaxation process in a thermal equilibrium state of the polystyrene over its glass transition temperature. The damping capacity of the resultant materials was greatly elevated due to the superposition of several individual damping sources in them.

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1. Introduction

High damping capacity has been one of the most important properties of materials used in engineering structures where undesirable noise and vibration are to be passively attenuated. Today, high damping materials with potential practicality mainly fall into two categories: high damping metallic materials and high damping viscoelastic polymer materials. Polymer materials commonly possess the highest damping capacity, but their inferior hardness and modulus severely limit their applications. By comparison, metallic materials display much more wide application foreground due to their better mechanical properties.

Among the prevalent high damping metallic materials, shape memory alloys (SMAs) can be one of the most promising candidates due to their very high damping capacity arising from the reversible martensitic transformation (MT) and the stress induced reorientation of martensite variants [1,2]. To further improve the damping capacity of SMAs, porous SMAs have been developed in recent years and are attracting more attention of researchers all over the world due to their excellent comprehensive properties [3–5]. In our previous works, porous CuAlMn SMAs were successfully fabricated by using sintering–dissolution method and infiltration method, respectively [3,6]. The resultant materials exhibit uniformly distributed and interconnected macroscopic pores, as well as remarkably improved damping capacity. However, the damping capacity of porous CuAlMn SMAs is still much lower than that of viscoelastic polymer materials. In the present study, for the first time, we developed an innovative

method for fabricating porous CuAlMn SMA based novel materials with further improved damping capacity by incorporating viscoelastic polymer material polystyrene into the pores of porous CuAlMn SMA. It is expected that these novel materials can couple the high damping capacity of viscoelastic polymer materials and the good mechanical properties of metallic materials, therefore overcoming the aforementioned disadvantages of the two categories of high damping materials and broadening their application fields. As a part of a series of investigations, this paper is focused on the fabrication and internal friction behaviors of the porous CuAlMn SMA based novel materials.

2. Experimental

The porous Cu–11.7Al–2.49Mn (wt%) SMA samples were fabricated by the sintering–dissolution method and were subjected to at least 5 thermal cycles before use (the sample with the porosity of 65% was used in the present study) [3,7]. The preparation of polystyrene/2-methyltetrahydrofuran solutions was based on the following method: required amounts of polystyrene and 2-methyltetrahydrofuran (the weight ratios of the polystyrene to the 2-methyltetrahydrofuran were 1:4, 1:5, 1:6, 1:7, 1:8, respectively) were mixed and stirred on a magnetic stirring apparatus until homogeneous and colorless solutions were obtained. Then the porous CuAlMn samples were immersed in the solutions and shocked using ultrasonic to allow the solutions sufficiently infiltrate into the interconnected pores of the porous CuAlMn samples. After standing for 12 h the samples were dried at 50 °C to obtain the final porous CuAlMn SMAs filled with polystyrene.

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Scanning electron microscopy (SEM) was used to characterize the microstructures of the samples. Internal friction (IF) behaviors of the samples were examined on a multifunctional IF apparatus by forced vibration method. All the samples used for IF measurement were cut using an electric sparking machine and had a dimension of 60 mm × 3.5 mm × 2 mm.

3. Results and discussion

Microstructure of the porous CuAlMn SMAs filled with polystyrene: Fig. 1 shows the longitudinal surfaces of the porous CuAlMn SMAs filled with polystyrene. Obviously, the pores in every sample are uniformly filled with polystyrene. It is noteworthy that when the weight ratios of polystyrene to 2-methyltetrahydrofuran are relatively

high, such as 1:4 and 1:5, the pores are solidly filled with polystyrene. When the weight ratio is 1:6, however, only a few pores are solidly filled, while in other pores the polystyrene has clear layer shape structure. Fig. 1(c) indicates that the polystyrene layers are highly dense and pore-free and have good adhesion with substrate. With further decreasing the weight ratio, as shown in Fig. 1(f)–(h), the thickness of the polystyrene layer decreases.

Typical IF behaviors of the porous CuAlMn SMAs filled with polystyrene: Fig. 2 shows the typical IF and the relative dynamic modulus (RDM) of the porous CuAlMn SMA filled with polystyrene against temperature at a heating rate of 2 °C/min. Two IF peaks appear at around 95 °C (termed α) and 119 °C (termed α'), respectively. Before and after the two IF peaks the RDM curve has little change, especially over 130 °C it keeps nearly constant. But in the temperature range of the two IF peaks, the RDM has a sharp

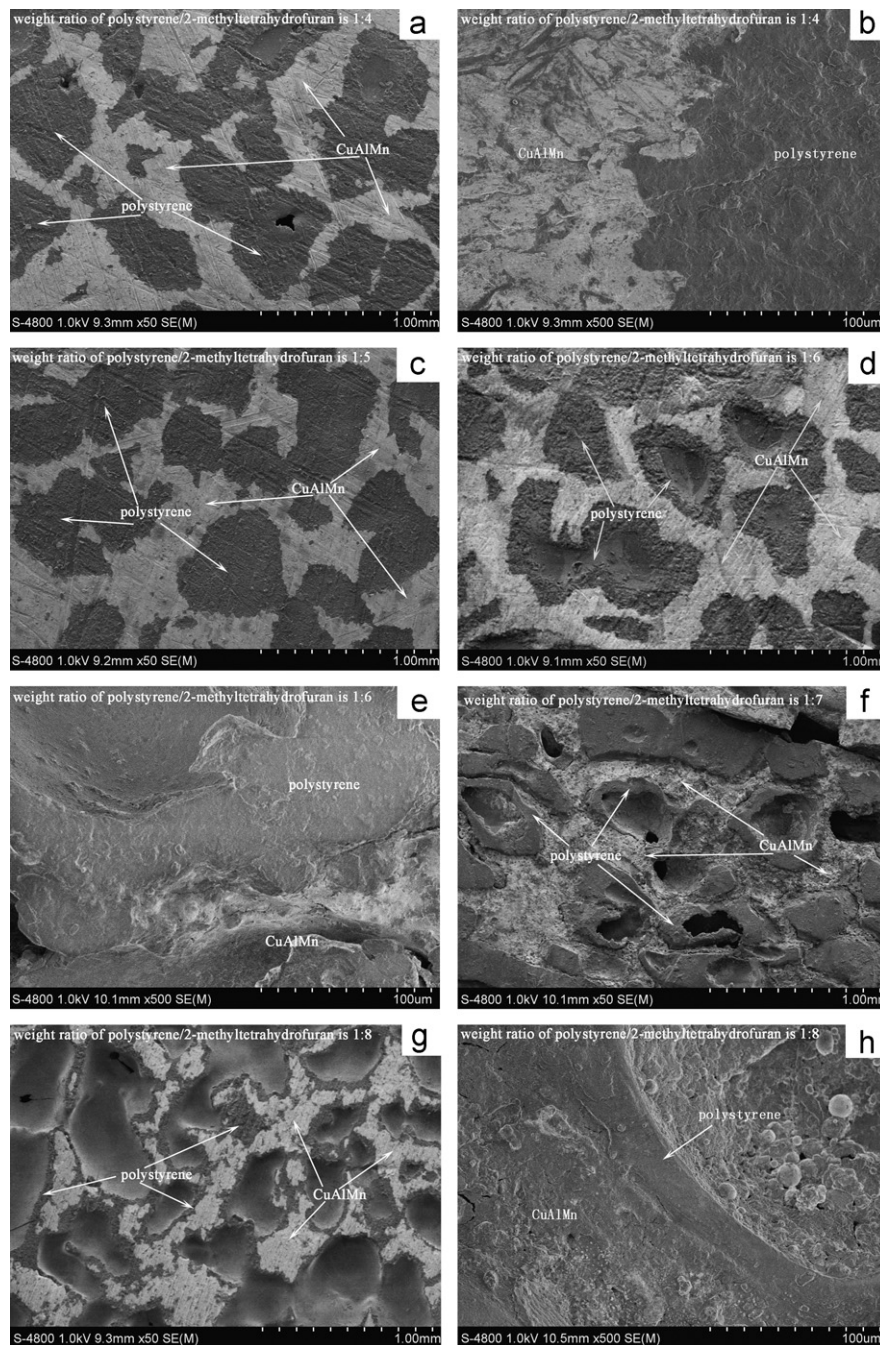


Fig. 1. Longitudinal surfaces of the porous CuAlMn SMAs filled with polystyrene.

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