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Zhou, Chao; Hu, L.N.; Yue, Yuanzheng

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A Hyperquenching-calorimetric Method to Determine the Activation Energy of Slow β Relaxation in Metallic Glasses

C. Zhou[1,2], L. N. Hu[2], Y. Z. Yue[1,2]

[1] *Department of Chemistry and Bioscience, Aalborg University, DK-9000 Aalborg, Denmark*
[2] *Key Laboratory for Liquid-Solid Structural Evolution and Processing of Materials (Ministry of Education), Shandong University, Jinan 250061, China*

czh@bio.aau.dk

Study on the slow β relaxation and its relationship with the α relaxation provides insight into glass transition and structural evolution during cooling of in metallic glass former.[1)] The slow β relaxation in metallic glasses can be detected through differential scanning calorimetric (DSC) or dynamical mechanical analysis (DMA) methods, as illustrated in Figure 1. However, using the DMA method, the loss modulus E'' patterns of different metallic glasses (MGs) exhibit either specific peaks or broad humps, or even excess wings which are hardly recognizable. On the other hand, the DSC method is clearly time-consuming.[2)] It is known that the competition and overlapping between the α and slow β relaxation in MGs make it difficult to distinguish the two relaxation modes in many glass systems. However, the hyperquenching-annealing-DSC upscan has recently been found to be a powerful method to explore the slow β relaxation characteristics in superclooled metallic glass-forming liquids by taking advantage of the distinct sub-T_g exothermic relaxation peaks in hyperquenched glasses.[3)] In the present work, we investigate the activation energy of the sub- T_g exothermic peaks (E_{onset}) in 28 metallic glasses (MGs) through calorimetric method and its dependence of the cooling rates. The results show a correspondence between E_{onset} and that of the β relaxation (E_β) in MGs with a certain fictive temperature T_c derived by certain hyperquenching rates. We reveal a linear relationship between this crossover temperature T_c in hyperquenched MGs and the liquid fragility (m) of metallic glass formers as shown in Figure 2. This correlation indicates the close connection between the competition among the α and slow β relaxation modes and liquid fragility in supercooled metallic glass formers, and can be quanlitatively explained by the potential energy landscape. The present work provides a new simple hyperquenching-calorimetric method to characterize the β relaxation and helps to trap its structural feature in MGs.

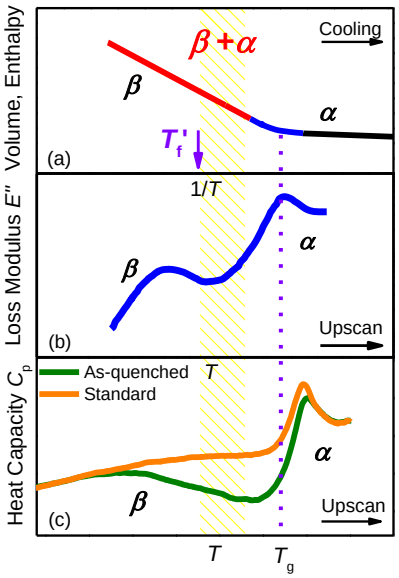

Figure 1: Schematic figures for understanding the α and slow β relaxation domains upon cooling (a) and during heating when characterized through DMA (b) and DSC (c) methods.

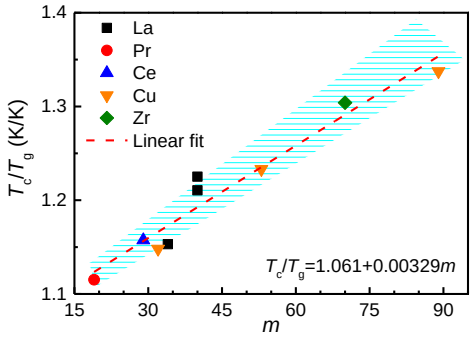

Figure 2: The relationship between T_c/T_g and m. The linear fitting result is illustrated as a dashed line.

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2) L. N. Hu and Y. Z. Yue, Secondary Relaxation in Metallic Glass Formers: Its Correlation with the Genuine Johari−Goldstein Relaxation, *Journal of Physical Chemistry C* **113** (2009) 15001-15006.
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