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材料科学与工程

远离平衡态玻璃的弛豫

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摘要:

本文阐述了关于远离平衡态玻璃(即急冷玻璃)弛豫的最新研究进展.结合实例,介绍了测量及计算急冷玻璃假想温度和冷却速度的新途径.急冷-退火-热扫描的方法是探索玻璃中能量和结构非均匀性的理想手段.如果对一个适当退火的急冷玻璃升温差热扫描, 将会先后出现预吸热峰, 释放急冷中储存在玻璃中能量的放热峰,以及玻璃转变吸热峰.介绍和分析了预吸热峰的几个典型特征, 并与玻璃转变吸热峰的特征进行比较, 这对理解玻璃弛豫的非指数和非线性特征是极其关键的.用急冷-退火-热扫描方法在硅酸盐玻璃获得的数据,可在一定程度上揭示水的玻璃转变现象.急冷强玻璃和弱玻璃在弛豫行为上体现出本质差别,本文对其差别的结构和能量根源进行了讨论.退火度对急冷玻璃的振动态密度具有明显影响,并通过显微结构因素对这一影响进行了分析.

关键词: 玻璃;弛豫;急冷;退火;热容;预吸热峰;震动态密度

Relaxation in glasses far from equilibrium

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Abstract:

This paper describes recent advances in the study of relaxation in hyperquenched glasses (HQGs), i.e., glasses far from equilibrium. The new approaches for determination of the fictive temperature and the cooling rate of the HQGsare introduced and two examples are presented. The hyperquenching-annealing-calorimetric scan (HAC) strategy is used to explore the energetic and structural heterogeneities in glasses. The occurrence of a pre-endotherm is observed when a properly annealed HQG undergoes a calorimetric upscan. The pre-endotherm is followed by an exotherm due to the release of the excess energy stored during hyperquenching, and subsequently by the endothermic glass transition. Several striking features of the pre-endotherm are demonstrated and compared with those of the glass transition. This comparison is crucial for understanding the non-linearity and non exponentiality of the relaxation in glass. The data obtained from the HACexperiments on silicate glasses are used to clarify the glass transition of water. Fundamental differences in relaxation behavior between a strong and a fragile HQG are found and analyzed in terms of their structural and energetic origins.The strong impact of the annealing degree on the vibrational density of states of HQGs are exhibited and discussed in terms of microstructure.

Keywords: glass; relaxation; hyperquenching; annealing; calorimetry; heat capacity; Boson peak

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