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Glass Transition in Oxide Glasses

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Glass transition is a long-standing, but also important and fascinating problem in condensed matter science. Despite considerable progress in understanding this problem, numerous key questions remain not completely answered yet. For instance, what is the microscopic origin of the dynamic and thermodynamic responses to glass transition? Why does its glass transition vary dramatically when a glass is formed under extremely conditions (such as high pressure, hyperquenching, high energy radiation, intense milling, and so on)? How is the atomic vibrational dynamics related to glass transition? How are the microscopic and the macroscopic glass transitions correlated? What is the role of dynamical and structural heterogeneity in affecting the microscopic glass transition? In this presentation, I will discuss these issues based on our recent studies of glass transition and relaxation in oxide glasses that are prepared under both normal and extreme conditions, respectively. The following aspects will be addressed.

First, by studying the enthalpy relaxation in hyperquenched glass, we reveal the consequences of the glass transition to atomic vibrational dynamics, microstructure and physical properties of glasses. By doing so, we give insights into the structural heterogeneity and the potential energy landscape of supercooled liquids. For such studies, we choose poor glass formers as objects since they possess abundant relaxation features.

Second, by probing the evolution of configurational heat capacity we clarify the structural source of the thermodynamic fragility. For such studies we use some simple model glass systems, e.g., ternary borosilicate system and binary vanadium tellurite system, in which regular compositional substitution is undertaken.

Third, by iso-statically compressing glass around T_g , we investigate the impact of the pressure-quenching on the structural change in both short-range and medium range order, and hence, on calorimetric glass transition. By doing so, we give insights into the relaxation mechanism of both glass structure and properties, and into the role of disorder in influencing the vibrational dynamics. For such studies, we choose simple glass forming systems such as vitreous silica, calcium phosphate, borate and boroaluminosilicate because of their fascinating features: speciation of structural units.

Finally, I will point out some potentially important directions in studying the glass transition of not only oxide, but also non-oxide glass formers.

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