Universality of Low-temperature Excess Heat Capacity in Oxide Glasses: A Scaling Feature

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Amorphous material shows a low-temperature excess heat capacity which is larger than the capacity expected from Debye $T^3$ law [1]. In other words, the $C_p/T^3$ plot provides a bump around 5–20 K (the so-called boson peak). Because origin of the boson peak has been unclear so that it is still under dispute in physics field. In order to understanding the boson peak, we studied one of the characteristic features, i.e., scaling law, in binary/multicomponent oxide glasses. In addition, we described the difference in scaled excess heat capacity between glass and crystal.

Figure 1 shows the temperature dependence of $C_p/T^3$ in typical glasses in this study. All of the glasses studied exhibited the broad peak in the low-temperature region. These boson peaks could be scaled by their maximum [i.e., $(C_p/T^3)_{\text{max}}$] and position ($T_{\text{max}}$). The scaled plots are displayed in Fig. 2 (21 glasses in this study) in addition to data of SiO$_2$ glass and crystal (Quartz) so far [2]. It is noticed that all of the scaled curves were overlapped regardless of the compositions. Furthermore, the scaling revealed a clear distinction between the glasses and SiO$_2$ crystal.