Development of high strength chemically strengthened glass

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Newly developed chemically strengthened glass, T2X-1, is demonstrated. T2X-1 has high strength and excellent ion-exchange property.

A cover glass is expected to have a deep compressive stress layer and a high compressive stress in order to obtain and to maintain a high fracture strength [1,2]. A 40μm or more compressive stress layer and a 700MPa or more compressive stress is usually recommended for a cover glass. However, there are two problems, one is a long ion-exchange time to create a deep compressive layer and the other is a deterioration of compressive stress in mass production by Na^+ contamination in molten KNO_3. Therefore, the following two improvements for ion exchange properties of chemically strengthened glass are requested. One is a fastening of ion-exchange speed. The other is to keep high compressive stress even in highly Na^+ ion contaminated molten KNO_3.

The fracture strength, the depth of compressive stress layer (DOL) and the compressive stress value (CS) of T2X-1 were investigated experimentally and compared with conventional glasses. Glass substrates, 0.7mm thick T2X-1, CX-01 (conventional Alumino-silicate: AS) and Soda-lime (SL), were used.

Specimens of dimensions 135.4×85.2×0.7mm were ion exchanged and tested by three point bending test. T2X-1, AS and SL were ion-exchanged in molten KNO_3 at 430°C for 4.5, 8 and 1 hours, respectively. Na^+ concentration in molten KNO_3 was 1,000ppm. The figure below shows a Weibull plot of fracture strength of T2X-1, AS and SL. DOL, CS and fracture strength 15 percentile (B_{15}) of each are also shown. T2X-1 has higher fracture strength than AS and SL. B_{15} of T2X-1 was 20% higher than that of conventional Alumino-silicate.

T2X-1, AS and SL were ion exchanged in molten KNO_3 at 430°C for 1 to 8 hours. T2X-1 achieved 40μm of DOL at 3 hours. On the other hand, 6 hours and over 8 hours were necessary for AS and SL, respectively. T2X1 has twice faster ion-exchange speed compared conventional Alkali-alumino-silicate.

T2X-1, AS and SL were ion-exchanged in molten KNO_3 at 430°C for 3, 6 and 13 hours, respectively, to create about 40μm of DOL. Na^+ concentration in molten KNO_3 ranged form 0 to 20,000ppm. T2X-1 could keep CS over 700MPa until 15,000ppm, whereas, AS could keep CS over 700MPa until 4,000ppm. SL could not achieve 700MPa. T2X-1 is durable against the CS deterioration by fourfold more Na^+ contamination in molten KNO_3 than conventional Alkali-alumino-silicate.

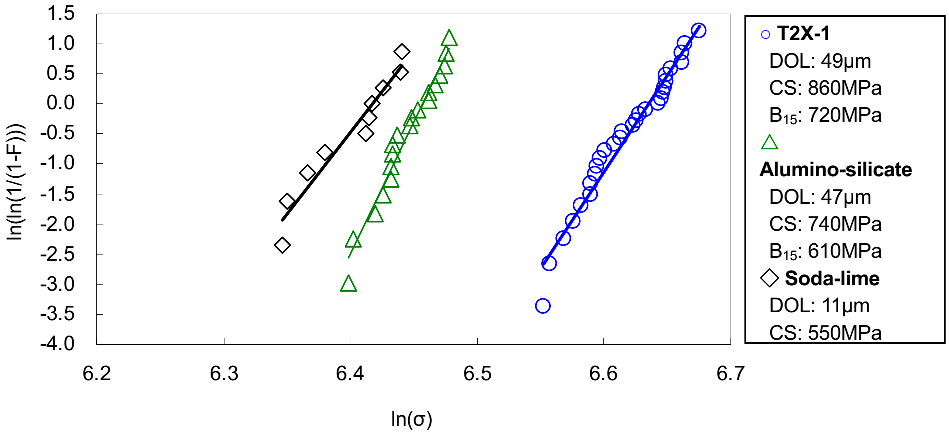

Fig. 1. Weibull plot of T2X-1, Alumino-silicate and Soda-lime. σ[MPa] is fracture strength. F is failure probability calculated by Mean ranks.

References

[1] Sinue Gomez et al, "Designing Strong Glass for Mobile Devices", SID 09 DIGEST, pp1045-1048

[2] James J. Price et al, "A Mechanics Framework for Ion-Exchanged Cover Glass with a Deep Compression Layer", SID 09 DIGEST, pp1049-1051