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Redox dynamics in the high-temperature float processing of glasses. I. Reaction between undoped and iron-doped borosilicate glassmelts and a gold–tin alloy

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Abstract

X-ray emission and Rutherford backscattering spectroscopies were used to characterize the dynamic chemical response in two borosilicate glassmelts (both Pyrex™ composition, one with 0.08 at.% Fe added) reacted with a Au-30Sn liquid alloy. Reactions were done at temperatures of 1250–1350°C for 30 min under a reducing atmosphere. Because of the metal alloy design and the glass structure, the chemical diffusion response shows less Sn incorporation into the glassmelt than in conventional commercial soda-lime float; the addition of Fe^{3+} acts decisively to reduce the kinetics of Sn penetration. The results indicate a cation-diffusion-limited reduction reaction as the dominant kinetic mechanism working towards equilibrium in the silicate melt/metal melt system. The proposed kinetic model is consistent, too, with many idiosyncratic features of chemical concentration profiles observed in soda-lime float glass.

1. Introduction

The processing steps in the manufacture of high-information-content flat panel displays (FPDs) for the computer and video markets places stringent demands on the substrate material that supports the electronic display elements. Required is a rigid transparent material that (i) is nearly atomically smooth and flat and has very low optical distortion, (ii) has dynamic resistance to thermal-stress buildup, (iii) has a thermal expansion coefficient close to that of silicon, (iv) has the ability to accept surface chemical modifications and coatings (including strong chemical washes), and (v) displays thermal stability at post-forming processing temperatures of 600–800°C for tens of hours [1–4].

The Fusion draw process, developed by Corning, can produce extremely flat, thin (<0.5 mm) glass sheet of a new class of alkaline earth aluminoborosilicate glass substrates [2,3,5] that meet the processing requirements above. Fusion, however, is fundamentally limited by the rate at which it can produce flat glass because of the high viscosity of the glassmelt required by the process technique.

Soda-lime-silica (NCS) glass manufactured by the float process [6] had been used exclusively for

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