08-010

EDS concentration profile of Na in soda-lime-silica glasses submitted to thermal poling

Escanhoela Jr, C. A. (1), Ziemath, E. C. (2)
(1) USP; (2) UNESP

In this work, we obtained the concentration profile of Na in soda-lime-silica glasses after thermal poling by energy dispersive spectroscopy, EDS. The thermal poling consists in applying a high intensity DC electric field (1 MV/m) on samples at high temperatures. During the poling process a permanent electric field is frozen in at the anodic region of the sample. Thermal poling was applied to glasses with composition (mol %) 22Na2O•8CaO•65SiO2•5MO2 (M = Si, Zr, Sn, Ce) at 145 ºC. The sample thickness was ~1.5 mm and area of 20 x 20 mm2. Gold foils with a diameter of 10 mm were used as electrodes. The high voltage (1 MV/m) was applied to the samples for 40 min. During the poling, the current and the temperature of the sample were measured simultaneously. The electrical current in these glasses is due to the migration of Na+ in the bulk of samples from the anode to the cathode, leading to the creation of a depletion layer near the anodic surface. As soon as the high power supply was turned on, the current increases until reaching a maximum, which takes place ~2 min later. This increase in the current is related to the heating of the sample due to the Joule effect. The EDS measurements were performed by the line scan resource on a polished surface, perpendicular to the electrode surfaces, in the vicinity of the anodic surface. The EDS profiles for Na enables to determine the thickness of the depletion layers. Their thickness depends on the tetravalent cations, M4+, and on the total electric charge displaced in the glass during the poling process. The minimum thickness was found for the glass with Ce, 3.9 µm, and the maximum one was for the glass with Sn, 12.0 µm. Each of the different tetravalent cations, M4+, have particular features in the glass structure which affects the electrical current and the depletion layer in different forms. The oxides of Si, Zr and Sn act as network formers while that of Ce act as a modifier. Therefore, the cations of these elements should influence the migration of Na+ during the poling. It was found that for the Sn-containing glass presents the maximum value of the current, i.e., ~0.6 mA while the maximum value for the Ce-containing glass reaches ~0.2 mA. Consequently, the total electric charge displaced in the different glasses, for a same time interval, also depends on the M4+ present in the glass composition. The value of electric charge displaced and depletion layer decreases according to the following M4+ sequence: Sn > Si > Zr > Ce. It is known that Sn and Zr ions have a high electronic polarizability and this property can be responsible for the higher conductivity observed for the corresponding glasses. On the other hand, the Ce4+ ion occupies the

interstices, like the Ca2+ ion, which reduces significantly the frequency of jumps of the cationic charge carriers between adjacent sites, thus resulting in lower currents. Financial support: FAPESP (Grant no 2008/07238-4)