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Application News

No.P97

Electron Probe Microanalyzer

Analyzing Foreign Matter in the Glass Substrate for Liquid Crystal Displays

Introduction

In recent years, liquid crystal displays have become ubiquitous in the world in which we live; they provide the screens for our televisions, cell phones, PC monitors, and so on. Active matrix liquid crystal displays (AM-LCD), which operate using thin-film transistors (TFT) mounted on a glass substrate, are capable of displaying truly beautiful images. Such AM-LCDs, in order to retain the thin-film functionality, demand that certain high-level characteristics be maintained. For example, the glass needs to be free of alkaline substances (they can lead to a degradation of the transistor properties by diffusing within the liquid crystal). The glass also needs to be heat-resistant (even at a thickness of approx. 0.7 mm, thermal contraction during the manufacturing process must be kept to a minimum), and it needs to be resistant to chemicals (such as component elution from chemical treatments during the manufacturing process).
We here introduce an example of the analysis of a TFT glass substrate using EPMA.

Foreign Matter in the Glass

Since its usefulness as a glass substrate cannot be upheld if the glass has internal defects such as bubbles or foreign matter, has scratches on its surface, or has other defects due to foreign matter, it is very important that the cause of such defects be investigated thoroughly. Foreign matter in the glass can be identified by analyzing the foreign matter and determining when it was generated and where the contamination occurred, from the raw material stage to the melting process.
As the result of a qualitative analysis (marked with yellow circle) of the foreign matter in the AM-LCD glass substrate (alumino-borosilicate glass), it was determined that it is SiO_2. Then spectrum measurements were done for the foreign matter, the matrix portion and reaction phase that has different SEM contrast in the periphery of the foreign matter. From the spectra of light element B and the main components Al and Si, it can be found that in the reaction phase and the foreign matter, B and Al were reduced, while Si increased.

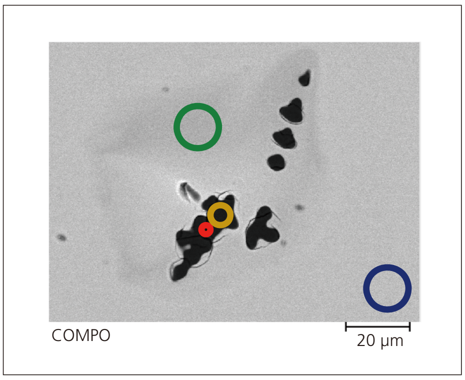

Fig. 1 COMPO Image

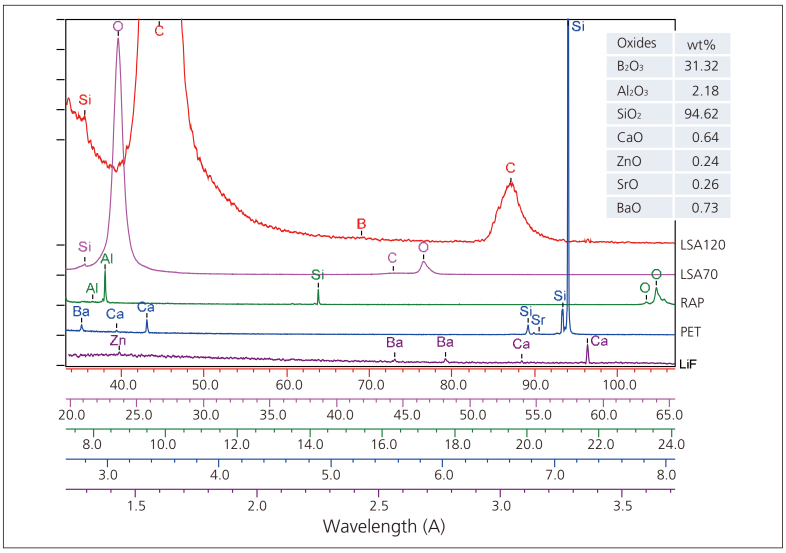

Fig. 2 Qualitative Analysis

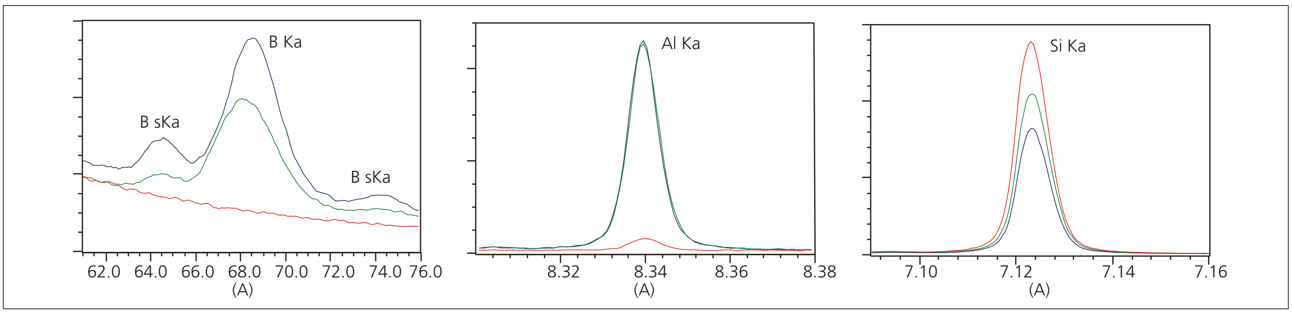

Fig. 3 Spectra of B, Al, and Si

Analysis of Foreign Matter in the Glass

The foreign matter in the glass is of a crystalline substance that is monocrystalline or polycrystalline, or is an amorphous glass phase. When seen through the naked eye, the color of the foreign matter is of a particulate white color, is of a black color, or is otherwise colored. When the foreign matter in the glass and the reaction phase are observed using a stereoscopic microscope, a white devitrified crystalline structure is found as shown in Fig. 4, and it can be assumed to be cristobalite, based on the qualitative results.

When observed with a laser microscope, in addition to being able to see the crystalline structure under visible light, it is also possible, by means of differential interference contrast imaging, to confirm the existence of the reaction phase through changes in the refractive index caused by differences in the composition of the glass.

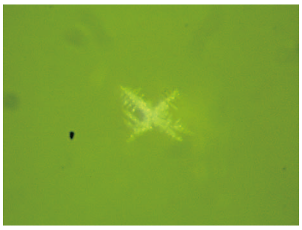

Fig. 4 Stereoscopic Microscopic Image

Fig. 5 Optical Microscopic Image

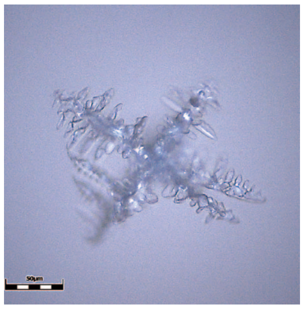

Fig. 6 Visible Light Microscopic Image

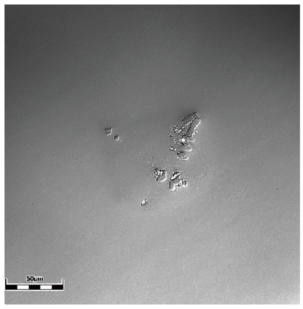

Fig. 7 Laser Differential Interference Contrast Image

Quantitative Mapping Analysis

Through mapping analysis of the reaction phase or the erosion phase, as well as the foreign matter, it is also possible to study the reaction process. Furthermore, the formation status can be inferred based on the composition concentrations indicated by the quantitative mapping.

The "wt%" value shown in Fig. 8 represents the concentration of simple oxides (such as B_2O_3).

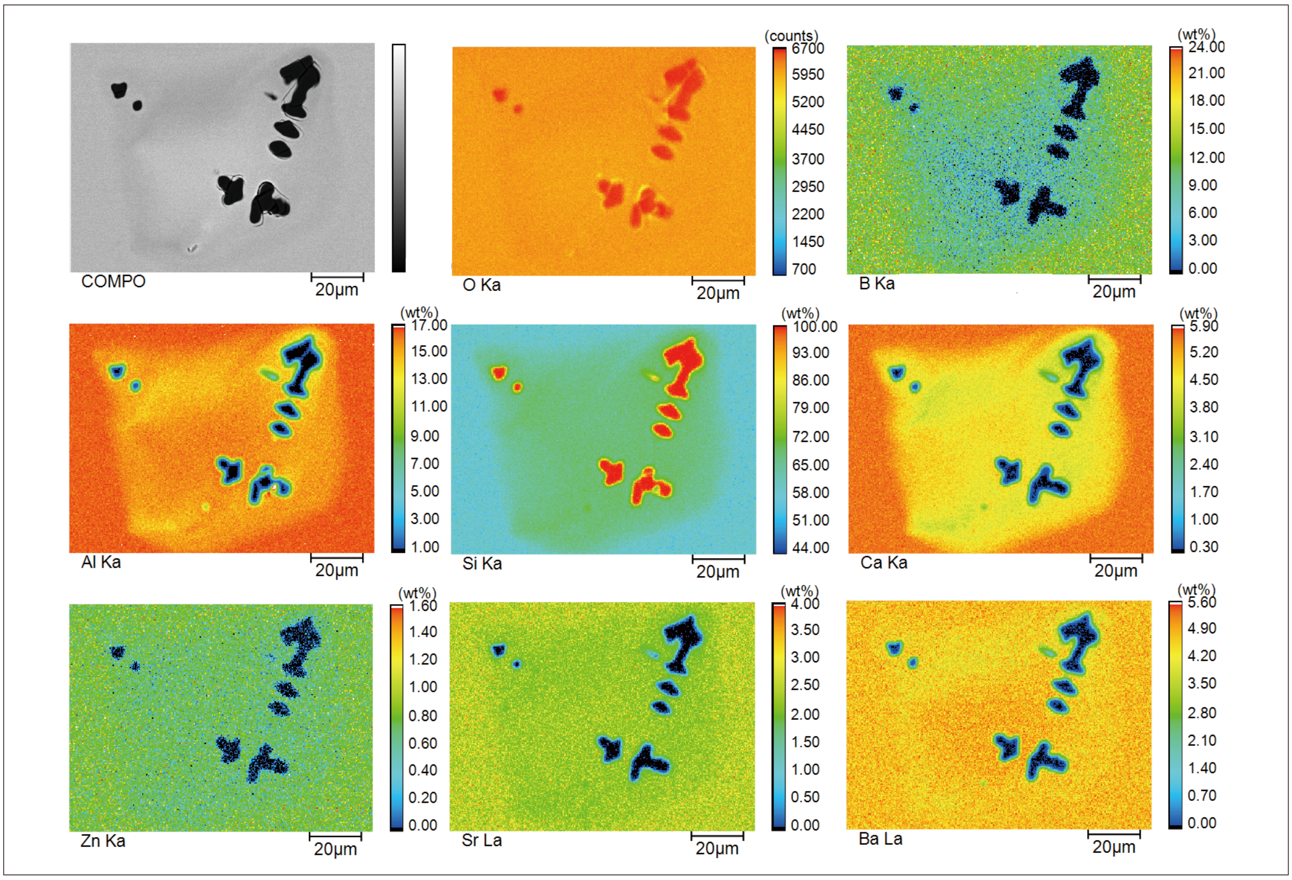

Fig. 8 Quantitative Mapping

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