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Quantitative assessment of touch-screen panel by nondestructive inspection with three-dimensional real-time display optical coherence tomography

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ABSTRACT

We investigated the use of optical coherence tomography (OCT) to measure several materials immersed in optical adhesives. The effects of variations in the concentration, physical characteristics, and thickness of the materials were studied, and these parameters were found to significantly affect the OCT measurement. The materials were selected for their distinct spectral properties in the infrared region. To ensure reliability, we acquired images using a scanning electron microscope after performing the semiconductor production process. We verified the feasibility of the application of OCT for defect inspection and product verification of touch-screen panels.

1. Introduction

Optical coherence tomography (OCT) is widely used as a non-invasive, high-resolution imaging modality for *in vivo* biological specimens. It has been successfully applied to the early diagnosis of many diseases originating under superficial areas, including cancers [1–4]. Although OCT's transmission depth is limited, it offers a high level of sensitivity when capturing depth-resolved images with a high signal-to-noise ratio. Commercial OCT products are widely used in ophthalmology as diagnostic equipment [1,2]. In recent years, in addition to medical imaging applications, OCT has also been finding uses in agricultural applications, where it is used to search for abnormalities in structures that would be undetectable to the naked eye [5–11]. Other interesting applications of OCT include the verification of pearls and identification of counterfeit notes [12–16].

In industrial fields such as the inspection of thin-film products, OCT is again attracting attention. Several reports have described attempts to adopt OCT as a means of inspection in several industrial fields [17–20]. Automated visual inspection with a charge-coupled device or visual inspection by an operator are widely adopted on the production lines of thin-film electronic devices such as touch-screen panels (TSPs) and liquid crystal displays (LCDs). The production of devices such as a TSP or an LCD involves several lamination processes that ultimately form a multilayered structure with a 100- to 250-μm gap between the layers. However, when automated visual inspection or operator-based visual inspection are used, the diagnostic information is limited to two dimensions; three-dimensional (3D) structure information is not readily available. Visual inspections can produce different results because the operator's judgment can be subjective; further, these inspections are not performed until near the end of the production process. Meanwhile, electrical tests are used to inspect the product's electrical functionality. Therefore, the manufacturing costs and failure ratio tend to increase because inspections are performed late in the production process.

In this study, to overcome these problems, we examined the sectional profile of a thin display panel, which is a typical example of a thin electronic device. We performed tests to detect failures and evaluate the suitability of OCT for application to the manufacturing lines of thin electronic devices. OCT imaging analysis at different depths was applied to various optical adhesives used in the TSP deposition process. In addition, changes in the refractive index during the drying process were studied over time using a similar approach. The purpose of this study was to evaluate changes in the refractive index of ultraviolet (UV) light in actual production lines. In many cases where an optical adhesive is used in the lamination process of a TSP and an LCD, we were able to

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0143-8166/

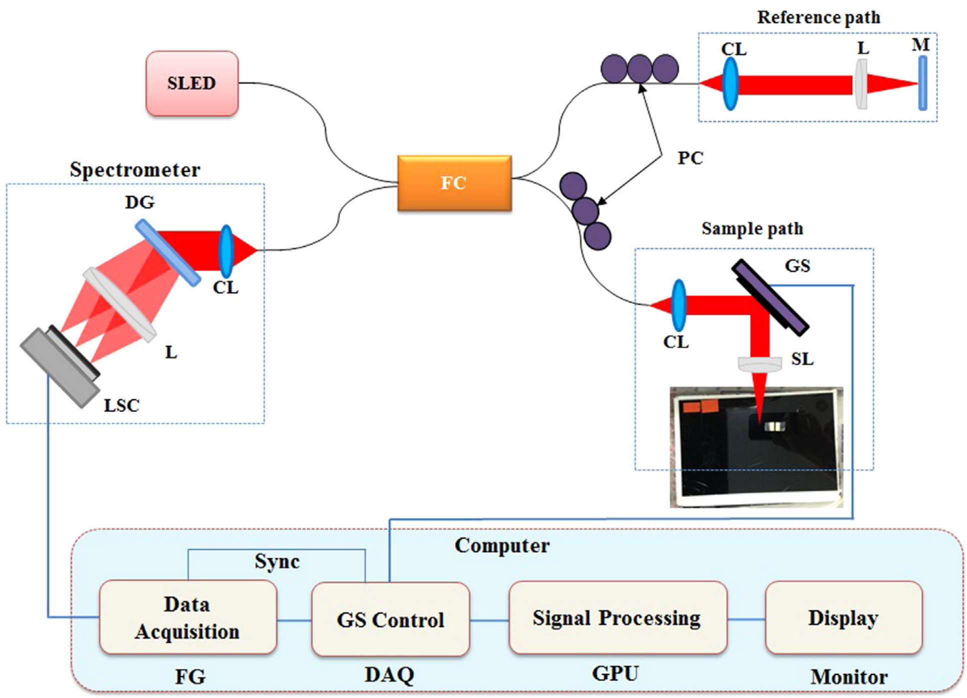

Fig. 1. Schematic of OCT for industrial 3D inspection. (SLED, superluminescent light-emitting diode; FC, fiber coupler; PC, polarization controllers; CL, collimator; L, lens; M, mirror; DG, diffraction grating; LSC, line scan camera; GS, galvanometer scanner; SL, scan lens.).

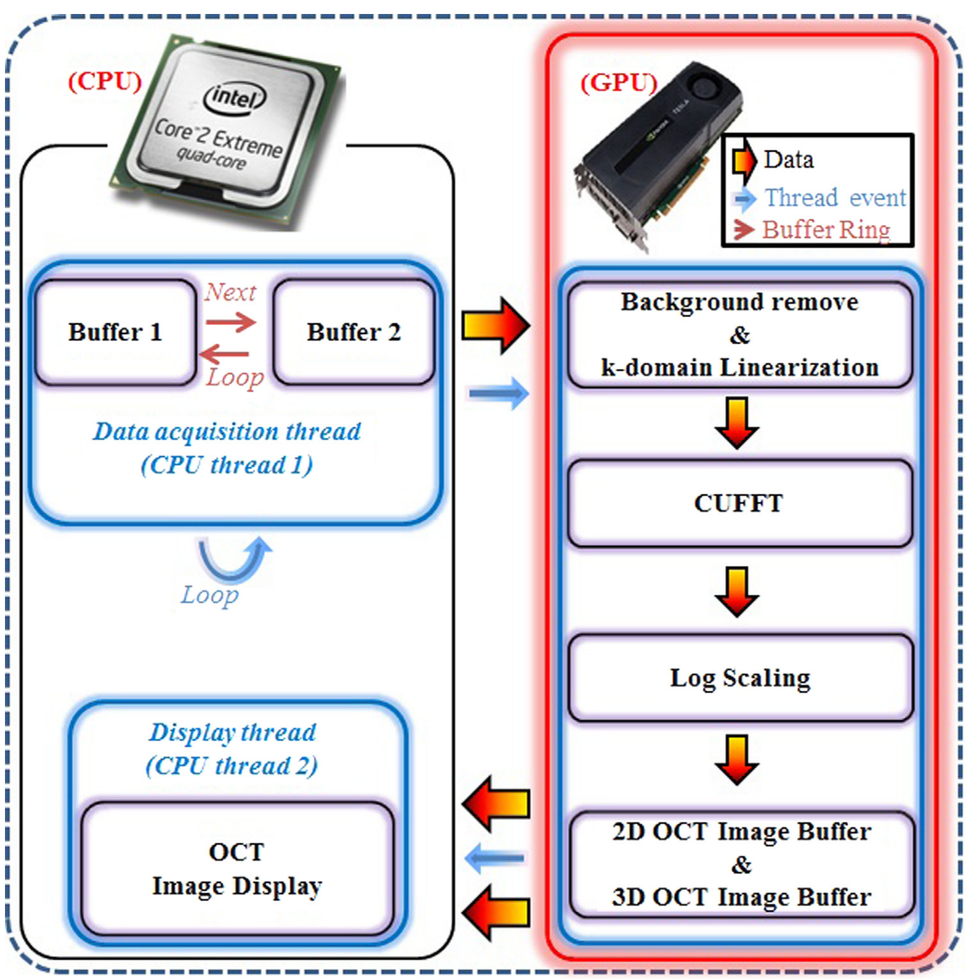

Fig. 2. Architecture of OCT system for industrial 3D inspection with signal processing part implemented in a GPU.