18-2: NOVEL SURFACE PROFILER SYTSTEM FOR INSPECTION OF FLAT PANEL DISPLAY

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Abstract
Novel surface profiler system for inspection of the display components is demonstrated. In the case of the liquid crystal display, for example, not only the flatness of the alignment film but also the quality of rubbing can be inspected. Furthermore, the shape of the component such as the color filter, electrode and mirror can be inspected without removing each component.

1. Introduction
In a manufacturing process of flat panel display, in-line inspection is strongly demanded. Because, product yield rate can be improved by the intermediate inspection. In the case of the liquid crystal display (LCD), for example, it is well known that the rubbing processes is possible to give damage against the thin film transistor, therefore the rubbing strength is expected to be weak. As a result, sometimes the surface alignment is inadequate, and "mura" faulty can be found in final product. At present, a possible technique to find an effective rubbing strength before filling liquid crystal compound has not been established yet. It is no doubt that intermediate inspection just after the rubbing process can improve the product yield rate.

For the purpose of estimating the surface topology, surface profiler system by the use of laser optics has been developed by several researchers. The main object for the profiler system is solid state matter such as semiconductor wafer, hard disk and optical mirror. Generally say, the surface profiler system was applied for non-transparent medium rather than the transparent medium. Recently, a novel surface profiler system was developed by Core System Co. Ltd. It is a remarkable feature that the novel profiler system is applicable to transparent medium such as polymer film and finger print.

In this report, novel surface profiler system for inspection of the display components is demonstrated.

2. Measurement principle[1]
Figure 1 depicts the fundamental concept of the novel three-dimensional surface profiler instrument (Scanning Laser Imaging Scope, Core System Co. Ltd.). The laser light beam is scanning on the surface of the curved object with maintaining the distance l. Scanning direction is along the x-axis. The surface profile of the measured object along the x-axis can be expressed by the function $f(x)$. Now, assume that the light beam from the laser light source L is emitted on the curved object at the point P. When the angle θ with respect to the x-axis is much less than 1, the gradient at P can be expressed by:

$$\frac{df(x)}{dx} = \tan\theta \sim \theta \qquad (1)$$

The angle between the incident light and the reflected light is approximated to 2θ, which corresponds to the deviation Δ from the incident light beam. Under such condition, Δ is approximated to $2\theta l$. When the deviation Δ is measured by scanning an object, the distribution function of the surface profile $f(x)$ can be obtained by the measurement of $\Delta(x)$. From the equation (1), $f(x)$ can be derived by:

$$\alpha \int dx\, \Delta(x) = \int dx\, \theta(x) = f(x) \qquad (2),$$

where $\alpha = 1/2l$. The coefficient α can be determined by the calibration measurement with the known object. Sequential scanning with the two dimensional direction can provide the three-dimensional surface profile. To carry out the sequential scanning with high speed, the beam spot has to be scanned along the x-axis and the reflected beam has to be detected by photo-detector. In this paper, an optical system which makes use of a spherical concave mirror in stead of the conventional lens system is proposed.[2] The rotation axis of the scanner mirror coincides with the curvature center of the spherical concave mirror. The beam reflected from the scanner mirror is incident perpendicularly onto the concave mirror, and the beam reflected from the concave mirror traces back the path of the incident beam. Therefore, the position of the beam spot on the detector is constant independently of the rotation angle of the scanner mirror.

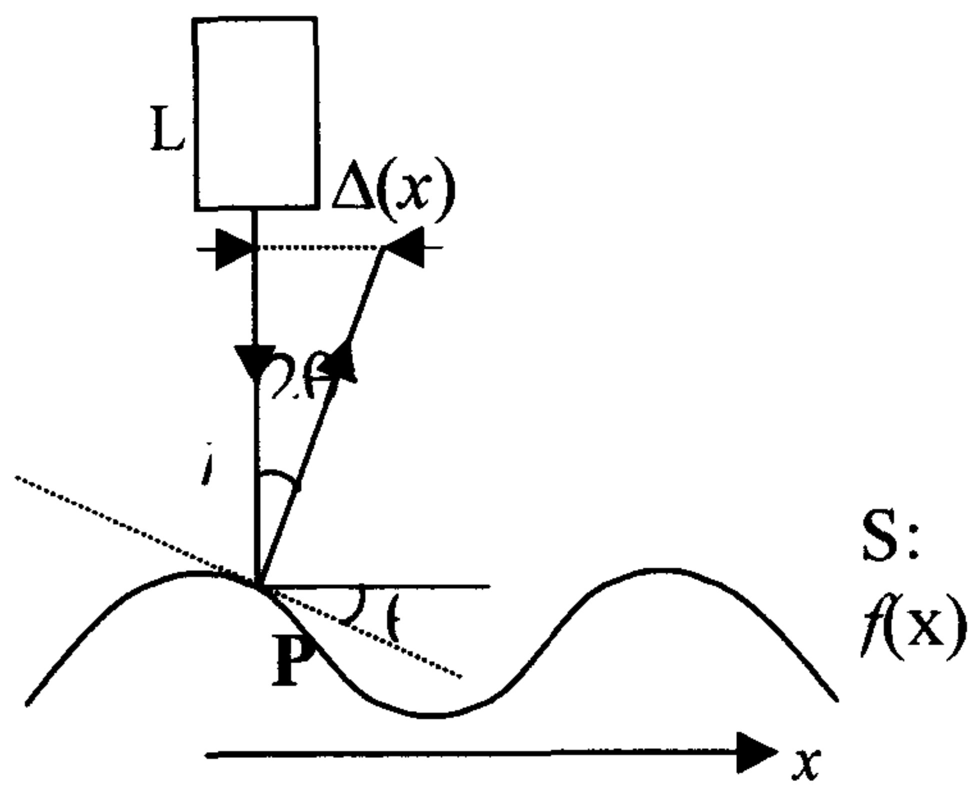

Fig. 1 Basic concept of the profile measurement.

3. Experimental

Corning–1737F (Corning Co.) glass substrate was used for the experiment. The photoalignment layer used were polyimide (PI) and polyvinylcinnamate (PVCi) which was spin coated on a glass substrate and then dried. b The periodically striped patterns were produced by He–Cd laser (λ=325 nm, 25 mW/cm^2) with a photo–mask (100 μm line and space). The exposure time was set to be 20 min. To verify the flatness of PVCi film, atomic force microscope (AFM, SPM–9500J2, Shimadzu Co. Ltd.) was used. For evaporation, 4'-n-pentyl-4-cyanobiphenyl (5CB, supplied by Merck, Japan) [T_{NI} =35.5°C] was heated on a hot plate at 90°C and was adsorbed on the substrate surface positioned 5 cm from the LC source. In this study, 5CB adsorption was controlled by the duration of evaporation.

3. Results and discussion

Figure 2 shows the typical experimental result of the surface topology of the LCD panel (transreflective type for cell phone), where the polyimide alignment layer, color filter, transparent electrode, reflection mirror were prepared on the glass substrate. The scanned area is 40 x 40 mm^2, and scan was completed within 20 min. It is noteworthy to point out that the topological shape of the concave mirror with hole can be clearly recognized. Here, it is quite beneficial that the transparent layer such as polyimide and electrode layer are not required to be removed beforehand. It is proposed that this instrument is applicable to the inspection of the surface of the LCD panel.

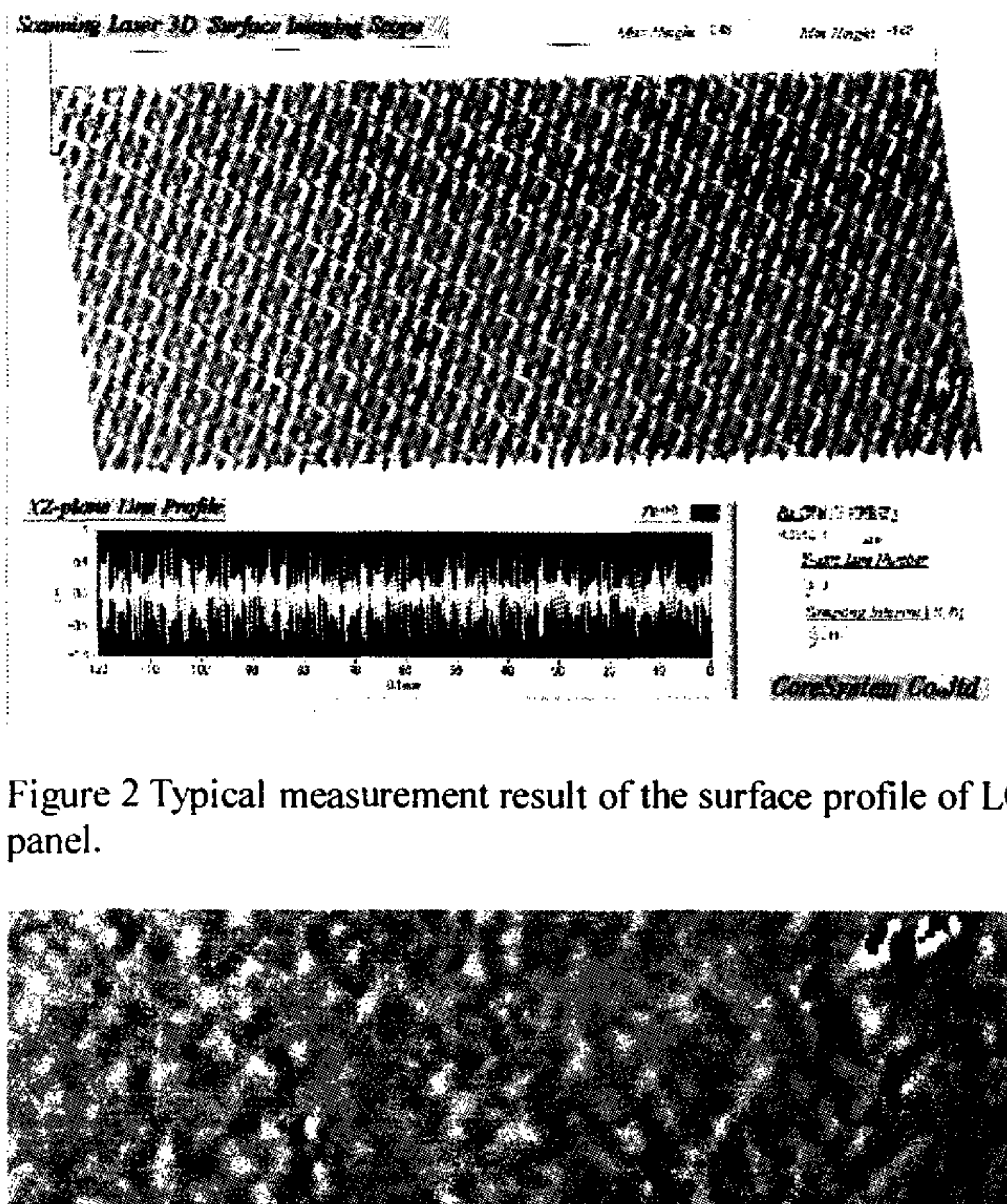

Figure 2 Typical measurement result of the surface profile of LCD panel.

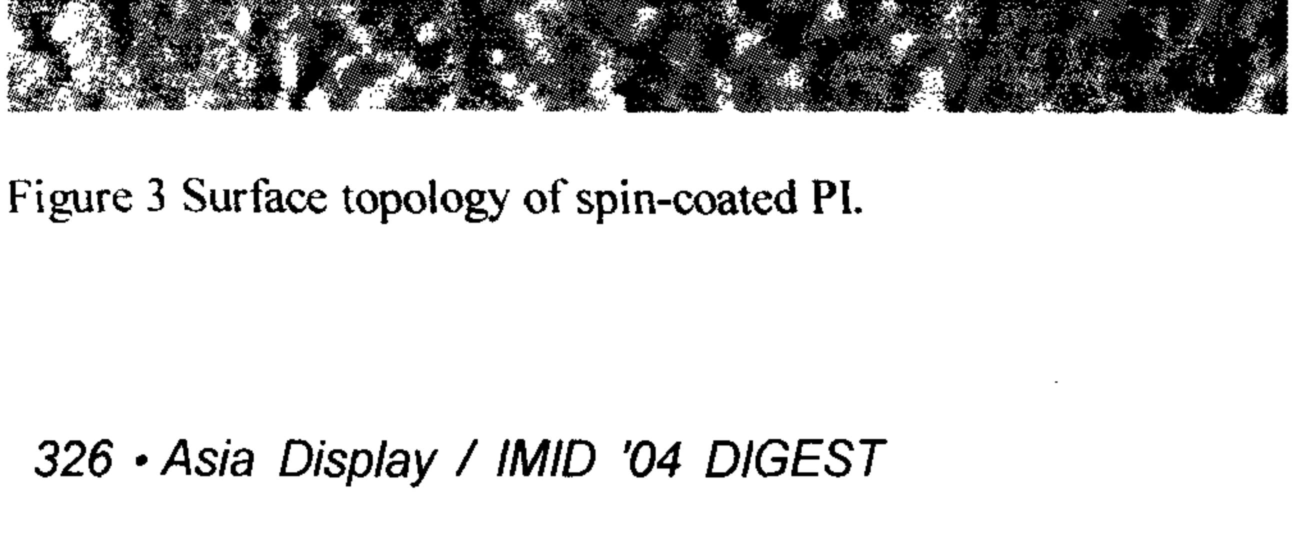

Figure 3 Surface topology of spin-coated PI.

Figure 3 shows the surface topology of spin-coated PI.[3]The scanned area is 5 x 10 mm^2. From fig.3, it is recognized that these nm-order roughness can be found by this surface profiler. It is known that the wrinkle of the PI skin would be caused when the thinner is vaporized by post-baking. These aspect of PI surface can not be observed by AFM, because the curvature of the wrinkle is too big to measure by using AFM. Besides, AFM is not good at such '*soft*' surface. Since these kinds of optical instruments are 'non-contact' measurement, the surface profiler can be a powerful tool for such '*soft*' surface.

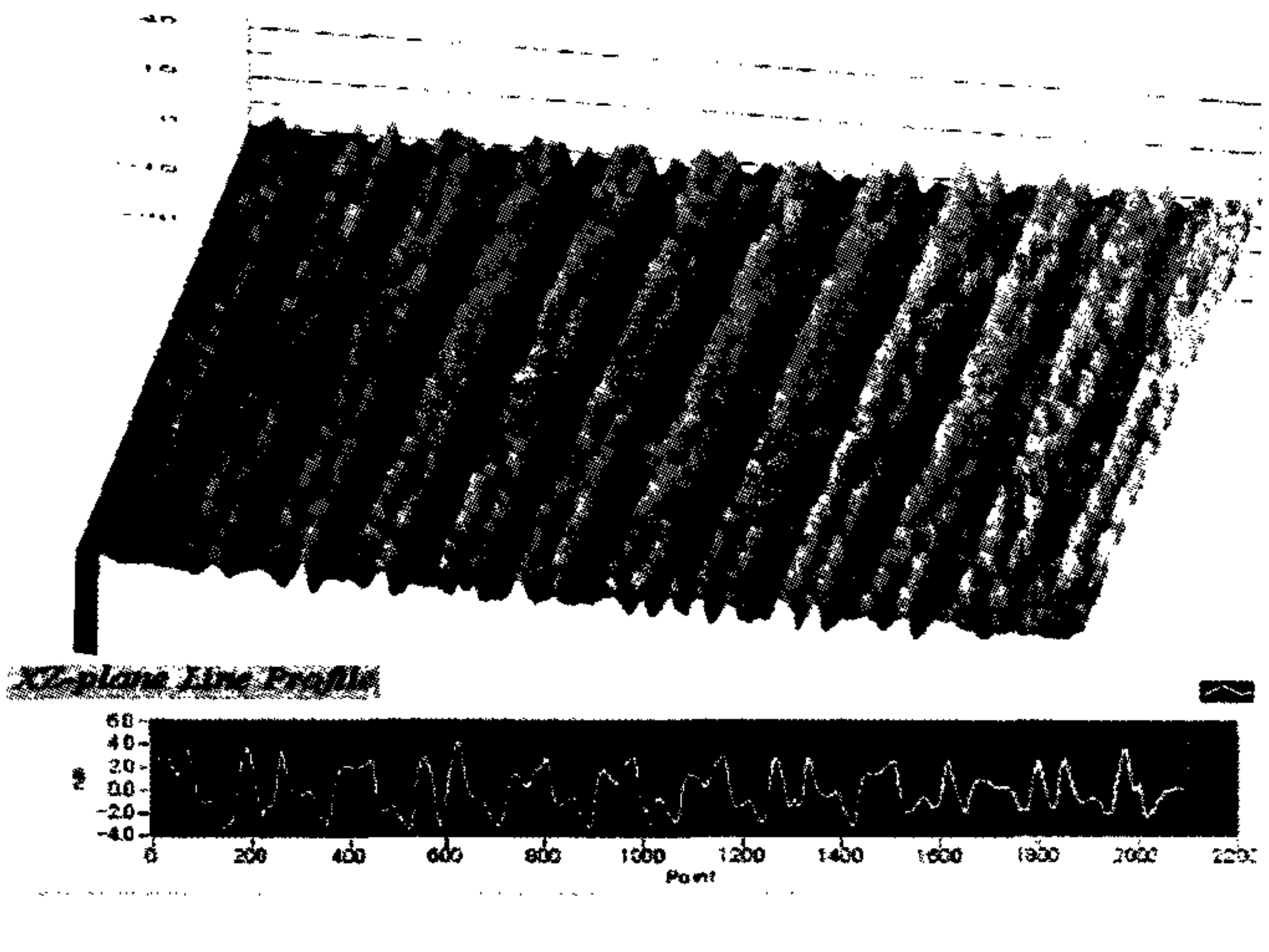

Figure 4 Surface topology of LC layer evaporated on PVCi.

For the sake of verifying our instrument, figure 4 shows the three–dimensional surface pattern mapping of the LC multilayer evaporated on PVCi film for duration of 3 hours evaporation. From fig.4, a periodic profile can be clearly seen, where the period corresponds to the photo–mask pattern. It is also recognized that the height of the UV exposed region is lower than that of the masked region, the difference is comparable to the size of 5CB molecule. This result implies that the surface molecular alignment at the masked region is voluminous compared with the UV exposed region. On the one hand, it is known that the surface LC molecules are well aligned parallel to the substrate along the direction perpendicular to the irradiated UV polarization. Besides, layer–by–layer nematic growth would form homogeneous alignment. In the masked region, on the other hand, LC molecular order is fairly low, therefore randomly oriented LC molecules seem to make the LCmultilayer voluminous.

4. Summary

The surface topology of LC alignment film and substrate were investigated by the novel three dimensional surface profiler instrument, which has an outstanding ability to visualize nano-scale profile with square millimeter area. This instrument is applicable for EL glass substrate as well as LCD and PDP. To visualize the shape of the back plane, no preparatory treatment (viz. remove the alignment film) is required. That is, in-line panel inspection of the real product can be realized.

5. Acknowledgements

This work is supported by Grant-in-Aid (No. 15760020) for Young Scientists (B) of Japan Society for the Promotion of Science. We appreciate Dr. H.Ichinose for providing us a LC material.

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