（様式乙 1-3-2）

THE SUMMARY OF Ph.D. DISSERTATION

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Title

Detection of the Low-contrast Defects on Optical Sheets

Abstract

The purpose of the research is to develop the automatic inspection technique for the low-contrast defects on optical sheets, which are indispensable materials for liquid crystal display (LCD). In the LCD market, the demand for the high resolution and large-sized display is increasing rapidly. Therefore, it is important to detect the point defects and the low-contrast defects in the inspecting process. The former is defects that have similar size to the display pixel. In many cases, since the point defects have high enough contrast, it is possible to apply the conventional commercial equipments to the inspection process. The latter is low-contrast defects that can be recognized under a broader view. In contrast to the former, the automatic inspection of the low-contrast defects is difficult because of the following reasons.

i) It is difficult to design the optimum observation system, because the mechanism of the defect generation has not been clarified.

ii) Inspection standard of the low-contrast defects is indistinct and is not quantified.

This paper describes development of the automatic inspection technique for the slight convexo-concave defects and the color shading defects. These are the most serious types of defects among the low-contrast ones. The paper is composed of the following chapters.

Chapter 1 introduces the background of the research and review of the previous studies..

In Chapter 2 a detection method for slight convexo-concave defects using patterned illumination is proposed. The characteristic of the defects and problems on typical inspection equipments are explained in detail. The principle of the defect detection and the corresponding image processing algorithm is described. The successful detection results are shown.

In Chapter 3, in order to make clear the detection limit of the proposed method, a simulation method using ray-tracing is proposed, and the validity of the method is confirmed. Detection sensitivities for various defect shapes are estimated based on computer graphics images generated by the simulation. Then a selection method of illumination pattern size is introduced.

In Chapter 4 an estimation method of effective area in the patterned illumination that contributes to the defect observation is proposed. Furthermore, a design method of the optical system including illumination pattern and optical alignment is described.

In Chapter 5 a quantitative evaluation method of the color shading defects on the anti-reflection coating is stated. First of all, it is made clear that the defects are caused by local disturbance of coating thickness. Then the correlation between coating thickness and the defects are discussed. Furthermore, the limit of thickness change for non-defective area is indicated.

In Chapter 6 an inspection method of color shading defect based on the quantitative evaluation described in chapter 5 is proposed. Variation of defect appearance with coating thickness and observation angle is discussed. Then an inspection standard to judge the quality of anti-reflection coating, which is based on MacAdam's ellipsoid, is proposed.

In Chapter 7 a new method of the sensory inspection for shading defect is proposed. This method is based on the frequency distribution of fluctuation of defect features. The method is applied on two different types of shading defect. The results are much in accord with visual inspection by human operators.

Chapter 8 summarizes the conclusion of this study.