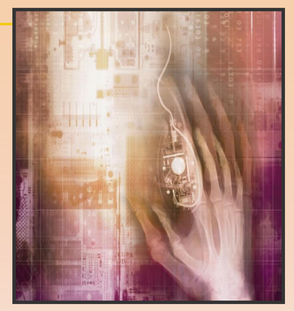
The feasibility study on Non-pixel detector using liquid crystal layer through simulation of transmittance and electric field



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1. INTRODUCTION

Digital X-ray radiographic systems are desirable as they offer high quality images which can be processed, transferred and stored without secondary steps. However, current clinical systems are extraordinarily expensive in comparison to film-based systems. Recently the improvement of about Pixel structured scintillator and needle-like columns scintillator growing technology make a presolution of medical image and large area fabrication have been a growing tendency in Digital X-ray Detector research. Though indirect conversion method, digital X-ray Detector has superior system performance like high stability, large area fabrication and use for dynamic moving image, there is light scattering problem which cause lowering resolution of image due to use of X-ray conversion material as a scintillator. The research progress to solve these problems, but it is less imaging resolution than direct conversion method. Direct conversion method, Digital X-ray Detector has higher resolution by shortening light conversion in X-ray conversion process, but its low system stability and high product cost and difficult in large area fabrication induce low use in commerce in spite of high resolution. Thus, there is a need for an economical digital imaging system for general radiology. The Non-pixel detector using liquid crystal layer is a novel digital x-ray detector concept with the potential for high image quality and low cost. This study has the laminate structure, Liquid Crystal on a-Se layer like Fig.1. However it is difficult to fabricate Detector due to the low surface uniformity of a-Se layer which affect on injection state and surface uniformity of Liquid crystal. In this study, novel structure model is suggested to solve this problem in fabrication of X-ray detector using Liquid Crystal and the possibility of suggested model is verified through simulation and experiment.

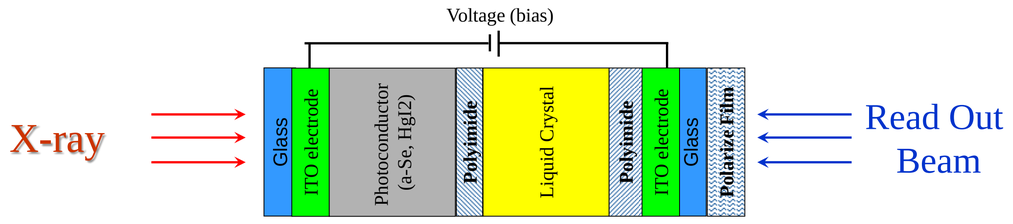
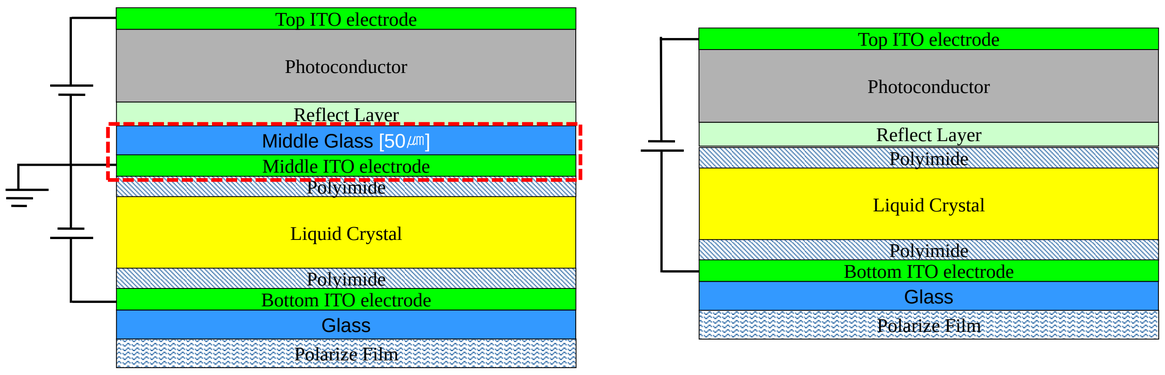


Fig.1 Operation principle of non-pixel x-ray detector using liquid crystal



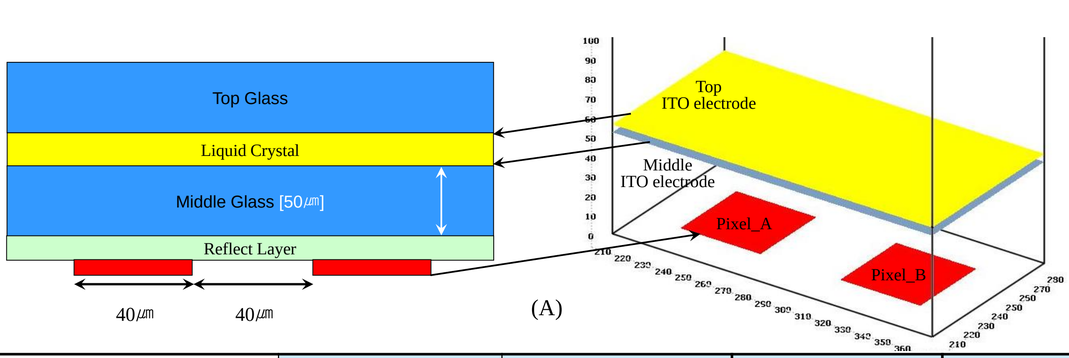
(A) New structure with middle layer (B) General non-pixel detector structure

Fig.2 Simulation Model structures

2. Simulation method & Results

The purpose of novel model suggested in this study is uniform injection of Liquid Crystal by using thin glass between Photoconductor Layer and Liquid Crystal Layer to solve fabrication problem in laminating process. It is possible to inject uniform Liquid Crystal in accordance with uniform glasses in this structure. Fig.2 is the cross-section of simulation model which has 50㎛ of Middle Glass between Photoconductor Layer and Liquid Crystal Layer. The difference between (A) and (B) in Fig.2 is presence of Middle ITO Glass under Middle Glass. Fig.2 (A) is three electrode layers structure including Middle ITO electrode and it applies different voltage to Liquid Crystal Layer and Photoconductor Layer. The simulation for non-pixel X-ray detector was simulated depending on the two condition.

In this research, the tech Wiz LCD 3D simulation tool was used to confirm the potential of new structures.(SANAYI system). The principal of non-pixel X-ray detector using liquid crystal is the twisting of Liquid Crystal molecule in accordance with transmitted electric field induced by X-ray. This is a potentially high-quality digital X-ray detector made of photoconductor layer and liquid-crystal cell, physically coupled in a sandwich structure. In simulation, the electric field from reciprocal action between X-ray and photoconductor was applied with electrode (Pixel A, Pixel B) upon middle glass. Also Top ITO electrode and Photoconductor was removed as shown in Fig3.



(A)

Factor 1.	Case1	Case2	Case3	Case4
Top ITO electrode	30V	30V	30V	30V
Middle ITO electrode	**27.5V**	**NO ITO electrode**	**Float (No Cap)**	**Float (Cap)**
Pixel_A	10V	10V	10V	10V
Pixel_B	-10V	-10V	-10V	-10V

Factor 2.	Case1	Case2	Case3	Case4
Top ITO electrode	30V	60V	300V	600V
Middle Glass Thickness (um)	**50**um	**100**um	**500**um	**1000**um
Pixel_A	10V	10V	10V	10V
Pixel_B	-10V	-10V	-10V	-10V

(B)

Fig3. (A) Simulation modeling structure , (B) Two simulation condition

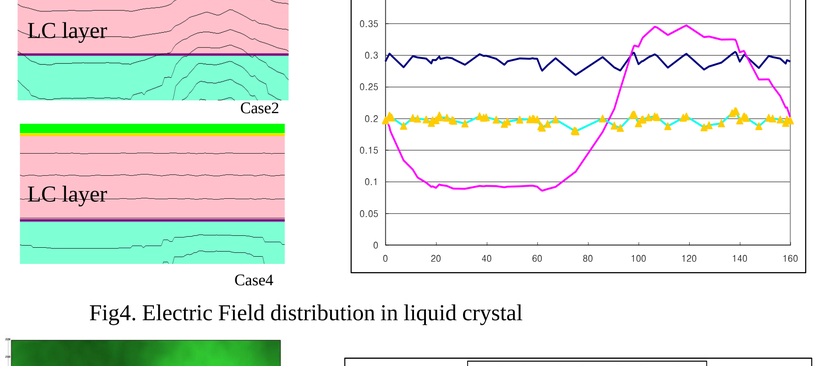


Fig4. Electric Field distribution in liquid crystal

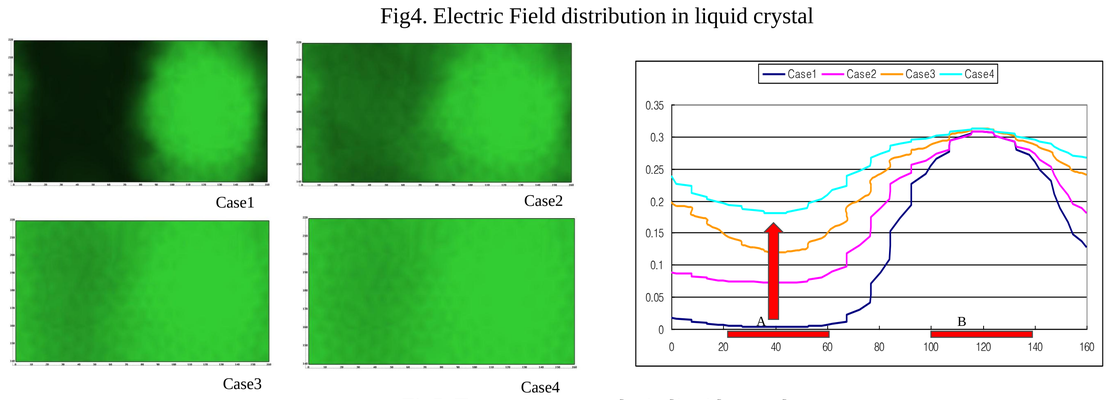


Fig5. Transmission results in liquid crystal

3. Experiment process & Conclusion

a) Liquid Crystal Fabrication

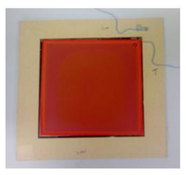
·Glass : Eagle-2000, thickness 500㎛
·Active area : Diagonal 4 inch
·Glass slimming : 50㎛

b) Dielectric reflect layer coating

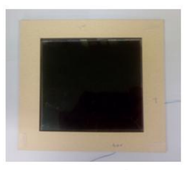
c) Photoconductor layer coating

·Material : Mercuric Iodide (HgI_2), Amorphous Selenium (a- Se)
·Coating method : screen printing , PVD
·Top electrode coating : sputtering system

c) Polarize film coating



HgI_2 sample



a-Se sample

Fig6. X-ray Film fabrication process & samples

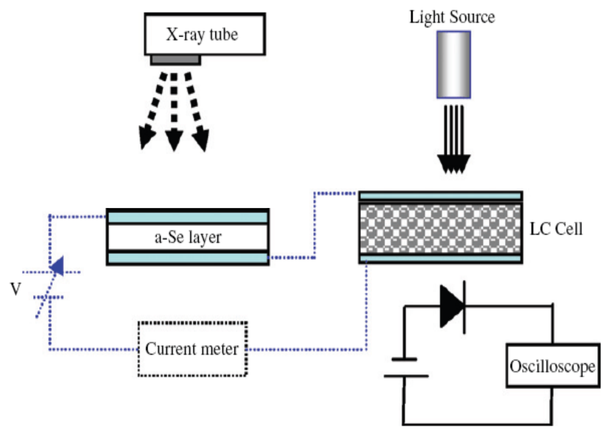
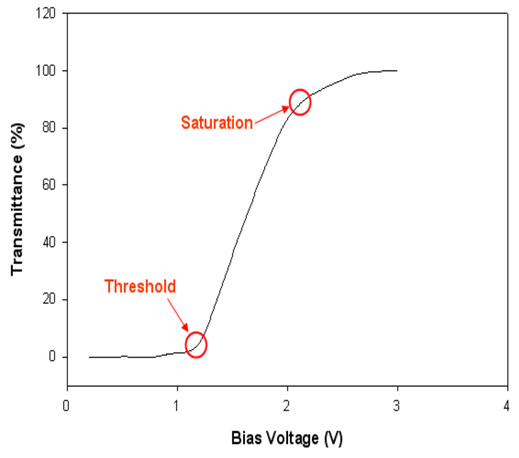


Fig7. Block diagram of equipment used to observe the electrical characteristic



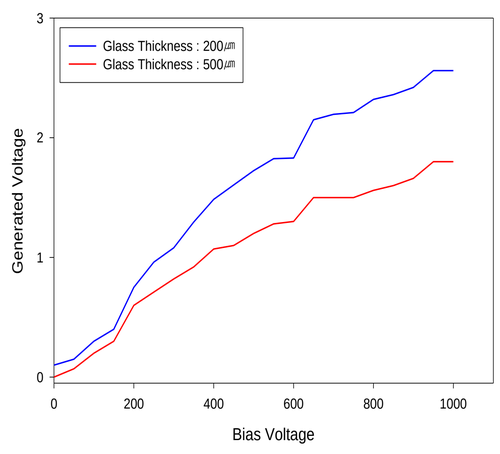


Fig8. The results of liquid crystal according to bias voltage

DISCUSSION

As a results of simulation, We have examined the influence of middle indium-tin-oxide electrode layer and glass thickness in non-pixel detector structure. First of all, it showed superior transmission in liquid crystal layer than other condition simulation in case of the thinner thickness of middle glass. As the second fact , in case the presence of middle electrode, the electric field in liquid crystal layer is not formed due to voltage distribution problem between photoconductor and liquid crystal interface. The non-pixel detector with liquid crystal fabricated based on the results of the simulation. Through the electric properties of two samples, we have found that the electron- hole pairs were generated in photoconductor by X-ray. And then, it affect the change in arrangement of molecules in liquid crystal. In other words, upon exposure to X-ray, charge is collected on the surface of the photoconductor, This cause a change in the optical properties of the liquid-crystal cell and a visible image is generated. Subsequently, it is digitized by scanned optical imager. This study made progress to solve such as structural problems to develop X-ray detector using Liquid Crystal. The simulation with two model condition, Fig3(B) were performed and Fig2(B) was evaluated as the structure which has possibility of X-ray detector using Liquid Crystal. Also, the results demonstrate the linearity transmission of Liquid Crystal against X-ray dose from experiment. In the future, we will make a study about charge collection efficiency in photoconductors and reproducibility on the fabricated X-ray films.

❖ Acknowledgement

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