Field emission display with catalysis cathode film material for graphite nano fiber

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Abstract

*We developed **new FED cathode film material** that has catalysis function for graphite nano fiber. Using the cathode film with catalyst, we can simplify the FED process. It is composed of Cr, Fe-Ni catalyst. Fabricating FED panel with the film, we confirmed good emission performance of the panel.*

1. Introduction

Field emission display (FED) is expected to be the lowest consumption of electricity in the flat panel displays, furthermore succeeds the amazing image performance of CRT. As a pioneer, Mo-spindt type emitter has been tried to FED, and recently carbon nano tube (CNT) has been tried to the emitter because it has an advantage of electric field concentration due to nano meter diameter tip.[1][2] However, CNT is grown by thermal CVD method higher than 600 degree C, or grown by PECVD method between 400 and 600 degree C.

Over 550 degree C, low cost glass substrates such as soda lime glass for PDP cannot be used because of higher temperature than the strain point of the glass. Graphite nano fiber (GNF) has the similar structure as CNT and can be grown by thermal CVD method lower than 550 degree C. We have developed FED using the GNF emitter these five years joined with ULVAC, and we got the GNF emitter that has good potential for FED, such as 30 volt of emission starting voltage, good enough emission current density, fluctuation, and life-time.[3][4]

Conventional fabricating process of FED with the GNF emitter includes catalyst deposition and lift-off. Lift-off process has the difficult issue since a residual of catalyst shall be a factor of defect on the FED panel. It needs long time to remove the resist covered the catalyst film.

The GNF emitters are grown with high density on the catalyst film. In such case, the emission is localized on the emission site because the concentrating of electric field on every tip is not strong enough to emit.[5][6]

In this paper, we propose a new FED process with a new cathode film including catalyst precipitates can omit catalyst deposition and lift-off in the conventional process. After we surveyed the best cathode material including catalyst to grow GNF and optimized conditions of thermal CVD on the selected cathode film, the FED panel with the cathode film was assembled, and I-V properties and light emission of FED panel was tested comparing the conventional processed FED with the GNF emitter.

2. Results

At the first step, catalysis function of GNF growing was tested on the several cathode film compositions to select the best material.

Cr-Fe and Cr-Fe-Ni were tested for the cathode film material with catalysis function. Cr-Fe and Cr-Fe-Ni were deposited to glass substrate for PDP by the sputtering method with Ar and/or N_2. After sputtering, GNF is grown on Cr-Fe film and Cr-Fe-Ni film at 525 degree C with CO and H_2 gas.

The process flow of FED cathode panel with Cr-Fe-Ni cathode is shown in Figure 1(a). The glass substrates for PDP were used. The Cr-Fe-Ni film was deposited by sputtering. After Cr-Fe-Ni film was patterned by photolithography method, silicon dioxide film as an insulating layer was deposited by sputtering. Cr film as a gate layer was deposited on the insulating layer by sputtering. After the gate layer was patterned lines and holes, the insulating layer was etched through the holes and then gate holes were made. GNF was grown in the emitter holes with CO and H_2 gas at 525 degrees C.

The process flow of the conventional process panel is shown in Figure 1(b). Cr film as a cathode, a gate layer, and silicon dioxide film as an insulating layer were deposited by sputtering. Fe-Ni catalyst film was deposited in the gate holes and on the surface of the resist. After lift-off, the catalyst was left in the holes. Finally, GNF was grown at 525 degrees C.

At second step, triode FED panel was assembled with conventional cathode panel or new process cathode panel and I-V property was measured. We used a vacuum equipment for testing I-V property as Figure2. FED cathode panel faced against the anode panel, ITO and the phosphor film coating on the glass substrate, with the spacer of 1mm gap.

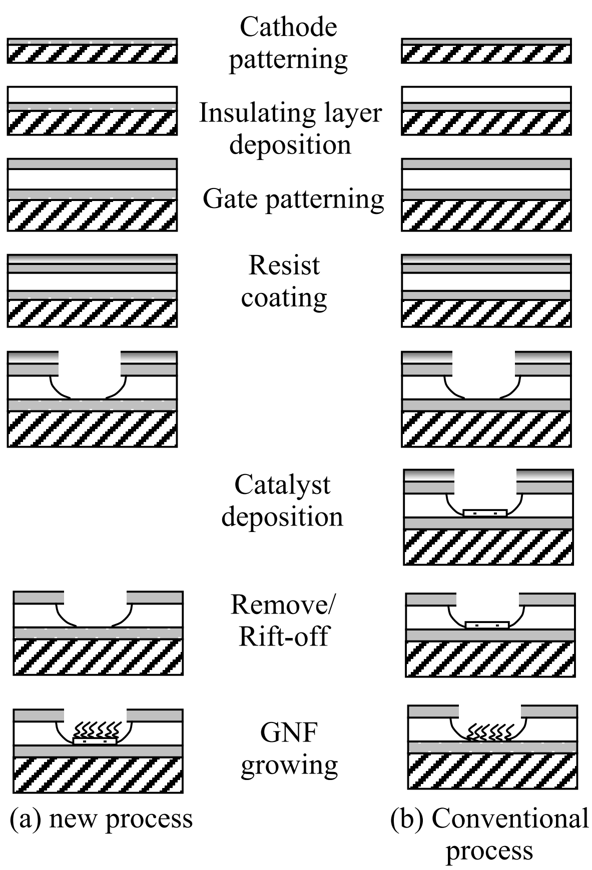


Figure 1. The process flow of FED cathode panel

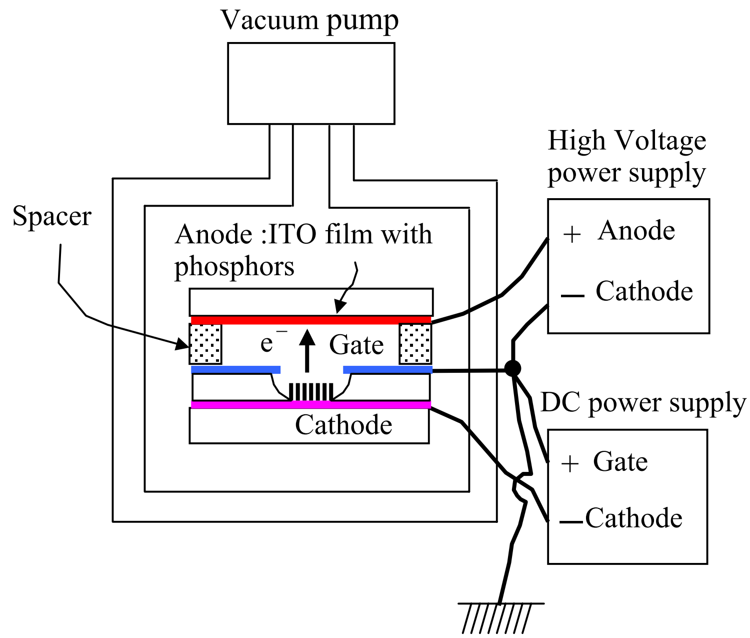


Figure 2. I-V property test equipment

The SEM images of GNF on the Cr-Fe film and Cr-Fe-Ni film were shown in Figure 3 and 4. GNF on Cr-Fe film grew not so high in Figure 3. However, in Figure 4 GNF on Cr-Fe-Ni film grew large when some amount of Ni was introduced and N_2 gas was added at cathode film deposition. Diameter of GNF was 20nm in Figure3, but that was 50nm in Figure4.

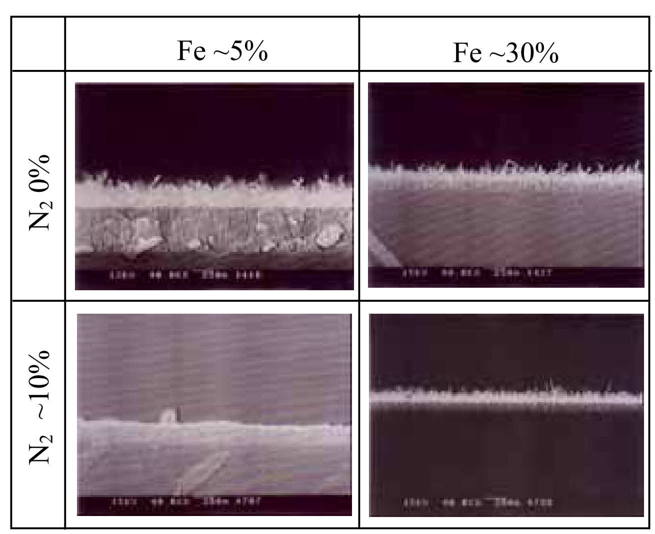


Figure 3. SEM cross-sections of GNF deposition on Cr-Fe_X-N system film
N_2: gas ratio to Ar at film deposition

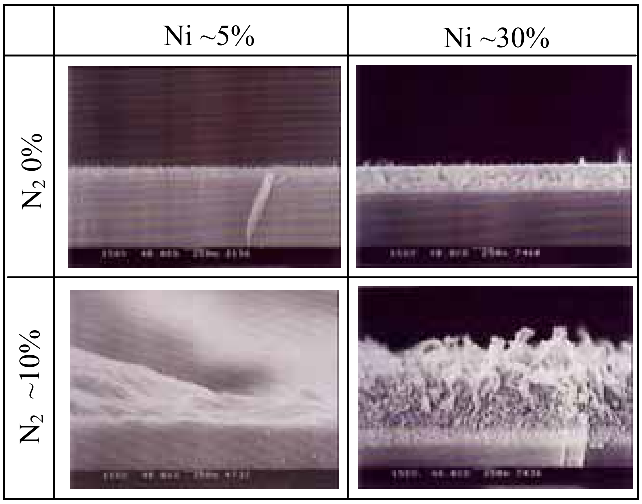


Figure 4. SEM cross-sections of GNF deposition on Cr-Fe_x-Ni_y-N system film
N_2: gas ratio to Ar at film deposition

XRD patterns of Cr-Fe-Ni films were shown in Figure 5. Fe-Cr or Ni-Cr was detected in Cr-Fe-Ni film, but Fe-N and hallow pattern were detected in Cr-Fe-Ni-N film. These data show that Fe-Cr or Ni-Cr phase precipitated in Cr-Fe-Ni film and Fe-N phase precipitated in amorphous phase of Cr-Fe-Ni-N film. The reason why GNF on Cr-Fe-Ni-N film grew largely is considered to relate with the fine Fe-N particle in the amorphous phase of Cr-Fe-Ni-N film.

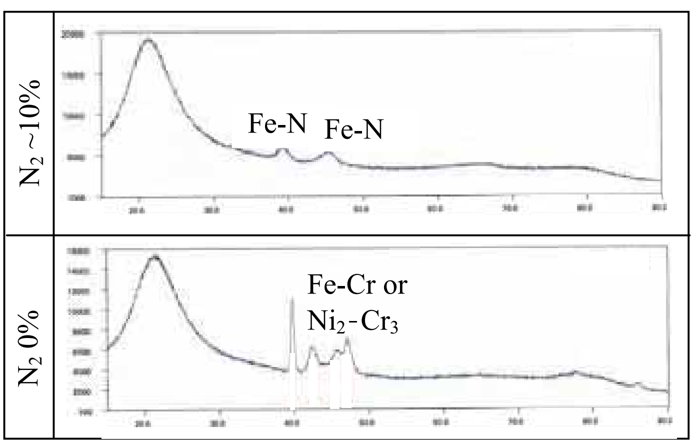


Figure 5. XRD patterns of Cr-Fe-Ni-N system films

The SEM images of GNF emitter in the gate hole were shown in Figure 6. At the new process panel, GNF grew uniformly on the whole bottom of the gate hole. However, GNF grew locally at the center of bottom in conventional FED panel. The GNF height of new process was about 0.3 µm and that of conventional was about 0.7 µm. At new process panel, the GNF emitters were same size on both cases of 3µm and 1.5µm thick insulating layer.

I-V properties of FED panels were shown in Figure 7. The emission current started at 40 V and emitted light was observed. In this time, the average current of new process FED panel was smaller than that of conventional one at 70 V. However, the range of current of new process panel was smaller than that of conventional one. After modifying insulating layer thickness and the gate hole structure in new process panel, emission current became same level as that of conventional panel. Optimizing the gap between height of GNF emitter and insulating layer could make better emission performance. The light emission of the new process panel in modified structure was shown in Figure 8. Some variation of emission can be shown in the line at this time, so it is necessary to improve uniformity.

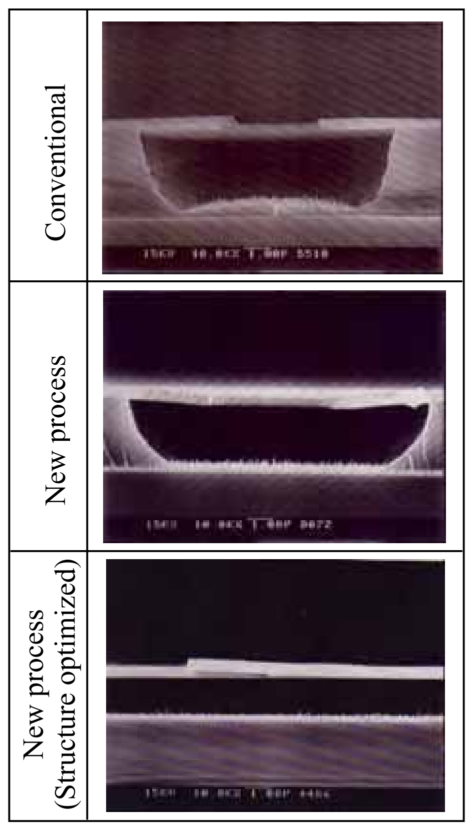


Figure 6. SEM cross-sections of GNF in the gate hole of FED cathode panel by conventional and new process

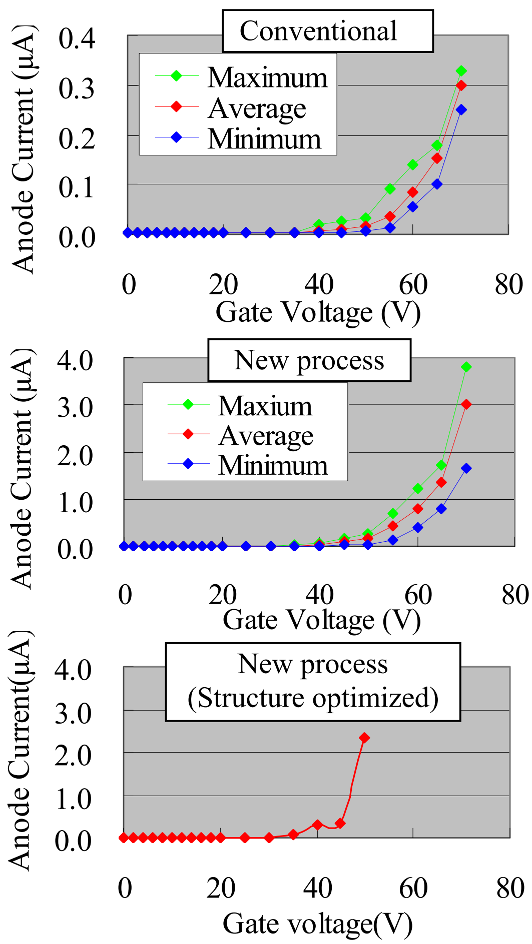
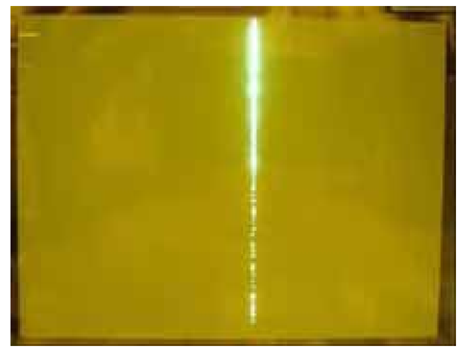


Figure 7. I-V properties of FED panels by conventional process and new processes

3. Conclusion

We surveyed a new cathode material including catalyst for the GNF emitter of FED. Cr-Fe-Ni-N film seems a promising candidate, as appropriate GNF was grown in proper combination with cathode material and thermal CVD. We think that fine Fe-N precipitation activates the catalysis property of this film and shows the good emission property from FED panel. Though there are many issues to be optimized, the new process using the new cathode material seems a good potential that cut manufacturing cost, since the lift-off process that generate the defects induced from catalyst residues can be omitted.



Anode voltage: 500V
Gate voltage: 50V
Gap of Anode & Cathode: 1mm

Figure 8. Light emission of new process FED panel optimizing hole structure

4. References

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