| | |
|---|---|
| | デバシッス　ゴシュ |
| 氏　　名 | DEBASISH GHOSH |
| 学位の種類 | 博士（工学） |
| 学位記番号 | 博第913号 |
| 学位授与の日付 | 平成25年12月18日 |
| 学位授与の条件 | 学位規則第４条第１項該当　課程博士 |
| 学位論文題目 | Development of transparent and flexible field emission display<br>（透明フレキシブル電界放射ディスプレイの開発） |
| 論文審査委員 | 主査　教授　種村眞幸<br>教授　曾我哲夫<br>教授　日原岳彦 |

# 論文内容の要旨


Transparency and flexibility are key words required for future bendable, lightweight and rollable display device applications. Among various types of displays, field emission displays (FEDs) offer promising advantages such as high brightness, wider viewer angle and less power consumption and very high response times. To achieve this, transparent and flexible following breakthroughs were necessary: (i) electrodes, (ii) electron emitters, and (iii) screen. In this dissertation, I tackled mainly the topics (i) and (ii) using nanocarbon materials, and by combining the oxide thin film transparent and flexible FED was demonstrated.

In Chapter 1, the background, a brief description of different displays and the purpose of this thesis are described in detail.

Chapter 2 describes the dispersion of single wall carbon nanotubes (SWCNTs) in 1,2-dicholoro ethane (DCE), and that the fabrication of transparent, conductive and flexible thin film using SWCNTs solution by spray coating on polymer substrate. By using this SWCNT film as both electrode and electron emitter, SWCNT-based transparent and flexible electron emitter with transmittance higher than 86% at 550 nm was first demonstrated.

Chapter 3 describes the development of the transparent and flexible anode phosphor screen for FED devices. For this purpose, Cesium Metavanadate ($CsVO_3$) was coated on the SWCNTs film on Arylite substrate at room temperature. By combining the SWCNT emitter developed in Chpater 2 with this phosphor screen, transparent and flexible FED was fabricated for the first time.

Chapter 4 describes the improvement in the conductivity for the cathode material using SWCNTs and conducting polymer Poly(3,4-ethylenedioxythiophene): poly(styrenesulfonate) (PEDOT:PSS) based hybrid structure. The field emission (FE) properties of the PEDOT:PSS/SWCNTs hybrid structure are dramatically increased than either PEDOT:PSS or SWCNTs material due to the emission properties of the SWCNTs material and the high conductivity of the PEDOT:PSS film. It is thus believed that the high conductivity of PEDOT:PSS material helps to the electron emitter SWCNTs, by continuous supply of electrons. Thus, the SWCNT-based transparent and flexible emitter with transmittance higher than 90% in the visible light region was achieved for the first time.

Chapter 5 deals with the improvement in the transparency and FE properties using the conical nanocarbon structures (CNCSs) fabricated directly on transparent and flexible nafion substrate by the irradiation with $Ne^+$ ions for short irradiation time (10 sec). The enhanced FE properties of the CNCSs and the transmittance higher than 90% in the visible light region can be achieved by simply coating a very small amount of SWCNTs dispersed solution on the CNCSs surfaces. Thus, the importance of the combination of SWCNTs and CNCSs was first demonstrated for the development of transparent and flexible FEDs.

Chapter 6 summarizes the present thesis and also focused on the future research work.

# 論文審査結果の要旨

Transparency, flexibility, and conductivity are key words required for the next generation of nanodevices, such as rollable displays. Among various types of displays, field emission displays (FEDs) possess promising advantages, such as high brightness, less power consumption and very high response times. To achieve transparent and flexible FEDs, (i) electrodes, (ii) electron emitters, and (iii) screen should be transparent and flexible. In this dissertation, the topics (i) and (ii) were mainly dealt with and a prototype of a transparent and flexible FED was demonstrated.

In Chapter 1, the background, a brief description of different types of displays and the purpose of this thesis are described in detail.

Chapter 2 deals with the fabrication of single wall carbon nanotube (SWCNT)-based transparent and flexible electron emitters. By using a simple spray coating of SWCNTs on polymer substrates, transparent and flexible electron emitter with transmittance higher than 86% at 550 nm was first demonstrated.

Chapter 3 describes the development of the transparent and flexible anode phosphor screen for FED devices. For this purpose, metavanadate phosphor coated on the SWCNTs/arylite film was used as transparent and flexible screen. The SWCNTs/arylite based electron emitters and the SWCNTs/arylite/metal-vanadate-based phosphor showed a transmittance value of 92.6% and 54%, respectively. Thus, a prototype of a transparent and flexible FED was demonstrated.

In Chapter 4, an efficient cathode material with high transparency (93%) based on conducting polymer poly(3,4-ethylenedioxythiophene): poly(styrenesulfonate) (PEDOT:PSS) and SWCNTs are developed. The field emission performance of the hybrid materials was dramatically improved compared to either SWCNTs and PEDOT:PSS, due to the hybridization effect of good emission property of the SWCNTs and the high conductivity of the PEDOT:PSS film. Thus, the SWCNT-based transparent and flexible emitter with transmittance higher than 90% in the visible light region was achieved for the first time.

In Chapter 5, a unique strategy to fabricate highly transparent and flexible FEEs based on conical nanocarbon structures (CNCSs) is proposed. The enhanced field emission properties of the CNCSs and the transmittance higher than 90% in the visible light region can be achieved by simply coating a very small amount of SWCNTs dispersed solution on the CNCSs/nafion surfaces prepared by the irradiation with $Ne^+$ ions for short irradiation time (10 sec).

Chapter 6 summarizes the present thesis and also focuses on the future research work.

These new findings were published in 5 high-impact factor journals including Chemical Communications (4 first author papers), and this is enough worth for PhD thesis.