International Journal of Engineering Continuity

The Design of a Detection Robot with OLED Display

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Abstract: OLED display has the advantages of self-illumination, wide viewing angle, fast response, small size, small weight, flexibility. It is a huge breakthrough in the field of display technology, and enhances the visual enjoyment and on-the-spot experience of people. With the rapid development of science and technology, the combination of OLED and robot has attracted attention from most of the fields. In this paper, the working principle, advantages and main application fields of OLED devices are introduced, and a detection robot with OLED is designed. The detection robot can accurately control the speed of the motor and the angle of the steering gear within a distance of 1,000 meters, and receive the images from airborne cameras in real time.

Keywords: OLED, robot, picture transmission, detector

Introduction

Display technology is a vital component of the information industry. (Kim et al., 2017; Lee et al., 2014; Pyo et al., 2016; Qu et al., 2017; Schwab, Schubert, Hofmann, et al., 2013). As the most effective method for presenting video and image data, display screens range from smart phones to enormous screens in stock exchanges. Every day, people are exposed to a variety of displays that provide them with information from all over the world. Display technology has become an integral element of our daily lives, industrial production, and numerous other facets. As a result, the demand for display technologies such as mobile phones, computers, and large-screen high-definition televisions, which have become the propelling force of display

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Received: June 21, 2023; Accepted: July 11, 2023; Publication: July 12, 2023.

technologies, continues to increase. (Kim et al., 2015; Schwab, Schubert, Müller-Meskamp, et al., 2013).

Organic electroluminescence (OLE) refers to the phenomenon that organic materials emit light under the excitation of current or electric field (Deppe et al., 1994; Dong et al., 2019; Fleetham et al., 2017; Fujii et al., 2004; Gaynor et al., 2013; Wierer et al., 2009; Xu et al., 2017). According to the different organic electroluminescent materials used, people sometimes call the devices made of small organic molecules as luminescent materials as organic electroluminescent devices, or OLED for short. The device made of polymer as electroluminescent material is called polymer electroluminescent device, or PLED for short. But they are generally called organic electroluminescent devices, also referred to as OLED. As is shown in Fig.1, the structure of OLED is generally a sandwich structure, that is, one or more organic films are sandwiched between a metal cathode and a transparent anode (Chou & Cheng, 2010; Pyo et al., 2016). After a certain voltage is applied between the electrodes, the luminescent layer film will emit light. OLED has many outstanding properties, such as ultra-thin, full curing, self-illumination, rich color, fast response, low driving voltage (3 ~ 12V), low power consumption, high efficiency, low production cost, good temperature characteristics, wide material selection range and soft display. Therefore, the application of OLED is much more than that of ordinary LCD, and it has a wide application prospect in various fields.

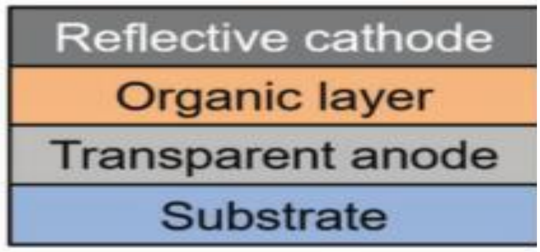

Figure 1 The Structure of OLED

Research Method

The Principle and Advantages of OLED

After more than a decade of development, the structure and functions of each layer of EL devices have become increasingly complex and intricate (Adamovich et al., 2003). Simultaneously, an increasing number of organic materials have been used to adapt to it. The device structure can be divided into single-layer device structures, double-layer device structures, three-layer device structures, multi-layer device structures, and doped devices based on the function of the organic film. Throughout this article, the operating principle of multilayer device structures is emphasized.

In order to optimize and balance the performance of organic EL devices, various functional layers with distinct functions are incorporated into the device design, as depicted in Fig. 2. The first is to add an injection layer (buffer layer) between the two poles, which reduces the interface barrier between the ITO electrode and the holes transport layer to increase the quantity of holes and electrons injected. In addition, the injection layer can improve the adhesion between the hole transport layer and the ITO electrode, enhance the hole injection contact, and balance the electron and hole injection. Another method is to augment the barrier layer. Electron barrier layer and hole barrier layer can frequently reduce the current traveling directly through the device without generating excitons, thereby increasing the device's efficiency (Kalinowski et al., 2011; Mizukami et al., 2006; Moorthy et al., 2007; Williams et al., 2008; Wong et al., 2005; Yang et al., 2007). In practical application, hole blocking layer is widely used, because the mobility of holes is higher than that of electrons. In order to prevent holes from crossing the organic light-emitting layer (ELL) too quickly and entering the ETL for quenching, a hole blocking layer is added between the ELL and ETL, so that as many holes as possible remain in the ELL layer to form excitons with the injected electrons, thus improving the luminous efficiency. The reason why these functional layers can play different roles is mainly determined by their energy level structure and carrier transport properties. The layers between the light-emitting layer and the cathode need to have good electron transmission performance; The layers between the light-emitting layer and the anode need to have good hole transport performance. In practice, depending on the specific situation, OLED devices may contain only a few layers.

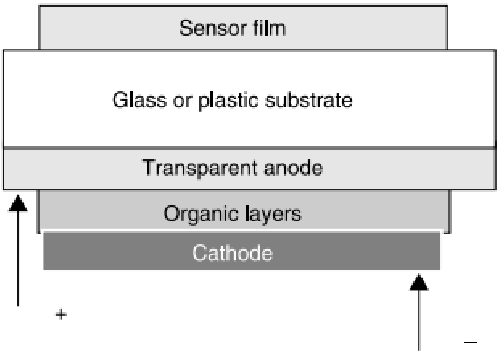

Figure 2 Multilayer Organic Light Emitting Device

As shown in Fig.3, the light-emitting principle of LCD mainly depends on the backlight layer, which is usually composed of a large number of LED backlights, and it has only one function, which is to display white light (Guarnieri et al., 2008; Mayr & Buchner, 2010; Soyguder & Alli, 2007). However, white light can't form an image, so a colored film is added on this white backlight layer, and the white backlight can show color after it penetrates through the colored film. Then, a control valve between the backlight layer and the color film is added to control the degree of opening and closing by changing the voltage, which is called liquid crystal layer. This layer can control the degree of opening and closing by changing the voltage. Thus, more light will be emitted when the opening and closing is large, and less light will be emitted when it is small. In this way,the amount of white light can be controlled and the ratio of red, green and blue can be adjusted.

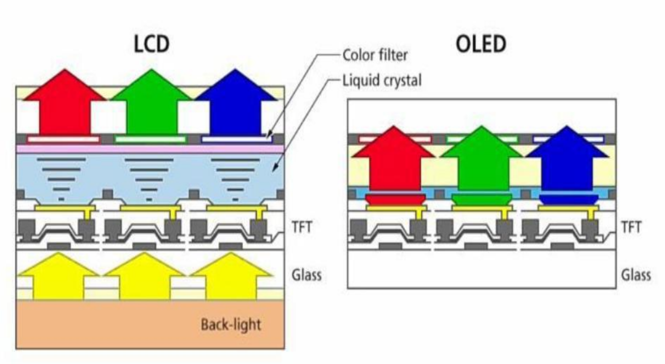

Figure 3 The Differences between LCD and OLED

Compared to LCD, the advantages of OLED mainly include the following points.

(1) The thickness of the core layer of the device is about one hundredth of a millimeter, which is much smaller than that of the liquid crystal device;

(2) The device is all-solid structure with no vacuum and good seismic performance;

(3) The active luminous characteristics of OLED make it much brighter than LCD, with large contrast and large viewing angle;

(4) The response speed of a single pixel of the device is 1000 times that of liquid crystal, which is beneficial to video playback;

(5) OLED has good low temperature resistance, and it can display normally at-40℃, which is obviously better than liquid crystal.

(6) OLED requires less materials, less producting process, and lower cost;

(7) High luminous conversion efficiency, low power supply voltage, no need of backlight, greatly reducing energy consumption;

(8) The single pixel of OLED device can be quite small, so it is very suitable for micro-display devices;

(9) OLED can be made into flexible and foldable portable displays on substrates made of different materials.

The Application Fields of OLED

There are two main application fields of OLED: one is as a display, and the other is as a lighting device. Pioneer Company introduced monochrome OLED car audio for the first time in 1997, and the organic display entered the commercial field for the first time. At the 2007 SID (Information Display Association) exhibition held in the United States last year, many companies exhibited OLED displays in various application fields, including TV, MP3, mobile phone, vehicle, white light source, flexible price tag and many other fields.

The Application of OLED in Display

OLED has won wide favor because of its advantages of no backlight, wide viewing angle, fast dynamic response and low power consumption. At present, OLED has gained a firm foothold in the application market of mobile phone sub-screen and MP3 player, accounting for 47% and 45% of OLED application market share respectively. As a display, OLED has been used in instruments, digital cameras, notebooks and televisions in addition to the traditional mobile phone display and MP3 display. Although this is still in the primary stage, the expansion of OLED application shows the broad prospects of OLED industry.

The Application of OLED in Lighting

Compared with other lighting sources, OLED is characterized by planar light emission, has the advantages of easier realization of white light, ultra-thin light source and arbitrary shape light source, and also has the advantages of high efficiency, environmental protection and safety. Therefore, as a new type of solid-state light source, white OLED has shown a good application prospect in lighting and flat panel display backlight. At present, the research of high-efficiency and long-life white light devices is the focus of OLED development in the field of lighting. Phosphorescence materials are widely favored in the field of white light illumination because of their high efficiency. In July 2006, Konica Minolta Technology Center successfully developed a white OLED device with a luminous efficiency of 64 lm/W and a luminance half-life of about 10,000 hours at an initial brightness of 1000 cd/m2, which is shown in Fig.4. The luminescent materials used in this device are all phosphorescent materials, and the blue light materials, which have been the bottleneck of phosphorescent materials, have achieved long life and high luminous efficiency. Under the initial brightness of 300 cd/m2, the brightness half-life of 16,000 hours has been achieved. At the SID exhibition in 2007, Japan developed a white light device reported by Kosuke, whose efficiency reached about 16.8 lm/W and its life span exceeded 40,000 hours. The luminescent material used in the white light device is fluorescent material, which is the most efficient fluorescent white light OLED at present. The development goal of white light OLED is to become a real flat white light source with low cost, high efficiency and long life. The challenge of white light OLED is to improve the efficiency and lifetime of the device under high current. The development and application of new materials and structures are expected to solve these two difficulties.

Figure 4 White OLED

Design of Detection Robot with OLED Display

In this paper, a detection robot based on STC15F2K60S2 single chip microcomputer is designed. The system wirelessly sends 6-channel remote control instructions through NRF24L01, of which four channels are controlled by two double potentiometer joysticks, which control the deceleration motor to drive the robot to walk and the direction of the camera pan/tilt, and the other two channels are controlled by two keys. The OLED screen of the handheld device can display the speed and angle of the detection robot. Part of the image adopts 5.8G image transmission module, the image sending module is installed on the robot and connected with the camera by wire, and the image receiving module is connected with the display screen of the control terminal.

System Scheme Design

The hardware system of the robot includes two parts: the transmitter and the receiver, which are mainly composed of the control module STC15F2K60S2, the steering gear module, the NRF24L01 wireless module, the OLED LCD display module and the image transmission module. The wireless module realizes the communication between the remote controller and the robot, and remotely controls the robot action. The OLED display module displays the motor speed and the angle of the steering gear. The steering gear is used to drive the camera on the robot to rotate, which is convenient for shooting different angles. The image transmission module is responsible for image transmission between the camera and the display screen. The system block diagram is shown in Figure 5.

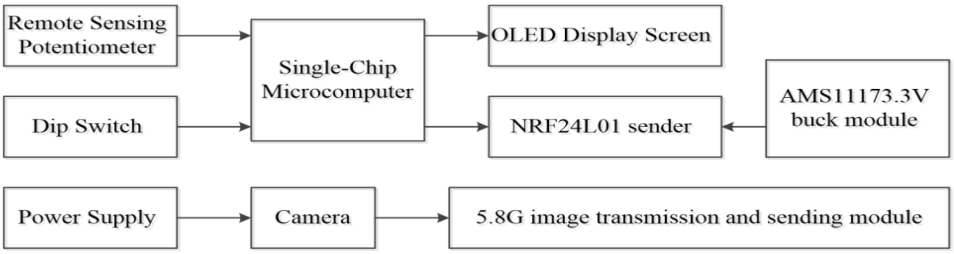

Figure 5 Block Diagram of Sender System

System Hardware Design

The STC15F2K60S2 single-chip microcomputer has a single clock cycle of 1T, a high-speed data processing function, and a 61-byte program memory Flash on the chip, which meets the requirements of the system for data processing speed. The system is powered by 12V power supply, which is stabilized by LM7805.After the chip is pressed, the voltage is converted to 5V and supplied to the MCU. The NRF24L01 wireless module transmits and receives information with the main control chip through software simulation SPI communication, and six pins are connected with the I/O of the single chip microcomputer. VCC requires the AMS1117 module to convert the 5V voltage to 3.3V voltage for the NRF24L01 wireless module, and the GND can be shared with the GND of the single chip.

The image transmission module is divided into a transmission module and a reception module, which communicate in the same frequency band. The image transmission module converts video signals into digital signals, sends them to the voice module of the image receiving end, and then converts them into video signals for display.

OLED is called organic light emitting diode, which has the advantages of small size and low power consumption. There are two types of data interfaces, SPI interface and IIC interface. The system adopts 7-pin 4-wire SPI interface communication mode.

The steering gear DC motor, motor controller and reducer are integrated into one body, which can realize the precise control of motor angle. There is a potentiometer or any other angle sensor inside the steering gear to measure the rotation angle of the central shaft, and the control board can accurately control and maintain the angle of the central shaft according to the data signal of the potentiometer or the angle sensor.

The software consists of main program and subprograms, and the main program combines all subprograms. There are subprograms: NRF24L01 wireless sending subprogram, NRF24L01 wireless receiving subprogram, OLED liquid crystal display subprogram and rudder subprogram. Realize remote control based on NRF24L01 wireless module, and accurately control the movement speed and direction of the robot and the rotation angle of the camera pan/tilt. The remote operation monitoring function of the detection robot is realized through the image transmission module.

The main flow chart of robot design is divided into sending part and receiving part. Send the remote control and robot control are completed by two single chip microcomputer systems at the end and the receiving end respectively. The main program of the sending end includes timer initialization and AD conversion initialization, and the subroutines include the digital-to-digital conversion subroutine of the remote potentiometer, the NRF24L01 wireless SPI communication subroutine and the wireless sending subroutine. The receiver main program includes NRF24L01 wireless SPI communication subroutine, wireless receiving subroutine, data receiving subroutine and peripheral control subroutine.

Result and Discussion

From tests result showed that the detection robot designed in this paper can remotely and accurately control the speed of the motor and the angle of the steering gear within a distance of 1,000 meters of the robot's action through NRF24L01+PA+LNA enhanced wireless module; 5.8G image transmission module is used to realize the communication between the airborne camera and the display screen of the control terminal so can receive the images in real time; LM7805 buck circuit makes the power supply of the system more efficient and stable.

Conclusions and Perspective

The development of OLED is very popular in the world, and it is considered that OLED will be a strong competitor of LCD at present. However, OLED still has some shortcomings, so how to overcome these shortcomings is the focus of research. In addition, the active matrix driven organic electroluminescent display technology, which combines robot technology with OLED, is the future development direction. In this respect, many enterprises are also innovating. A booming robot ecological environment is coming, and more innovative robots will appear to further change people’s life and work.

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