Alternative System for Data Communication based on Organic Devices and Links for Local Area Network

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Abstract-**Organic devices and links offer considerable potential for data communication by virtue of their ability to transmit, modulate and detect light in an architecture that is low cost, flexible, lightweight and robust. Here we have discussed an all organic optical communication system comprising of organic optoelectronic devices such as organic light-emitting diodes, organic photodiodes etc. for data communication. A polymeric (organic) optical fiber (POF) is used as transmission line connecting an organic light emitting diode and organic photodiode working as transmitter & detector respectively. A quasi solid state Dye Sensitized photo diode has been used as optical signal detector. Device characteristics including emission spectra, I-V-curves and the dynamic behavior for various optical components as used in this communication system have been recorded and analyzed. Such designed all organic optical communication system may be used for data communication in a local area communication network.**

Keywords: **Optical communication system, Organic photo detector, Organic photodiode, data communication**

I. Introduction

The rapid development of computer and telecommunication systems has led to dramatic improvements in computing power and data transfer rates. Though contemporary advancements pertaining to data communication technology has opened up new vistas of applications yet there exist various challenges pertaining to such communication technologies including higher data transfer rate, transmission distance, reduced cross talk and heat-dissipation. Optical interconnects based optical communication system offers considerable potential to minimize such problems. An optical interconnection based communication system is basically comprising of a light-emitting device as source (lasers or LEDs), a light-guiding channel (optical fibers or waveguides) and a receiver (photo-diodes).The light source can either be modulated actively or can be working in continuous wave mode using an additional modulator. The optical receiver decodes the transmitted signal utilizing a photo detector and subsequent electronics. Such optical interconnections based communication system is used for a wide range of applications. These systems can be used at several levels of a computer or a communication system like cabinet-to-cabinet,

Board-to-board and chip-to-chip. Besides the long-haul, for the internet protocol based high-speed data

Transmission, short-range applications, such as multimedia data transfer, is increasingly realized via optical links. Most of the commercially available optical interconnects based communication systems, particularly for low-speed applications with multimode fibers, are comprising of inorganic semiconductors based lasers, LEDs and photo-diodes. In last two decades organic semiconductor have been explored extensively in various applications due to their multiple merits over inorganic

semiconductors. Attractive features of organic semiconductor materials include the possibilities for large area ultra-thin fabrication, flexible and low-cost devices, high-throughput, low-temperature solution-processing technique based fabrication approaches such as spin-coating technique[7], screen-printing technique [8], spray-coating technique[9], ink-jet printing technique[10], doctor-blading technique[11] etc.

Organic semiconductors possessing such qualities may be used to fabricate various components of optical interconnect based optical communication system to design an alternative low cost all organic communication system. In principle, it is possible to realize a completely low-cost organic optical system[12] for local-area communications, connecting an organic transmitter (OLEDs i.e organic Light Emitting diodes[13] or OTFLs i.e organic thin film lasers[14]) and a receiver (OPDs i.e organic photodiodes[15-17]) with a plastic optical fiber (POF) as transmission line[18].A complete system made from organic materials could provide a highly integrated and very cost effective solution for optical interconnects. Organic devices like OLEDs and OPDs can be fabricated on all kind of substrates including silicon, glass and plastics. Direct patterning of organic devices on waveguides would significantly simplify the assembly process, avoiding the most expensive fabrication steps. Several components of optical interconnects based on organic semiconductors have been investigated recently. Ohmori et al. [1-3] demonstrated both organic light emitting diodes and organic photodiodes (OPDs) on polymeric waveguides for data transfer purposes. Electro-optic modulators based on organic materials have reached modulation frequencies in the 100 gigahertz regime [4-6]. Here we have discussed an all organic optical communication system comprising of organic optoelectronic devices such as organic light-emitting diodes, organic photodiodes etc. for data communication. A polymeric (organic) optical fiber (POF) is used as transmission line connecting an organic light emitting diode and organic photodiode working as transmitter & detector respectively. A quasi solid state Dye Sensitized photo diode has been used as optical signal detector. Device characteristics including emission spectra, I-V-curves and the dynamic behavior for various optical components as used in this communication system have been recorded and analyzed. Such designed all organic optical communication system may be used for data communication in a local area communication network.

II. Experimental Details

Figure 1 shows block diagram of proposed optical communication system based on all organic components.

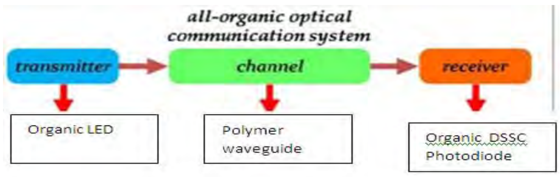

Figure 1: Block diagram of optical communication system based on all organic components

The system is comprising of three major parts namely modulated light source Organic Light Emitting Diode (OLED), polymeric optical fiber (POF) and organic photodiode (OPD). We have fabricated organic LED and Organic photo diode as transmitter and receiver respectively.

A. Fabrication of OLED

The OLEDs were fabricated on indium tin oxide (ITO) glass substrates. The ITO substrates were cleaned by ultrasonication in acetone and isopropyl alcohol and cleaned subsequently in an oxygen plasma chamber [12-13]. Hole transporting layer was formed by triphenyl diamine (TPD) . High vacuum thermal evaporation was used for deposition of the small molecule material Alq3 and to deposit top Al cathode layer. The structure of the OLED is as shown in Fig. 2.

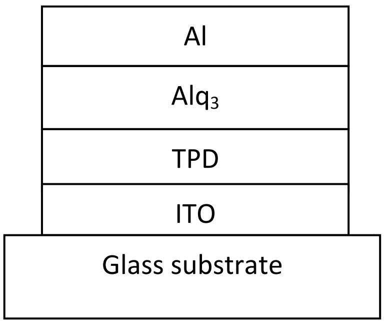

Figure 2: Structure of Organic LED

B. Fabrication of organic Dye Sensitized Photodiode

Fluorine doped tin oxide (FTO) glass plates were cleaned in detergent solution, rinsed with de-ionized water & acetone and dried in ambient conditions. A TiO2 colloidal dispersion was prepared A plastic adhesive tape was fixed as spacer on the three sides of conducting glass substrate (FTO) to restrict the area and thickness of TiO2 film. The prepared colloidal paste of TiO2 was spread over FTO substrate employing Doctor blade technique to obtain a nanocrystalline layer [19-20] . After the TiO2 layers get dried, the films were sintered at 450°C for 30 minutes in air to improve the electronic contact among particles and to burnout organic binders. We have oxidized standard Alizarin dye in alkaline medium. Solution of oxidized Alizarin dye was prepared in methanol. The DSSCs were made by clamping the photo electrode consisting of polymer electrolyte with counter electrode. We have fabricated quasi solid state DSSCs with the configuration of FTO / TiO2–Alizarin (oxidized) / polymer electrolyte / PEDOT:PSS coated FTO [22-23].Such fabricated Dye sensitized photodiode is as shown in Figure 3:

Figure 3 : Fabricated dye sensitized Photo Diode

C. Polymeric Optical Fibers (POF)

POFs are optical fiber made with plastic materials which transmit the light through the core. Size of such fiber is considerably larger than glass fiber. POF has also been called the "consumer" optical fiber because the fiber and associated optical links, connectors, and installation are all inexpensive. Among the different types, the poly(methyl methacrylate) plastic optical fiber (PMMA-POF[147]) is the most used for low-speed, short-distance (few hundreds of meters) applications in digital home appliances, home networks, industrial networks (PROFIBUS and PROFINET), and vehicle networks (MOST). PMMA-POF has three attenuation windows in the visible range, in particular the green window (450-540nm), with the absolute minimum at ~520nm; this attenuation window matches excellently the EQE maximum value of P3HT: PCBM devices (near λ=513nm). Therefore we have also used PMMA-POF as optical data link in this work.

D. Characterisation:

UV-Visible absorption spectra of organic materials used to fabricate devices was recorded using a Perkin Elmer Spectrophotometer (F-4500 model)[21]. The current–voltage (J–V) characteristics in dark and under illumination were recorded by a Keithley electrometer with built in power supply. The electrochemical impedance spectra (EIS) measurements were carried out by applying bias of the open circuit voltage (Voc) and recorded over a frequency range of 1 mHz to 105 Hz with ac amplitude of 10 mV. The above measurements were recorded with an Auto lab Potentiostat PGSTAT-30 equipped with frequency response analyzer (FRA).

E. Results and discussions:

The fabricated OLED was tested and their electroluminescence spectra was recorded as shown in figure 4. This LED shows the characteristic broad spectra of organic emitter materials. It exhibits an emission maximum at a wavelength of 520 nm . This LED can be easily interfaced with the polymer optical fiber.

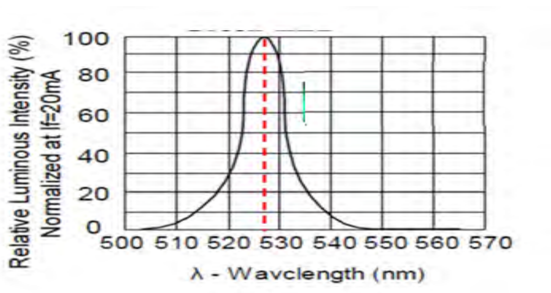

Figure 4: Electroluminescence spectra of OLED

Fig. 5 shows the The J–V characteristics of dye sensitized photo diode under illumination. The photovoltaic parameter, i.e. short circuit current (Jsc), open circuit voltage (Voc), fill factor (FF) and power conversion efficiency (η) was estimated from these curves. The value of overall power conversion efficiency is about 4.8%.

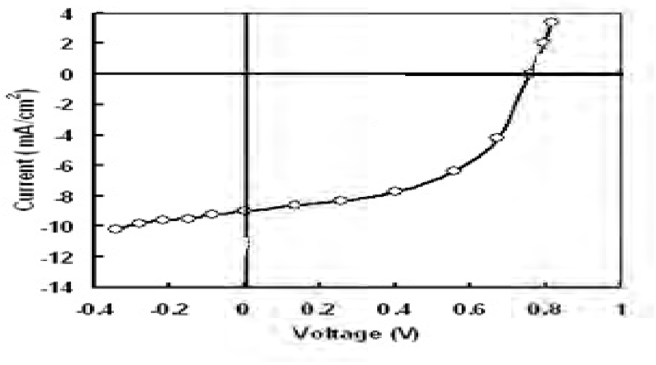

Figure 5: J–V characteristics of dye sensitized photo diode under illumination

Figure 6 shows functional structure of optical communication system based on all organic components.

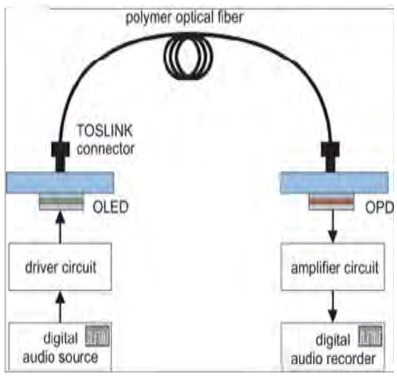

Figure 6: Functional structure of optical communication system based on all organic components

Here the Signal is applied after amplification and filtering to the OLED such that the light produced by the OLED is intensity modulated i.e the intensity of the light produced bty the OLED varies in accordance with the variation in the amplitude of the modulating signal. The so produced light by OLED is coupled to the POF for the transmission of the data in the form of light. At the receiving end the photo detector comes in to play. It converts the received light in to the electrical signal. The amplitude of the electrical signal is proportional to the intensity of the incident light through the POF. The so received signal is amplified and is fed to the receiving Oscilloscope and it was found the received signal almost resembles the transmitted signal.

III. CONCLUSION

An all organic optical communication system comprising of organic optoelectronic devices such as organic light-emitting diodes, organic photodiodes etc. for data communication has been discussed. A polymeric (organic) optical fiber (POF) made up of PMMA is used as transmission line. An organic light emitting diode using Alq3 as active layer was fabricated and characterized. This OLED was used as transmitter. A dye sensitized photo diode comprising of oxidized Alizarine sensitized TiO2 electrode was fabricated and has been used as organic photodiode to work as detector. Device characteristics including emission spectra, I-V-curves and the dynamic behavior for various optical components as used in this communication system have been recorded and analyzed. Functioning of this organic optical communication system has been explained on specific frequencies. Such designed all organic optical communication system may be used for data communication in a local area communication network. Moreover the POF provides higher data transmission rates in comparison to conventional silicon based optical fibers.

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