Recent Progress in Organic Semiconductor Materials and Devices

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This presentation reports the recent progress in semiconductor materials which can be used for the applications in organic light emitting diodes (OLEDs), organic thin film transistors (OTFTs) and organic photovoltaics (OPVs). The first OLED was reported by Prof. C. W. Tang in 1987. The concept of an bi-layer OLED was proposed. In this device, an organometallic compound, Alq_3 was as a light emitting and electron transport material and triaryl amine was used as a hole-transport material. Thereafter, multilayer OLED was proposed. Besides the light emitting layer, hole-transport layer and electron-transport layer, hole-blocking and electron-blocking layers were introduced in this device to enhance the light emitting efficiency of an OLED device. Another major breakthrough in OLED is the invention of triplet material to enhance the quantum efficiency from 25 % to 100 %. An iridium complex, $Ir(PPy)_3$ was synthesized by Thompson and Forest in 1998. The phosphorescent material plays the major role in high luminescent and high efficiency OLED devices. Today, OLED technology is used in commercial applications such as displays for mobile phones and portable digital media player, car radio and digital cameras. Solid state lighting is another potential commercial product for OLED technology. Polymer light emitting diode (PLED) was invented by Prof. R. Friend in 1990. A conjugated polymer, poly (p-phenylene vinylene) was placed between ITO and Al electrode, emitting green-yellow light under applied voltage. The polymer can be processed in solution, and spin-coating in a common method of depositing thin polymer film.

In recent years, energy-related issue have received considerable attention concerning the rising cost of fossils and growing global green gas. There is an urgent need to develop clean and renewable energy technologies. The largest potential source of renewable energy is the solar energy incident on the Earth's surface. An OPV cell deals with conductive organic polymers or small organic molecules for light absorption and charge transport to produce electricity from sunlight by the photovoltaic effect. The first OPV cell was also invented by Prof. C. W. Tang in 1986. A p-type layer for hole-transport and n-type layer for electron transport was proposed for a bi-layer hetero-junction photovoltaic cell. The power conversion efficiency (PCE) of such kinds of cell is only 1 %. A major breakthrough is the invention of bulk hetero-junction cells, devices incorporating a blend of poly (3-alkylthiophene) and a fullerene derivative, [6,6]-phenyl-C60-butyric acid methyl ester (PCBM), have approaching 5 %. During the past few years, several important low-band gap polymers with enhanced absorption abilities have appeared. Researchers made a breakthrough in fabricating OPVs with PCEs up to 10 % based on tandem cell and low band gap polymers. OPVs offer great potential for fabricating of low cost, large area, light weight and flexible devices by using printing and coating technologies.