CHAPTER I

INTRODUCTION

The push towards flexible electronic materials has been evident in the past decade. Achievement of this new promising concept can easily lead to flexible displays and optoelectronics, as well as more novel ideas such as smart textiles, photovoltanic cells, and building lighting. Among the flexible electronic displays, organic light emitting diode (OLED) [1] is a versatile platform system that has attracted worldwide attention. OLED has been traditionally fabricated on rigid glass sheet substrates [2]. Although flexible polymer substrates have been expected as potential alternatives in replacing the glass substrate [3-6] , the use of conventional polymer substrates has been limited by their coefficient of thermal expansion (CTE). Okahisa et al. [7] and Choi et al. [8] suggested that the CTE of the substrate should be restricted to 20 ppm/K at most, as the thermal expansion of the substrate can lead to the destruction of functional materials of the OLED circuit during the temperature fluctuation in OLED assembly and mounting processes.

To overcome the CTE limitation of the flexible polymer substrate, our previous works have focused on the exploitation of the nanocomposite of nano-sized cellulose and polymeric matrices [9, 10]. Bacterial cellulose, which is a nano-sized extracellular product of the bacteria strain *Acetobacter xylinum*, has the CTE of as low as 0.1 ppm/K [11] . The incorporation of bacterial cellulose into polymeric matrix can be expected to yield a nanocomposite film with much decreased CTE. Bacterial cellulose has the typical thickness and width of 10 and 50 nm [11]. Its nano-entity will allow the fabrication of optically transparent OLED substrate as any element with size smaller than one-tenth of visible light wavelength is free of visible light-scattering [12, 13]. Bacterial cellulose is also an outstanding reinforcing agent for the design of environmentally friendly nanocomposites. It is renewable and biodegradable. The Young's modulus of its single fibril was measured to be as high as 114 GPa [14] . It also has attractive features of high degree of crystallinity (89 %)

[15], high degree of polymerization (14400) [16], and high specific area (37 m^2/g) [17].

However, one limitation of cellulose-based nanocomposites in electronics application is the hydrophilic nature of cellulose. Electronic devices, especially OLED, is highly sensitive to moisture. For an OLED lifetime of > 10,000 hours, the low water vapor transmission rate (WTVR) of 10^{-6} $g/m^2/day$ is required [8, 18]. Water vapor can oxidize metallic cathode and active organic materials, and thus drastically reduce the lifetime and efficiency of OLED. In order to overcome this issue, various barrier technologies have been investigated [18-21] . The critical challenge lies in the creation of barrier material that offers flexibility and optical transparency. The reflective index (RI) of the barrier must also match that of the nanocomposite, as mismatching RI will disrupt the transparency of the OLED substrate. In this part, we tackle the barrier challenge by coating the bacterial cellulose OLED substrate with Si-O layer. Optically transparent Si-O barrier film with the thickness in nano-scale was deposited through plasma enhanced chemical vapor deposition (PECVD). Si-O film prepared through this technique offers the epitaxial crystal growth on surface with excellent uniformity and adherence to the substrate[19-21]. PECVD uses the ion bombardment on the surface, allowing the possibility of depositing high film quality at low temperature [22].

Furthermore, we wish to develop the surface smoothness of bacterial cellulose nanocomposite by ferrofluid solution. The ferrofluid solution was successfully synthesized by the wet chemical synthesis of Fe salt that was well responded under magnetic field. In order to reduce surface smoothness, ferrofluid solution was put between magnet and nanocomposite. Then, it was rotated under Y-axis.

The objective of this research was further continuously developed for printed electronic. Anode, cathode and emissive layer were prepared and deposited layer by layer on our bacterial cellulose nanocomposite.

The research proposal includes the literature reviews of related work, research objectives, methodology, preliminary results, discussions, and conclusion. Results were divided into 7 chapters; chapter 5 describes the preparation of transparent and flexible bacterial cellulose nanocomposite, chapter 6 describes the preparation of super thin glass (Si-O) as barrier layer for water vapor transmission rate (WVTR) reduction and maintaining the device lifetime, chapter 7 describes the synthesis and application as nano-abrasion of ferrofluid solution under magnetic field in order to reduce the surface smoothness of bacterial cellulose nanocomposite. Then, chapter 8, 9, 10 and 11 were described the preparation of anode, cathode and emissive layer for printed electronic propose.