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Inkjet Conductive Inks for Printing Textile Materials and Applications *

Yang-Pei-Qi Yi, Yi Li*

School of Material, Oxford road, Manchester, M13 9PL, United Kingdom

Abstract

The inkjet printing technique has been rapidly developing for the realization of flexible electronic devices. The antennas, sensors and transistors have been successfully introduced on flexible substrates such as glass, silicone and many films. Since the inkjet printing technique is a direct writing process, the benefits include flexible design, low-cost and environmentally friendly. It is also possible to create a high resolution of printed lines. Therefore, this technique is believed to have a great potential for applying on textile substrates. However, the challenge is to ensure that the small droplets can penetrate through the thickness of the fabric in order to spread along the threads. Thus, the uniformity and continuity are not acceptable for practical applications. This paper summarises inkjet printing technologies and potential applications on textile substrates.

Keywords: Ink Jet Printers; Conductive Material; Smart Fabrics

1 Introduction

E-textiles are defined as textiles that enable electronic components such as sensors, batteries, light, chips and small computers and electronic circuits to be embedded and built from fibres and textile structures. E-textile is designed to sense, react with, and adapt to external conditions or stimuli in a manual or programmed manner [1]. An important target is to achieve conductive property. Traditionally, textile-based wearable devices are manufactured through weaving, knitting, sewing and embroidering conductive threads inside non-conductive substrates. Traditional technologies face limitations such as difficulty in obtaining a homogeneous line width and gap [2] and the significant skin effect that occurs at high frequency [3]. Hence, inkjet printing technology is a promising method to provide thin conductive films with very high resolution. The inkjet printed line and space dimensions can be as small as 10-20 μm, which is at least one-fifth of a screen printed

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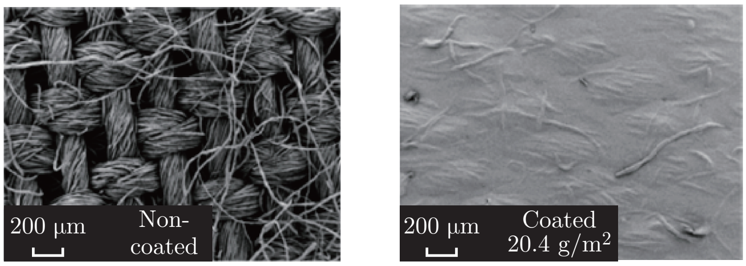
*Corresponding author.
Email address: henry.yili@manchester.ac.uk (Yi Li).

line [4]. At present, this technique has formed conductive tracks on the smooth, homogeneous, impermeable and non-deformable substrates like paper [5], PET [6], PDMS [7], Kapton [8] films. Although the inkjet printing technology provides an ideal approach to produce entire electronic circuits, the textile substrate itself hinders the development. The rough and porous surface results in a discontinuous track with low resolution because the droplet penetrates through the thickness of fabric and then spreads along the yarns [9]. The typical solution to overcome the roughness and porosity is coating a hydrophobic interface layer. As shown in Fig.1, the crimps and gaps between fibres and yarns are filled after coating. The average thickness of the interface layer is around 100 μm with a surface roughness of 5 μm [10]. This paper reviews the inkjet printing techniques and discusses the potential applications on textile substrates.



(a) (b)

Fig. 1: Comparisons of (a) non-coated and (b) coated fabrics [11] Copyright© 2017 American Chemical Society

2 Inkjet Printing Techniques

Before the development of inkjet printing, printing technologies such as gravure, flexography, lithography and screen printing have been used to print inks on textile substrates. The conventional graphics printing produces images made up of isolated drops, while the functional materials printing require the drops to overlap to form lines or continuous areas from the overlap of lines [12]. Table 1 compares the advantages and disadvantages of various printing technologies. The inkjet printing technology has bright future because it only needs to follow a pre-designed computer layout and directly creates a pattern without utilising masks. The inkjet printing technique is divided into direct printing or indirect transfer printing. In general, the direct printing process deposits conductive inks on the desired substrate, while the transfer printing process firstly prints on a transfer paper then heat transfers to the desired substrates [13]. The limitation of transfer printing technique is only suitable for the heat resistance polymers, while the direct printing process has no restriction to substrates [14].

2.1 Printable Inks

The printable ink has wide range of choices such as conductive, semi-conductive, and physical inks. Usually, the conductive inks are separated into metal nanoparticle inks, organometallic inks, conductive polymers, graphene ink and carbon nanotubes ink [16]. The metal nanoparticle ink is an excellent choice due to the high surface area to volume ratio. Hence, metal nanoparticle inks get unique properties including electronic, magnetic, optic, catalytic, and thermody-