11.4 Fabrication of a printed, flexible temperature and humidity sensor device that is technology enabler for IoT

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The Internet of Things (IoT) has been a key driver for the development of sensing devices to monitor environmental conditions for a range of real world applications. The temperature sensor market has an estimated worth of around $20billion in the US alone and it is proposed this market will be worth $40billion by 2022 [1]. Many types of temperature sensors exist from simple thermometers to high temperature resistance detectors (RTDs). At present fully printed temperature sensors make up only a small fraction of this market with estimated sales of $5.3million (US) in 2017 [2]. However, it is forecast that this will grow significantly with a compound annual growth rate of 65% to 2025 leading to a market estimated at over $100million. Temperature sensors can be used in almost every IoT environment, for instance, to measure and monitor the temperature of a package containing a high value, thermally-degradable product. Humidity is another key factor that could affect the integrity of a product.

In this paper, we summarise the manufacture of an Atomic Layer Deposition (ALD) enhanced screen-printed temperature and humidity sensing system. The sensor is integrated with an antenna for data transmission over an NFC protocol to a Bluetooth enabled device, such as a smartphone, running a bespoke application. These sensing devices have been printed on a flexible PET substrate, using commercially available inks for all aspects of the device architecture. ALD is an important technology for organic electronics. Aluminium oxide deposited by ALD has been used to encapsulate the device and differentiate the sensor response to environmental stimuli, allowing for the collection of both temperature and humidity data. The optimal sensor architecture has been fine-tuned using a femtosecond laser tool. This was achieved by laser ablation of the screen-printed sensing material. This offers high precision digital patterning, ablation and singulation processes.

The sensor devices have been tested on a wide range of temperature and humidity conditions of interest for the packaging application market. For a temperature stimulus in the 20-90°C range the response is linear, while there is an exponential change in the relative humidity response between 10-90%.

References (optional)


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