Final Publishable Summary for 14SIP04 TF-Plastic - Standardisation and Dissemination for Measurements of High Performance Barrier Layers

Overview

This Support for Impact (SIP) project builds on the improved measurement techniques for water vapour transmission rates (WVTR) of barrier materials developed in EMRP joint research project IND07 Metrology for the Manufacture of Thin Films (Thin Films). These measurement techniques for WVTR are important for high-value technologies, from electronic displays to solar cells, where the barrier materials are used to protect electronic devices from exposure to moisture which can damage performance.

Prior to this project, there was a need for the measurement techniques developed in the IND07 Thin Films to be made available to organisations beyond the metrology community.

This project therefore incorporated the work of the IND07 Thin Films project into standardisation, and supported uptake by European industry. This project has also contributed to the development of traceable measurement WVTR facilities that will enable industry to test innovative thin film materials, commercial instrumentation and electronic devices.

Need

One of the biggest challenges for emerging technology based on organic electronics and graphene is assuring the lifetime of the product. These thin film materials are highly sensitive to moisture and oxygen, therefore, reliable measurements to determine the performance of the encapsulating barriers is essential for the future success of this technology. For example: organic thin film LEDs used in phones and televisions need moisture barriers capable of preventing the ingress of even a few micrograms of water per square metre per day – roughly equivalent to one drop across an area the size of a football pitch over a month.

The preceding project IND07 Thin Films developed a traceable measurement system, which reliably assesses the water protection capability of barrier layers manufactured to protect thin film electronic devices, at these very low levels. This measurement system has the capability to allow industries producing devices such as light emitting diodes and solar cells to determine whether the barrier layers provide adequate protection. However, effective dissemination of the measurement protocols and the know-how developed in the IND07 Thin Films project via documentary standards was challenging due to the technology not being sufficiently mature. Now with barrier materials being used more widely in industry, and the technology having matured considerably across Europe, the need for standardisation to provide specific advice to industry and end-users on how to conduct and calibrate measurements correctly is vital.

The Centre for Process Innovation (CPI) identified the need for written advice and standards supporting best practice, as well as a measurement system accessible to industry and the highest measurement accuracy. CPI is a UK-based technology innovation centre and has very strong links to industry throughout Europe. CPI uses applied knowledge in science and engineering combined with state of the art facilities to enable its clients to develop, prove, prototype and scale up the next generation of products and processes. Therefore, this project worked with CPI to develop a capability for the measurement of WVTR in barrier materials. The project also addressed the need to incorporate the measurement protocols and techniques developed in IND07 Thin Films into international standards, thus supporting their uptake across European industry.

Objectives

1. To incorporate the measurement protocols and techniques developed in project IND07 Thin Films into standardisation (e.g. under ISO/TC 61 Plastics, IEC/TC 119 Printed electronics and via the Organic

Electronics Association (OEA)) to support their up-take and dissemination and in order to enable European industry to make accurate, traceable and comparable measurements.

2. To transfer the knowledge developed in project IND07 Thin Films to the primary supporter (CPI) and contribute to the development of traceable measurement WVTR facilities that can be used by industry to test and validate innovative thin film materials, commercial instrumentation and electronic devices.

Results

Incorporate the measurement protocols and techniques developed in JRP IND07 into standardisation (e.g. ISO/TC 61, IEC 119) to support up-take and dissemination and enable European industry to make accurate, traceable and comparable measurements.

A new work item was submitted to ISO/TC 61 "Plastics", aimed at providing over-arching guidance for the measurement of water vapour transmission rates. It considers general quality aspects and the sensitivities of a variety of measurement parameters of WVTR. There is also a particular focus on measurements of WVTR below 1 x 10^{-4} g m^2 day^{-1} for application in organic electronics, where the largest measurement challenges lie and where there is the most pressing requirement from industry to have confidence in measurement comparability. This work item provides best practice guidance on a range of processes in the measurement of WVTR such as test conditions used (relative humidity and temperature), sample preconditioning, lag-time, specification of gases and reagents used and measurement traceability to improve measurement comparability and provide a basis for quality assurance of products. Until now there has been a lack of comparability in reported measurements of WVTR due to the wide variety of techniques, experimental conditions used and differences in opinion about the qualitative and quantitative nature of the methods. This had created inconsistencies in reported data that impact on the development of barrier materials. Therefore there is an urgent requirement for standardisation of WVTR and the best practices that this work item proposes.

NPL chaired and organised a one day stakeholder meeting on standardisation for encapsulation of plastic electronics in cooperation with the Encapsulation Working Group of the Organic Electronics Association (OEA), a group that aims to provide guidance to the organic electronics community. The stakeholder meeting was attended by over 30 experts and discussed current standardisation activities for encapsulation of plastic electronics and the requirements from a variety of end user/ industrial stakeholders. Discussions focussed on general quality aspects and sensitivities in the measurement of water vapour transmission rate, new technologies, adhesives, mechanical properties and test architectures. The meeting outputs were used as a contributed to the new work item submitted to ISO/TC 61.

To transfer knowledge developed in IND07 Thin Films to the primary supporter (CPI) and contribute to the development of traceable measurement WVTR facilities that will enable industry to test and validate innovative thin film materials, commercial instrumentation and electronic devices.

CPI is a UK based technology innovation centre which was established to support the UK process manufacturing industry, CPI collaborates with universities, SMEs and large companies to help overcome innovation challenges and develop next generation products and processes. The CPI is well-placed to work with this project to develop WVTR measurement facilities, and through its interactions with the end user communities working in organics electronics to make such facilities available to industry.

NPL reviewed the existing CPI facilities, and knowledge from IND07 Thin Films was used to develop a plan to build a new measurement system at CPI, in order to provide high accuracy WVTR calibrations, traceable to national standards.

Using this plan the new facility for high accuracy WVTR calibrations was construted at CPI. Training of CPI staff on the new facilities was then followed by an evaluation of the performance of the new CPI facilities for high accuracy WVTR calibrations. Finally, NPL prepared a protocol for best measurement practice for traceable WVTR measurement facilities for adoption by CPI (2017). Certain aspects of this protocol are already being used at CPI, with full adoption planned as further developments (i.e. optimising the system) take place on the facility.

Impact

Benefits to the immediate user communities

Exploitation of the outputs from IND07 Thin Films has directly benefitted the primary supporter CPI as it has instilled a greater understanding of the sensitivities of various WVTR measurement parameters, such as test conditions used (relative humidity and temperature), sample preconditioning, specification of gases and reagents used and measurement traceability, therefore improving measurement comparability in the measurement of WVTR within CPI.

The project has also resulted in the development of a capability for high accuracy WVTR measurements that is traceable to reference standards. The outputs of IND07 Thin Films were transferred, as part of this project to CPI in the form of guidance on the design and assembly of the facility and subsequent high accuracy WVTR calibrations. This facility benefits customers, who are provided with quality assurance of products and information to assist in the development of barrier materials.

Standardisation

As a result of this project NPL is now leading a group devoted to developing standards for encapsulation of organic electronics which has enabled the outputs from IND07 Thin Films to be exploited and to maximise the up-take by industry. This has been achieved by working with the ISO/TC 61 sub-committee SC11, working group WG3 “Plastics”, to provide input to a new draft documentary standard for WVTR measurements. The outputs of IND07 Thin Films identified the critical parameters in the measurement of WVTR, and their sensitivities with respect to measurement accuracy and uncertainty. The new work item delivered to the committee as part of this project focussed on guidance to improve the accuracy of WVTR measurements and their estimated uncertainties. It used the outputs from IND07 Thin Films to set out the most critical parameters in the measurement equation so that these are considered and adopted in measurement facilities for WVTR worldwide. This widespread adoption has already started with CPI and its customers, and will provide the basis for future improvements in international comparability of WVTR measurements.

International industrial bodies such as the OEA recognise encapsulation as one of the major considerations in the quest to make applications based on flexible and printed electronics viable. The working group dedicated to encapsulation highlighted a critical need for standardisation, accuracy and more reliability in measurements of the WVTR of barrier layers. Involvement in this OEA working group has resulted in the dissemination of outputs to the relevant communities of manufacturers, suppliers and end-users. Direct beneficiaries of this include manufacturers of products based on organic electronics and graphene, barrier producers, instrument manufacturers for measuring degradation and encapsulation, standardisation committees, testing labs and the metrology community who have benefitted from better quality data for WVTR to aid their decision making.

Potential Impact

By supporting the adoption of new measurement methods through the development of new standards, the work of this project will encourage innovation within the advanced manufacturing industry. By underpinning the development of high efficiency, low cost photovoltaic devices, it will also have a substantial impact on the environment. Specific examples of wider benefits resulting from greater measurement reliability are:

- Greater accuracy in assessing the performance and suitability of water vapour barrier layers.
- Increased support for instrument developers needing to assess encapsulation performance through accurate measurements of WVTR.
- Reduced time to market for new products from organic electronics developers by greater rigor in assessing material stability and barrier performance.
- Increased product reliability through better comparability of material data between different organisations.

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