Title: Metrology for highly-parallel manufacturing

Abstract

A clear trend in modern advanced manufacturing is to produce parts in a highly parallel fashion. Many structures are produced on large-area substrates (up to metres squared) but with high feature resolutions (down to micrometres). Vision-based metrology solutions go some way to addressing the quality control issues, but what is needed is the ability to measure 3D structure over metres squared to very high spatial resolution. Additionally, such metrology solutions need to be fast – substrates may be travelling along the production line at speeds of several metres per second. A number of measurement techniques could be developed and proven by the incorporation of a number of industrial case studies.

Keywords

Large-area substrate, large-area electronics, high dynamic range, optical metrology, printed electronics, roll-to-roll, in-line metrology, screen printing, high throughput manufacturing

Background to the Metrological Challenges

Large area printed electronics on flexible substrates has the potential to be used in a wide range of low-value items such as medical sensors, smart packaging, RFID and product security. It represents one of the most promising and disruptive technologies of our time. Large-substrate-based manufacturing throws up a whole range of metrology challenges. For example, the measurement of tiny defects during the manufacture of flat sheets of glass or the measurement of deviations from nominal in laser machined lines for plastic electronics. Further examples come from the trend to use deterministic surface structuring to produce functional surfaces.

Several advances have been made in the field of surface topography measurement over the last three decades, from the development of optical instrumentation, which is now a fully-fledged rival to contacting techniques, to the development of specification standards for areal topography. However, there are two distinct classes of instrument: 1. those that measure over large areas (metres squared) with tens to hundreds of micrometres spatial resolution (for example, fringe projection, photogrammetry and Moiré interferometry), and 2. those that measure over small areas (up to a few millimetres squared) with spatial resolutions of the order of a micrometre (for example, coherence scanning interferometry, confocal microscopy and focus variation microscopy). Essentially, the former class is camera-limited, and the latter is objective-limited. There have been several attempts to try to combine the two classes, but more progress is required before such hybrids can be used in high dynamic range manufacturing. A third class of instrument is scatterometers, where the scattered light from a surface is studied. Scatterometers can be integrated into production lines, but their full potential still needs to be unlocked. There has also been limited success in developing intelligent sampling strategies to minimise the amount of data that needs to be collected and the measurement time, but more work is required to develop robust techniques capable of operating in industrial manufacturing environments. The proposed project will investigate a number of the above techniques, including new instrument development, instrument hybridisation, design of intelligent sampling techniques and robust methods for resolution enhancement.

Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the proposal.

The JRP shall focus on the traceable measurement and characterisation of 2D and 3D surface features on large-area substrates to enable quality control for highly parallel manufacturing methods.

The specific objectives are

1. To develop measurement techniques to measure 2D and 3D surface structure (topography and/or defects) to high resolution (down to 1 µm lateral and 100 nm in height) in a manufacturing environment. The techniques should be suitable for large-area, often transparent or non-reflective substrates up to 1.5 m in width.
2. To develop methods for handling large-area substrates (up to 1.5 m wide) in sheet-based and roll-to-roll applications to allow substrate handling and overlay accuracy of better than 1 µm. The methods should include the measurement of substrate deformation and the dynamic properties of substrate materials. Methods involving instrumenting the substrate to be considered.
3. To define and characterise morphological parameters to be used for real-time process control and correlation between these parameters and the functional behaviour of the devices under test.
4. To provide a traceability infrastructure for large-area, high resolution, high throughput surface measurement technology, including the use of transfer artefacts, reference instrumentation and new reference-free measurement methods. Input should be provided to relevant standards bodies.
5. To apply a selection of the developed measurement technologies in a number of industrial case studies, ensuring that a large cross-section of industries is considered. To engage with industry in order to facilitate the take up of the technology and measurement infrastructure developed by the project.

Proposers shall give priority to work that meets documented industrial needs and include measures to support transfer into industry by cooperation and by standardisation. An active involvement of industrial stakeholders is expected in order to align the project with their needs – both through project steering boards and participation in the research activities.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this.

EURAMET expects the average EU Contribution for the selected JRPs to be 1.5 M€, and has defined an upper limit of 1.8 M€ for any project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution to the project. Any deviation from this must be justified.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the “end user” community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Drive innovation in industrial production and facilitate new or significantly improved products through exploiting top-level metrological technology,
- Improve the competitiveness of EU industry,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the parallel manufacturing sector.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects”

You should also detail how your approach to realising the objectives will further the aim of EMPIR to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.