European Metrology Programme for Innovation and Research

Delivering Impact

Optical methods for inline inspection

Industry is increasingly applying high-throughput production processes to modern electronic devices to decrease the cost of goods by applying an 'economy of scale'. Such products can be composed of hundreds of components requiring correct assembly to function as intended, which presents problems when using mass production techniques. New ways of inline monitoring are required that must be fast, accurate, and cost-effective to ensure European competitiveness in this growing sector.

Europe's National Measurement Institutes working together

The European Metrology Programme for Innovation and Research (EMPIR) has been developed as part of Horizon 2020, the EU Framework Programme for Research and Innovation. EMPIR funding is drawn from 28 participating EURAMET member states to support collaborative research between Measurement Institutes, academia and industry both within and outside Europe to address key metrology challenges and ensure that measurement science meets the future.

Challenge

Modern technology is producing increasingly complex devices containing hundreds of components, often fabricated by different techniques. These products may also be composed of multiple layers of different materials with nanometre-sized features, each requiring precise positioning for reliable performance. To ensure these devices are free from defects and imperfections manufacturers need quality checks at multiple stages of the production process. To increase competitiveness these measurements must be cost-effective, high-speed, accurate, and capable of being performed inline during production to allow problems to be detected at an early stage.

Optical metrology techniques are an attractive solution that fulfills many of these criteria. In addition, light-based measurement methods are non-contact and have the potential to analyse the surface topology and the different layers of a sample simultaneously. However, such methods are currently limited due to measurement instrument sensitivity to features such as surface roughness, finish, or interference caused by reflected or refracted light. New technologies have the potential to overcome these problems but lack the calibration standards and methodologies to validate their use in modern production lines.

Solution

In the EMPIR project *Metrology for highly-parallel manufacturing* VTT, the National Metrology Institute of Finland, developed a method capable of measurements at the nanometre level – or better than 0.1% height- scale accuracy. This method was developed to characterise an optical sensor, the FocalSpec LCI1200 sensor. Based on patented Line Confocal Imaging (LCI) technology, the LCI1200 sensor illuminates a target with light that has height information encoded into different wavelengths, or 'colours', and the reflected or returned light provides information on the sample's surface features. Characterisation was performed for factors known to affect optical measurements including the instrument's resolution level and magnification scale, or sample properties such as slope angle, colour, and reflectivity. The methods developed, although used specifically to assess an LCI sensor, are applicable to a wide range of optical instrument types.

Impact

FocalSpec 3D Line Confocal sensors, such as the LCI1200, deliver high resolution 3D topography, tomography, and 2D intensity date for industrial use, mainly in the '3C' sector - Computers, Communication, and Consumer electronics. FocalSpec sensors are capable of inline inspection of a range of high-tech items that would normally be problematic for monitoring by optical methods, such as curved or transparent materials or printed and flexible electronics.

The characterisation by VTT confirmed the accuracy of the LCI1200 and highlighted factors that can affect the performance of optical sensors, knowledge used to further improve the lineup of FocalSpec products. FocalSpec sensors now leverage the methods and reference plates validated in the project for fast, in-the-field calibration of their instruments, ensuring the stability and accuracy of their systems for customers at the point of use.

The new methods will help the introduction of optical sensors for rapid and cost-effective monitoring into European production lines, allowing them a competitive edge in the emerging field of highly-parallel manufacturing.

Optical methods for inline inspection

The EMPIR project *Metrology for highly-parallel manufacturing* addressed the measurement methodologies required for industries that apply mass production techniques to high value goods such as printed circuits, flexible photovoltaics, and touch screen electronics.

New sensor systems were developed and validated including a portable spectroscopic scatterometer and a hybrid 2D/3D inspection platform capable of rapid location of nano- and micrometre defects in large area substrates. Systems for inline monitoring for multi-layered printing technologies were developed achieving beyond state-of-the-art accuracies in alignment detection and substrate overlay. Standards and methods for the calibration of optical topography sensors were validated facilitating the use of these devices for rapid, inline monitoring of substrate defects and features. These results will help European manufacturers to increase the efficiency and quality of production processes and reduce the costs of high value products by applying 'economy of scale', allowing them a competitive edge in this emerging field.

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Christopher Jones
NPL, UK
(+44) 020 8943 7024 | christopher.jones@npl.co.uk

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