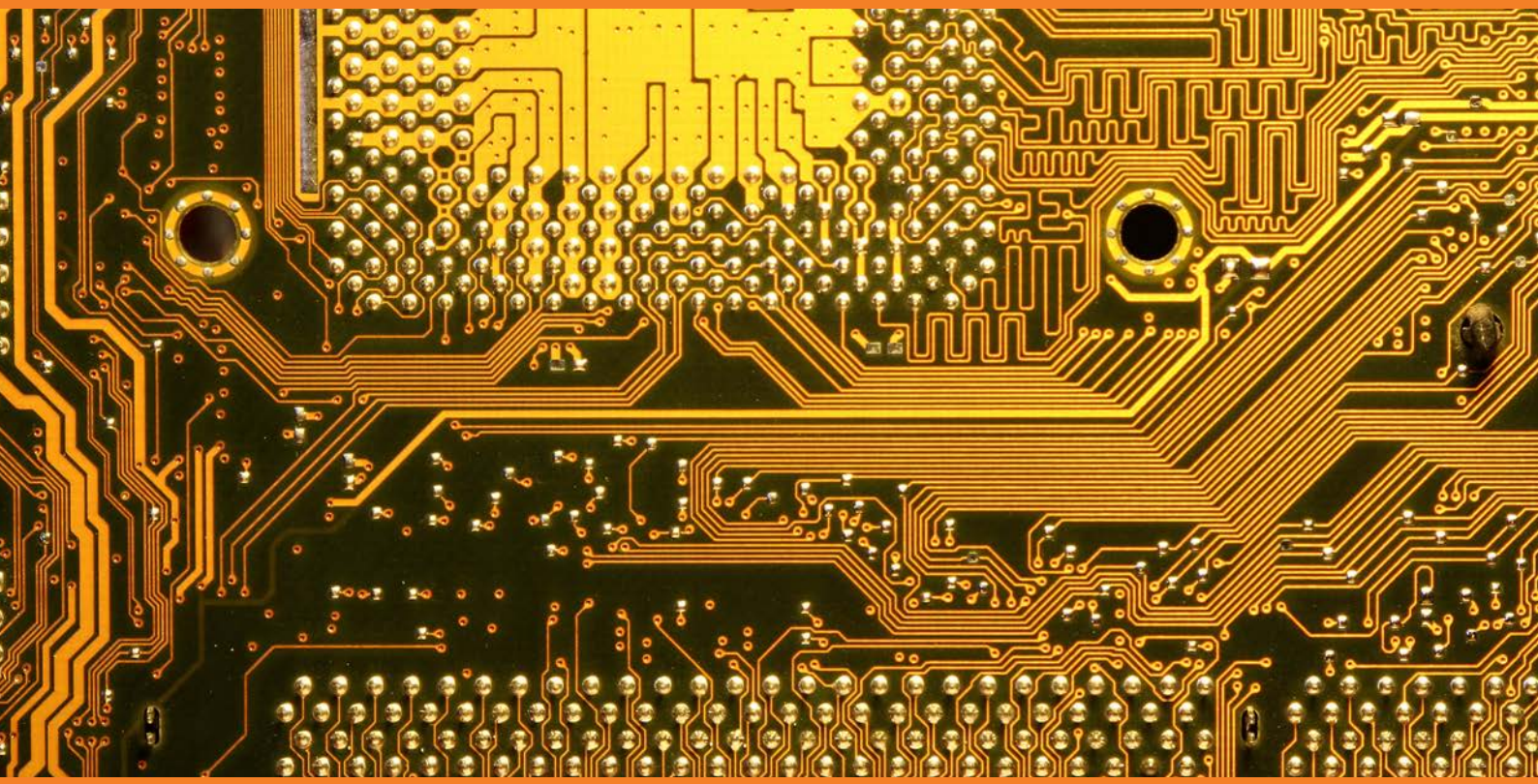
European Metrology Programme for Innovation and Research

Delivering Impact



Measurements for high speed production

High-speed roll-to-roll (R2R) printing techniques, can reduce the cost of goods through an increased efficiency and by application of 'economy of scale'. They are being increasingly used to manufacture high value items such as solar cells, smartphones and printed and flexible electronics. Fashioned from multiple layers, often containing nanometer sized components, correct alignment is vital for product performance. Quality control requires faster, more accurate measurements to support this rapidly 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 the Europe to address key metrology challenges and ensure that measurement science meets the future.

Challenge

The manufacture of many low-value items is being outsourced to countries outside of Europe. In response European manufacturers are repurposing high-throughput processes, such as printing and injection moulding, to produce high-value devices, recognising the [potential] 'economy of scale'. Roll-to-roll (R2R) manufacturing is an established platform for the mass production of a range of film-type products where multiple copies can be printed simultaneously using rollers. This is now being applied to the manufacture of integrated circuits, solar cells and 'smart packaging' and has the advantage that multiple layers of different materials can be overlaid during printing.

Many of these items, such as printed circuits, contain nanometre sized components the correct alignment or 'registration' of which on, and between, layers is critical to product performance. Measurements to ensure registration must be accurate, fast and made in-line during production to allow defects to be detected at an early stage and criteria are tightening as designers look to further miniaturise their devices. Stakeholders in the R2R sector have stated that an overlay registration accuracy of ± 20 µm is the target required for promoting this technology but the current state of the art for this measurement was ± 50 µm.

Solution

The EMPIR project *Metrology for highly-parallel manufacturing* not only achieved a 1- 5 µm measurement accuracy for detecting registration error but also a ± 20 µm overlay accuracy, an improvement on the current state-of the-art and the target identified as vital by stakeholders.

This was accomplished by project partners VTT and Offcode, who developed a new system for handling large-area substrates. This comprised integrating 'registration mark metrology', where alignment markings are printed onto the various layers using a cylinder, with in-line feedback from a high-resolution camera to verify the alignment accuracy. The process was then optimised for detecting errors by taking into account contributions from the substrate, the printing hardware, printed registration marks and the accuracy of the instrumentation itself. The system was then verified for use with different printing materials and different process speeds.

Impact

Offcode, an engineering firm located in Oulu, Finland specializes in integrating electronics into larger systems and, as well as helping their customers to implement and coordinate complex, multiple technologies, they also provide measurement instruments for R2R production lines.

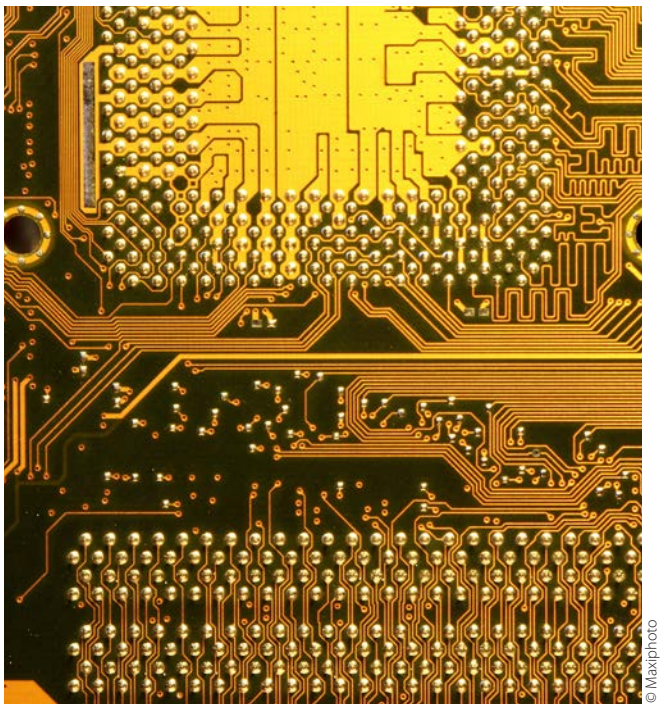
Offcode's advanced ARCOS camera for printing machines formed the basis of the novel registration system developed in the project. As a result of participation this system was improved and can now detect registration errors down to 1 µm. Offcode has sold a number of these upgraded cameras since the end of the project but the company considers that the greatest benefit from the work was the knowledge gained, which they can now include in the other products and services they deliver to their customers.

The manufacturing techniques developed, and the increase in measurement accuracy achieved for substrate alignment and verification as a result of the project, will help further reduce the cost of production of European goods. This in turn will lead to a stronger manufacturing base in Europe.

Measurements for high speed production

The EMPIR project *Metrology for highly-parallel manufacturing* delivered new measurement tools for this sector which applies mass production techniques to high value goods such as printed integrated circuits, flexible photovoltaics and touch screen electronics. The project developed in-line measurement sensors and tools for high-speed analysis of the sub-micron features that these products contain and achieved accuracies in alignment detection and substrate overlay that went beyond the state of the art. New artefacts were generated for the calibration of optical topography sensors which will facilitate the use of these devices for in-line monitoring of substrate defects and features.

These results will help European manufacturers to increase efficiency and quality of production processes and reduce the costs of these high value products by applying 'economy of scale', allowing them a competitive edge in this emerging field.



EMPIR EURAMET

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