



Surface metrology challenges for printed electronics

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Manufacturing for Printed Electronics
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What is NPL?

World-leading
NMI

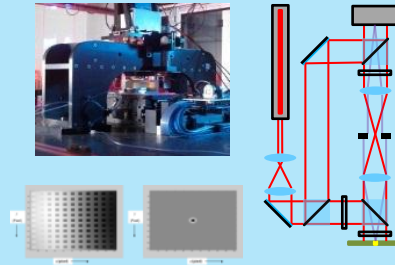
600+
measurement
specialists

Heart of UK NMS
for business and
industry

Dimensional metrology in engineering measurement:



Traceability and
standards



Measurement
science



Advice,
good practice

... complementing activity by our Materials and Analytical Sciences divisions

Surface metrology challenges for printed electronics

Overview: specific surface metrology challenges
... and what NPL is doing about them

1. Measure smarter
2. Use better in-line sensors
3. Tackle absolute positioning

Relevant applications – and defects

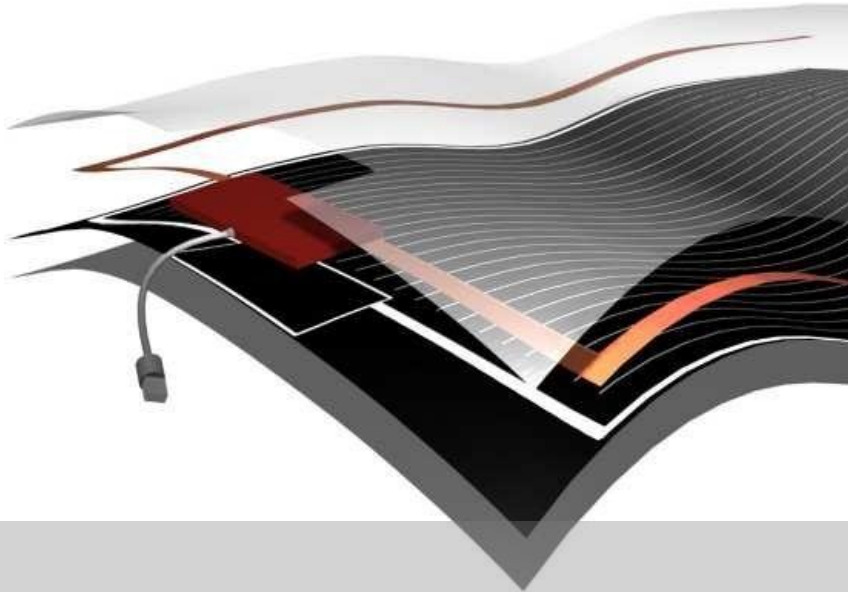
Just some examples:

- Flexible circuit boards: breaks and shorts in printed tracks
 - Components: critical dimensions w.r.t. tolerances
 - Encapsulation and barrier layers: sparse pinholes and scratches
 - PE-based sensors: properties inferred from appearance
- Range of product value points, substrates, supply chain positions
- Increasingly 2.5D: topography + imaging



NANOMEND
METROLOGY FOR ENHANCED NANOSCALE DETECTION, CLEANING AND REPAIR

www.nanomend.eu



Flexible Solar modules

Image courtesy of Flisom



The inside of food and liquid packaging

Image courtesy of Stora Enso

Detection – cleaning – repair Demonstrators planned for 2015

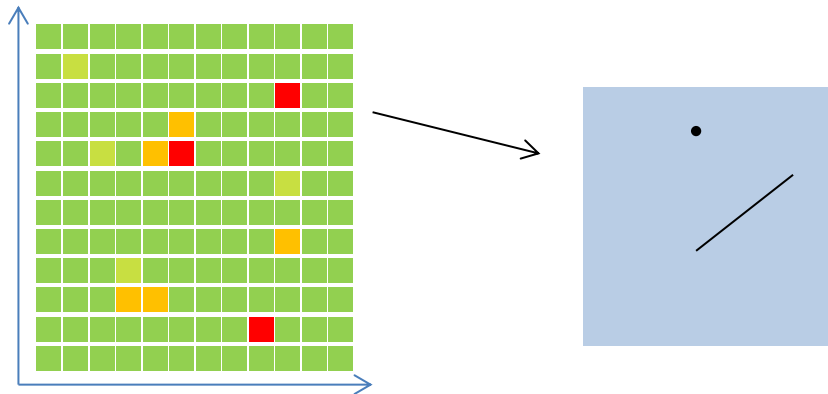
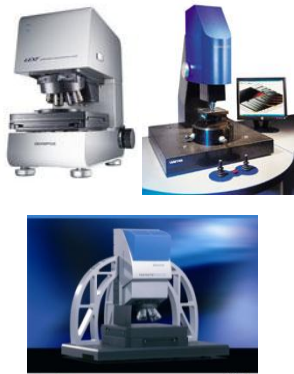
The NANOMend (formerly NANOClear) project has received funding from the European Community's Seventh Framework Program (FP7/2007-2013) under Grant Agreement No. 280581

Measure smarter!

- Understand the defects
- Exploit *a priori* information
- Use intelligent inspection methods

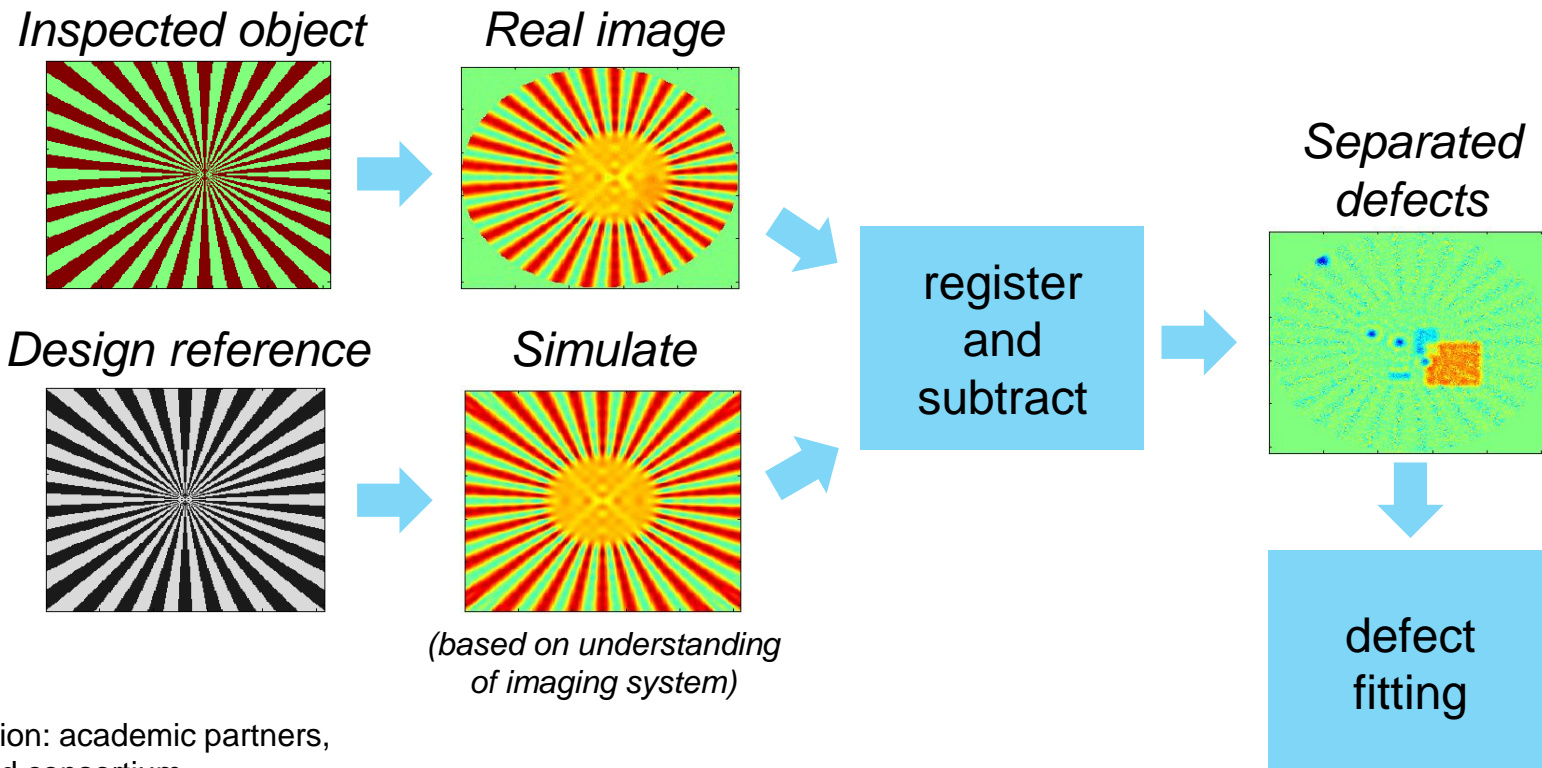
Measure smarter!

- Understand the defects
 - Correlate surface data to functional tests (also at NPL)
e.g. WVTR for barrier layers
 - Prioritise function-critical defects



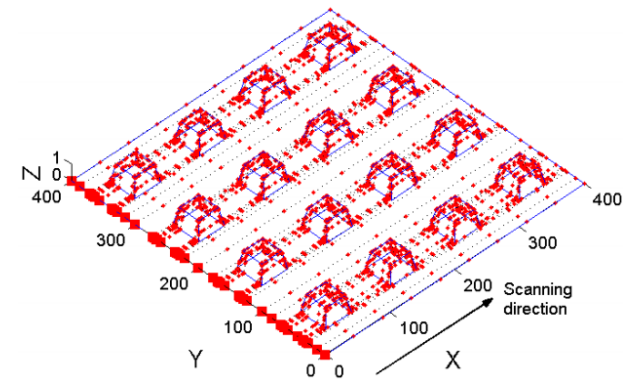
Measure smarter!

- Exploit *a priori* information
 - Resolution enhancement and feature-defect separation

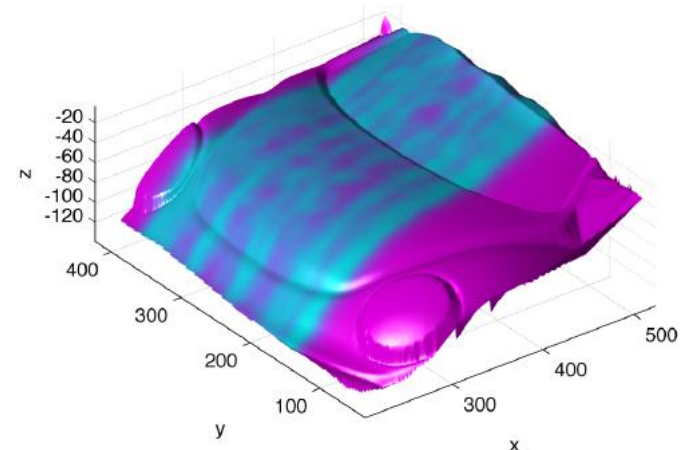


Measure smarter!

- Use intelligent inspection methods – maximise exploitation and immediate feedback of inspection information
 - Adaptive sampling
 - Efficient use of hybrid sensors
 - Data fusion
 - Data volume management



Courtesy collaborators



Build better sensors!

... or use proven instruments better

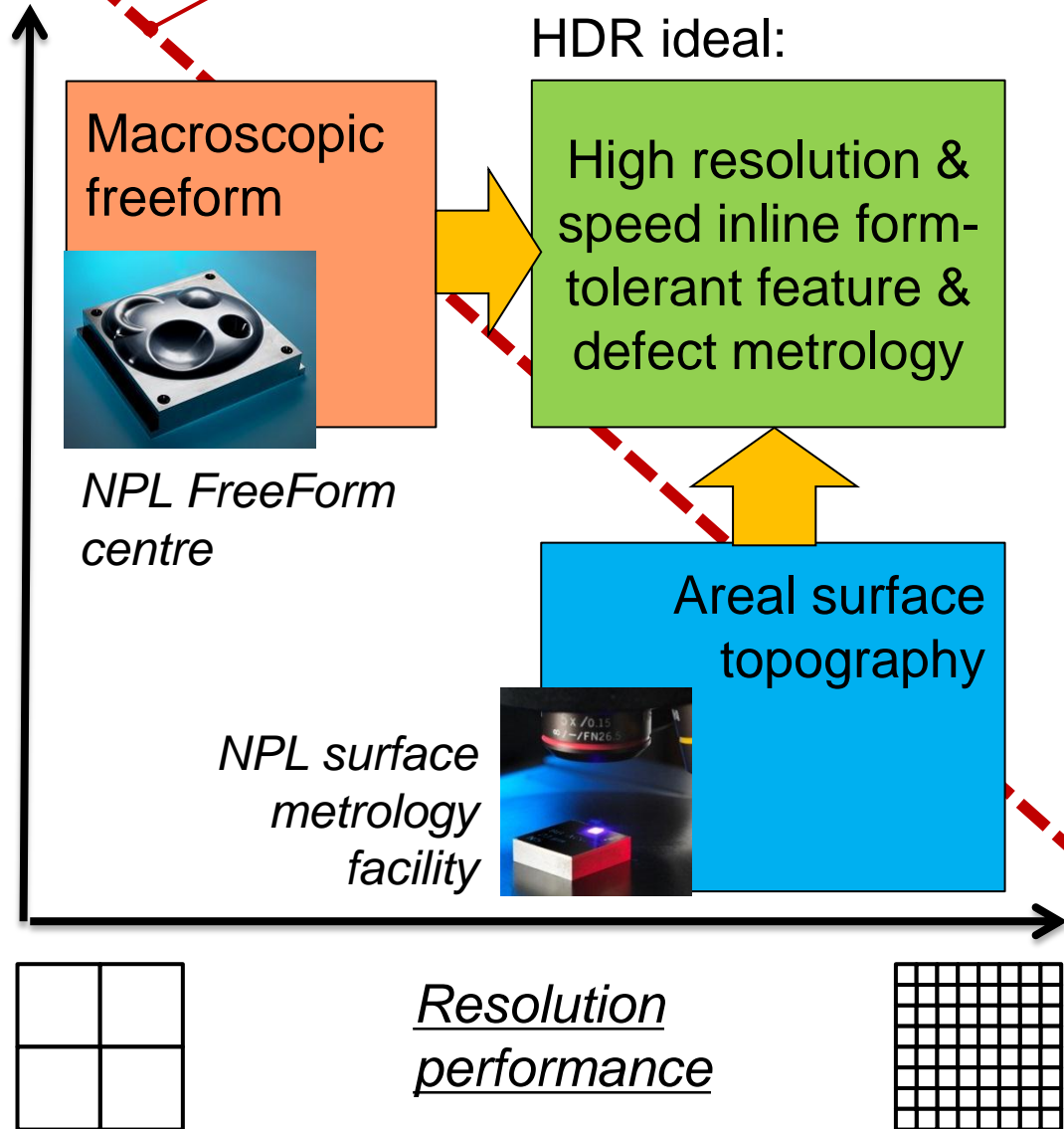
- 'High Dynamic Range'
- Full-field and hybrid sensors
- Point (array/line) sensors and motion planning
- Calibration

conventional performance limits

Large area,
high speed

Sample area
throughput
performance

Small area,
low speed



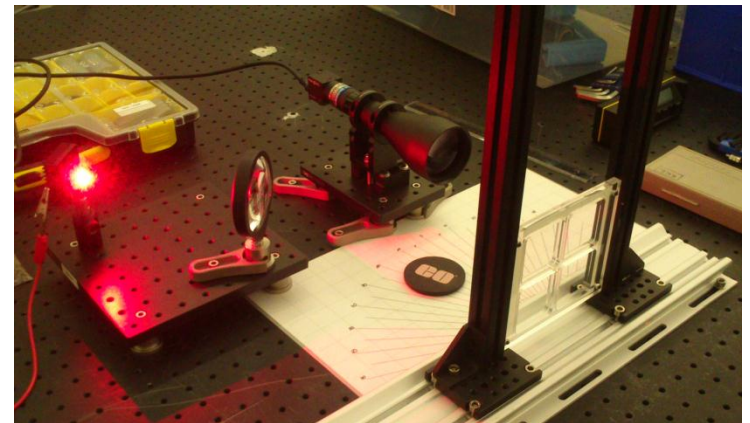
Build better sensors!

- Full-field and hybrid sensors, e.g.

Novel sensors for sparse defects using bright/dark field imaging

e.g. contamination of protective films

- EngD exploratory project
- Extraction of height information from 2D image data
- Prototypes under development
- Links to NanoMend



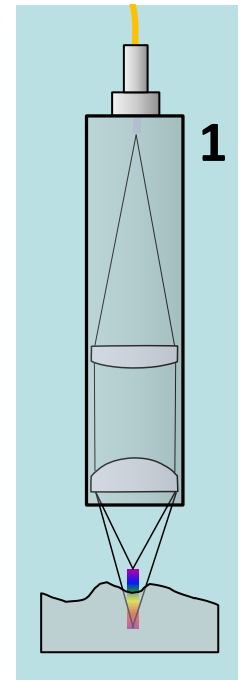
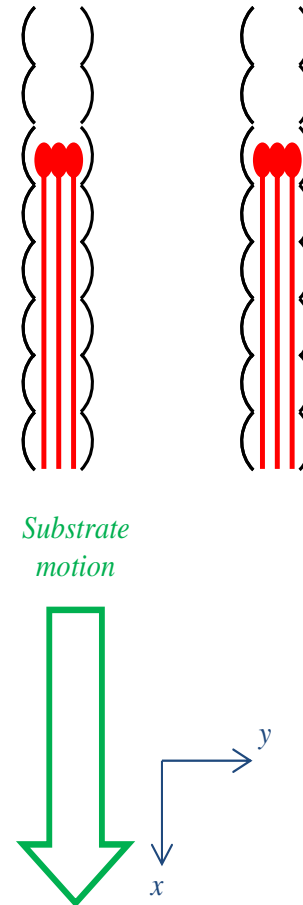
Build better sensors!

- Point array sensors, e.g.

Exploit *a priori* defect information to inspect surface with sparse, targeted optical profiles

e.g. very high speed inspection of linear features ($5 \mu\text{m}$ at 1 m s^{-1})

- Distil metrology challenge
- Support new industry sensors
- Benchmark existing sensors
- High speed data processing



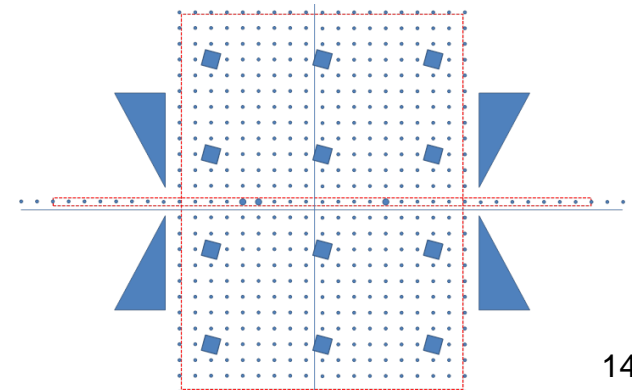
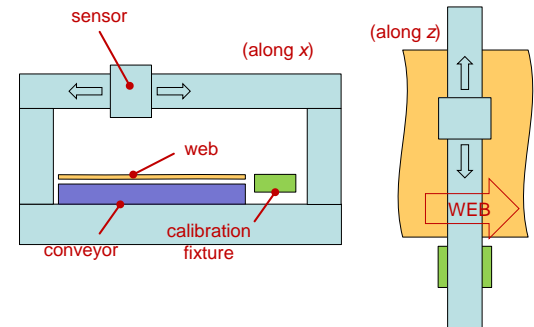
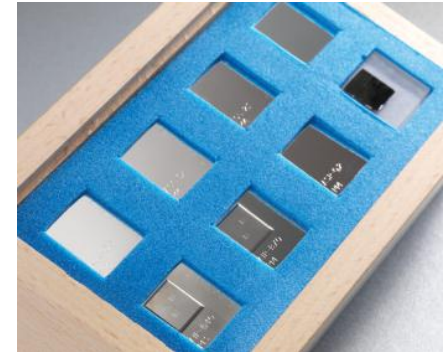
Build better sensors!

- Calibration and traceability for inspection

Support traceability in industrial inspection applications

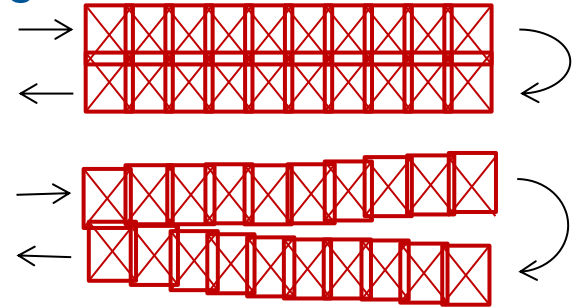
e.g. consistent substrate inspection for roll-to-roll production (NanoMend)

- Prioritise and simplify calibration/ verification tasks to encourage use
- Generic artefacts – Areal calibration set and new camera adjustment artefacts



Tackle absolute positioning!

- Ensure 100 % inspection without double-counting
- Registration of multi-layer/step products
- Web-handling
 - Edge tracking, web mechanics, drift
- Defect location tracking between inspection and repair
- Standardisation across supply chain
 - Send defect map with unrepaired roll?



Tackle absolute positioning!

- Import metrology good practice
 - Joined-up measurement system architecture: direct alignment reference c.f. to the system frame
 - Alignment accuracy \neq alignment uncertainty
 - Crooked, stable camera \rightarrow correct images and continue
 - Aligned, wobbly camera \rightarrow stop and go home...
 - Calibrate the measurement not the machine
 - Plan ahead \rightarrow lower operational burden

Surface metrology challenges for printed electronics

Conclusions – and future work in HDR at NPL

- 1. Measure smarter
 - Get closer to industry!
 - Case studies now for inline metrology
 - Resolution/defect enhancement
- 2. Use better in-line sensors
 - R2R system for benchmarking
 - Line scanning technology
 - Large area scanning
- 3. Tackle absolute positioning
 - Metrology support to integrators

+ support for PE materials research at NPL – speak to Martin Wickham and Fernando Castro here today