A universal substrate sample fixture for efficient multi-instrument inspection of large, flexible substrates, with absolute position registration support

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A universal substrate sample fixture for efficient multi-instrument inspection of large, flexible substrates, with absolute position registration support

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Abstract
Diagnostic inspection for process optimisation and accelerated lifetime testing occupies a significant fraction of unit cost for both traditional, and emerging printed large-area electronic devices. Much of this testing is time-intensive, involving multiple instruments and expert-driven laboratory analysis, developing and correlating maps of local surface topography parameter variation, functional performance indicators and visual appearance. We present the concept and development of an affordable, universal substrate sample fixture (USSF) to enable large-area topography and functional performance measurements with greater efficiency, autonomy and accuracy of absolute feature registration. The USSF is initially optimised for diagnostic inspection of thin, rigid and flexible, highly-parallel manufactured samples up to 180 mm × 180 mm. The USSF is, therefore, particularly relevant for photovoltaic wafers, injection-moulded or embossed nanostructures, and roll-to-roll printed large-area electronics. The USSF incorporates a universal base plate for permanent installation, kinematic locators and semi-disposable substrate clamps. The USSF will also incorporate calibration artefact holders to encourage routine use of, for example, stage calibration line-scales and areal calibration artefacts. We demonstrate a semi-disposable sample mount designed to transfer an absolute coordinate system with a lateral repeatability of 100 µm between multiple instruments, including via storage and mail transport.

Keywords: sample handling, universal fixture, surface-function correlation, automated diagnostic inspection, metrology for highly-parallel manufacturing, calibration

1. Motivation for development

Solutions for overcoming throughput barriers in large-area, high-resolution inspection of, for example, photovoltaic (PV) wafers or diffractive films require intelligent measurement simplification based on sound *a priori* knowledge of defect classes and feature geometries [1]. This preparatory analysis should be automated and standardised to reduce costs and uncertainty. The MetHPM project [2] includes development of lab tools for sample study for parameterised surface-function correlation, GPS-tolerancing, and inline process control.

Handling and measurement of large, flexible samples introduces challenges not encountered with conventional rigid workpieces. Common functional tests require access to both sides of flexible samples, yet support is required to match the vertical working ranges of optical instruments, and to minimise flutter induced by local airflow. Thin substrates are easily deformed and often lack well-defined edges or features visible by eye. These factors make it challenging to maintain the registration of recorded features or defects from instrument to instrument. Samples may also be environmentally sensitive and require contamination control, especially during storage.

Relevant state of the art in sample manipulation from precision machining [3], silicon wafer processing and medical microscopy must be combined into a simple-to-use and cost-effective solution to encourage its uptake.

Section 2 describes the general USSF concept designed to address these handling challenges. Sections 3 and 4 present implementations for the study of semi-rigid PV wafers and roll-to-roll embossed nanostructures respectively. In section 5 the remaining challenges are considered and the outlook noted.

2. Universal substrate sample fixture (USSF) concept

In the current working concept, the USSF consists of a universal permanent element (PE) (a plate with kinematic locator points), installed on multiple instruments, and multiple classes of sample holder ('semi-disposable element', SDE) that are quickly and repeatably installed onto the PE (see figure 1). The PE would require the development of an adapter plate for each instrument. The specifications of SDE classes would be matched to the needs of the application, as exemplified in the following sections. Reference (datum) markers on each element support a global coordinate system shared across instruments. This simplifies the labelling and documentation of notable features, and improves confidence in feature-finding, especially during rapid process optimisation. The split PE-SDE approach supports rapid sample exchange for higher utilisation of high-capital instruments, sharing of instruments between collaborators, and routine insertion of calibration plates for dark-hours instrument verification.

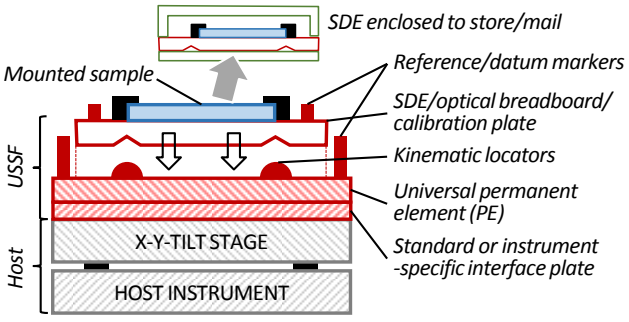

Figure 1. Block diagram of generalised USSF concept (lateral view).

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