New traceability routes for nanometrology

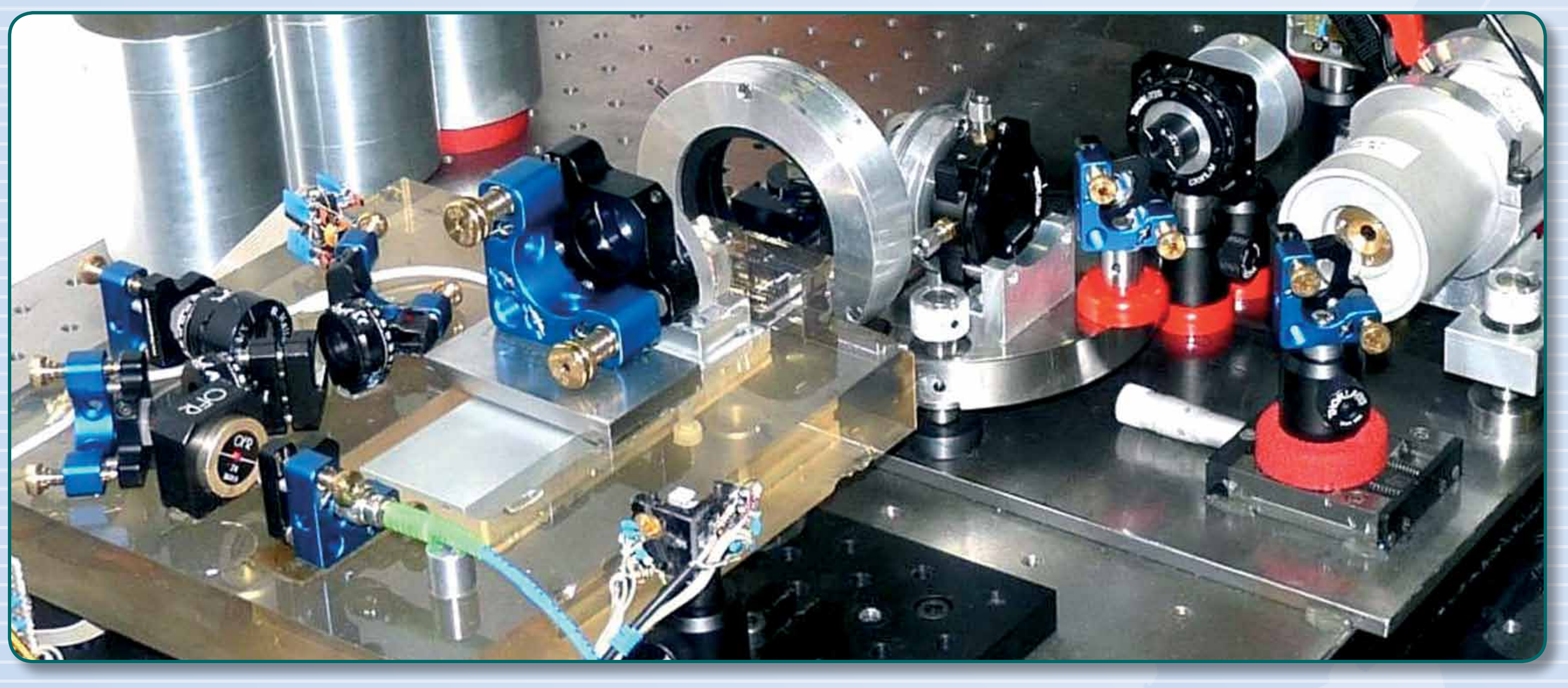
EURAMET
European Association of National Metrology Institutes

The need for the project

As nanotechnologies and ICT (Information and Communication Technologies) play increasingly crucial roles in modern life, the demand for increased accuracy of dimensional measurements is rapidly growing.

One example is in semiconductor manufacturing, where laser interferometers are currently the essential measurement tool. The increased use of double-patterning techniques with a reproducibility of about 0.3 nm for mask metrology tools require more accurate techniques than are currently available.

This project aimed to achieve a 10 pm accuracy for displacement metrology by developing and refining next generation optical interferometers. The challenge was to reduce the uncertainty values by one order of magnitude with respect to the present state-of-the-art.

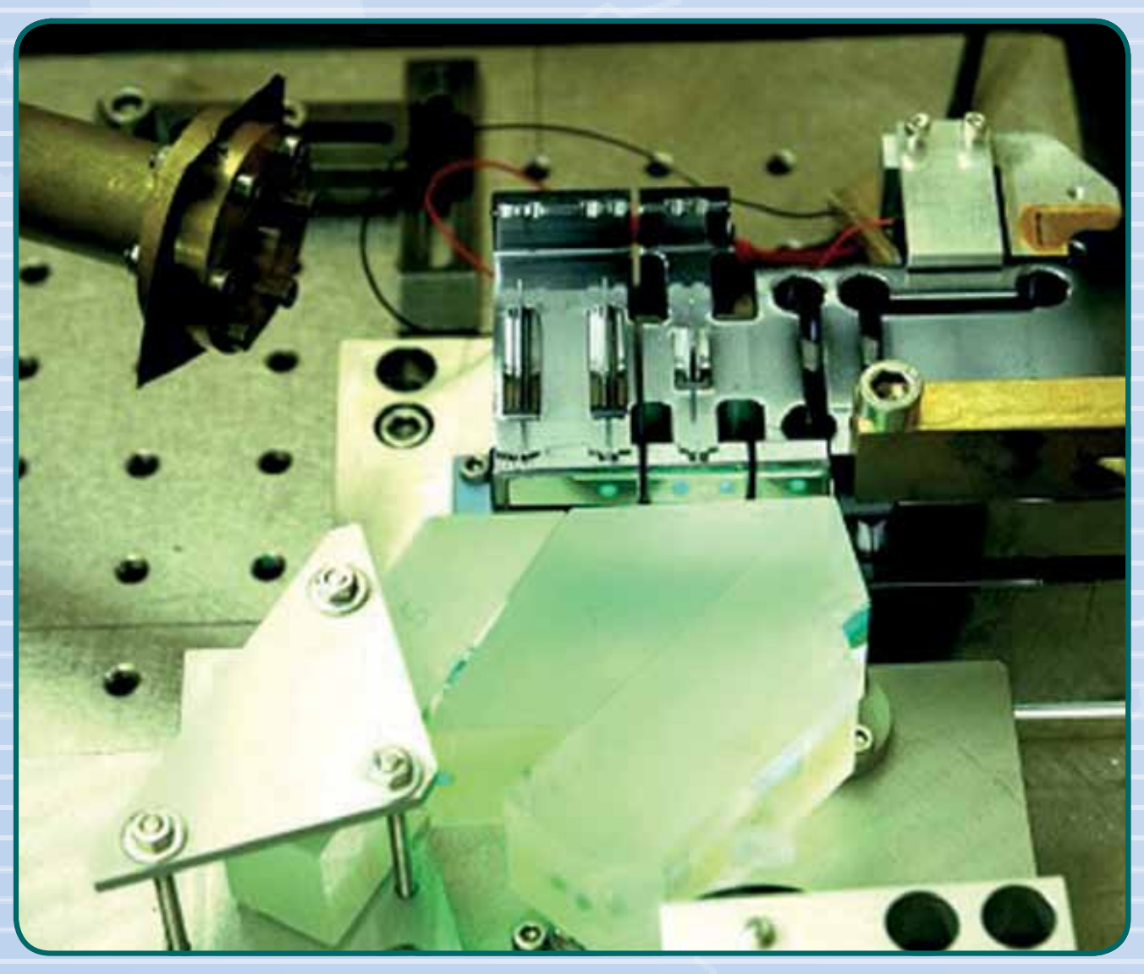


Optical set-up for the comparison between the EOM-based heterodyne interferometer (in the background) and the Transfer Standard based on multipass interferometer (in the foreground).

Technical achievements

The project produced six high-resolution interferometers, based on the different techniques developed in the project: including a cost-effective method that uses combined capacitive distance sensors for modelling and correction of interferometer non-linearity with 10 pm accuracy.

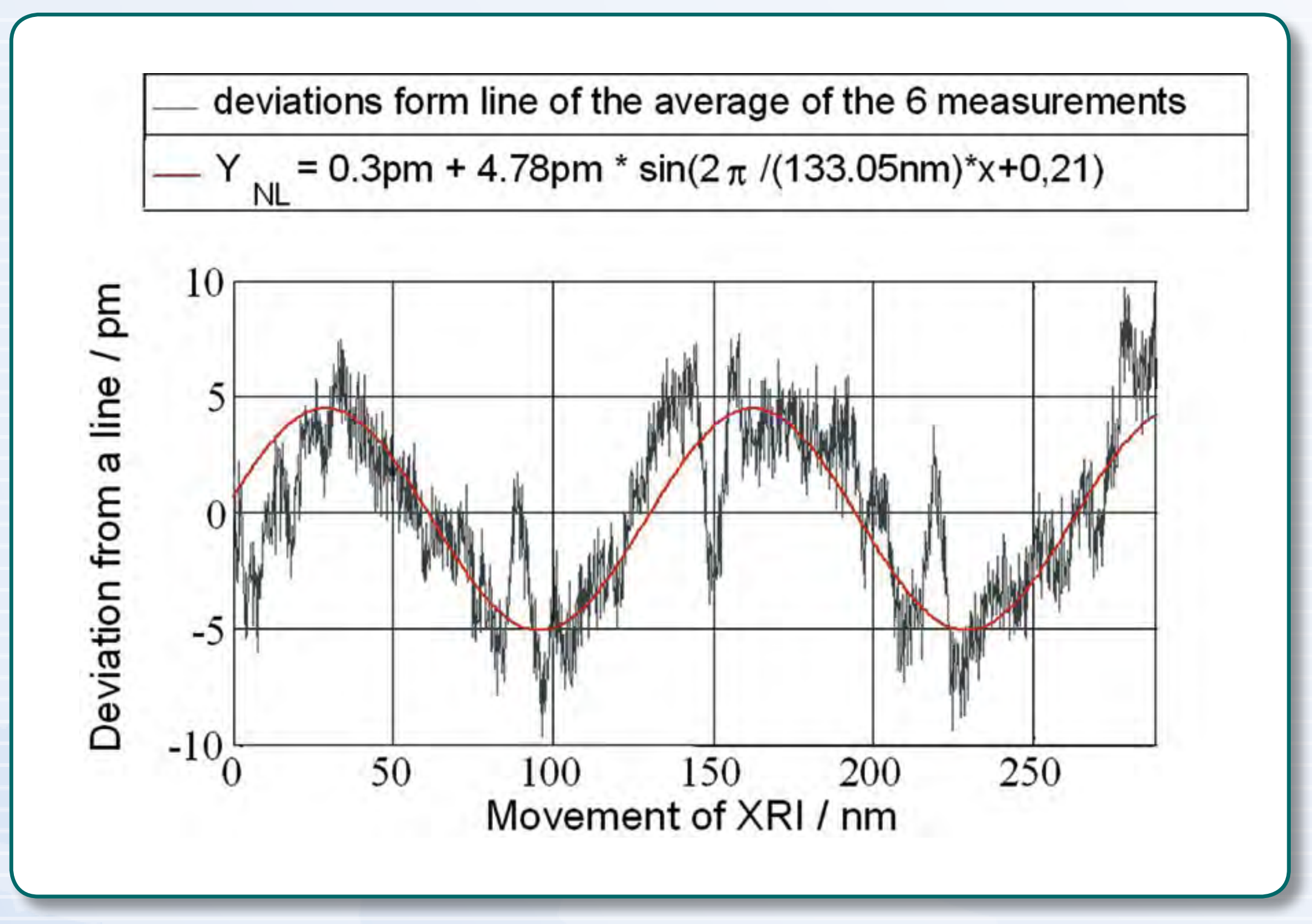
The performance of five of these optical interferometers has been verified using the NPL x-ray interferometry facility which was redesigned and refined. A fast phasemeter was developed, that will be used to upgrade PTB linescales and angle measurement facilities. Also a differential Fabry–Pérot interferometer, used for ultra-small angle measurements, was produced.



The separated beams interferometer (left) facing the x-ray interferometer (black silicon on the right) during the comparison.

Both the x-ray interferometer and the Fabry–Pérot interferometer have supported the results of the JRP NAH, where they will be used to accurately measure the lattice constant and determine the shape of the silicon-28 sphere, respectively.

Guidelines on the use of interferometers for traceability at the nanoscale, based on the experience gained within the project, will be available for researchers on the Nanotrace website.



Comparison between a separated beams interferometer and an x-ray interferometer. A maximum ± 5 pm error is observed.

New metrology tools

Produced a phasemeter and interferometer that can be used to improve the line scale comparator at PTB, Germany's National Metrology Institute, by reducing measurement uncertainty and short periodic errors to below 0.1 nm.

The phasemeter will also be used to improve the speed and accuracy of Atomic Force Microscopes and Scanning Electron Microscopes for the determination of line width, form and fluctuation, where the required accuracy is below 0.1 nm.

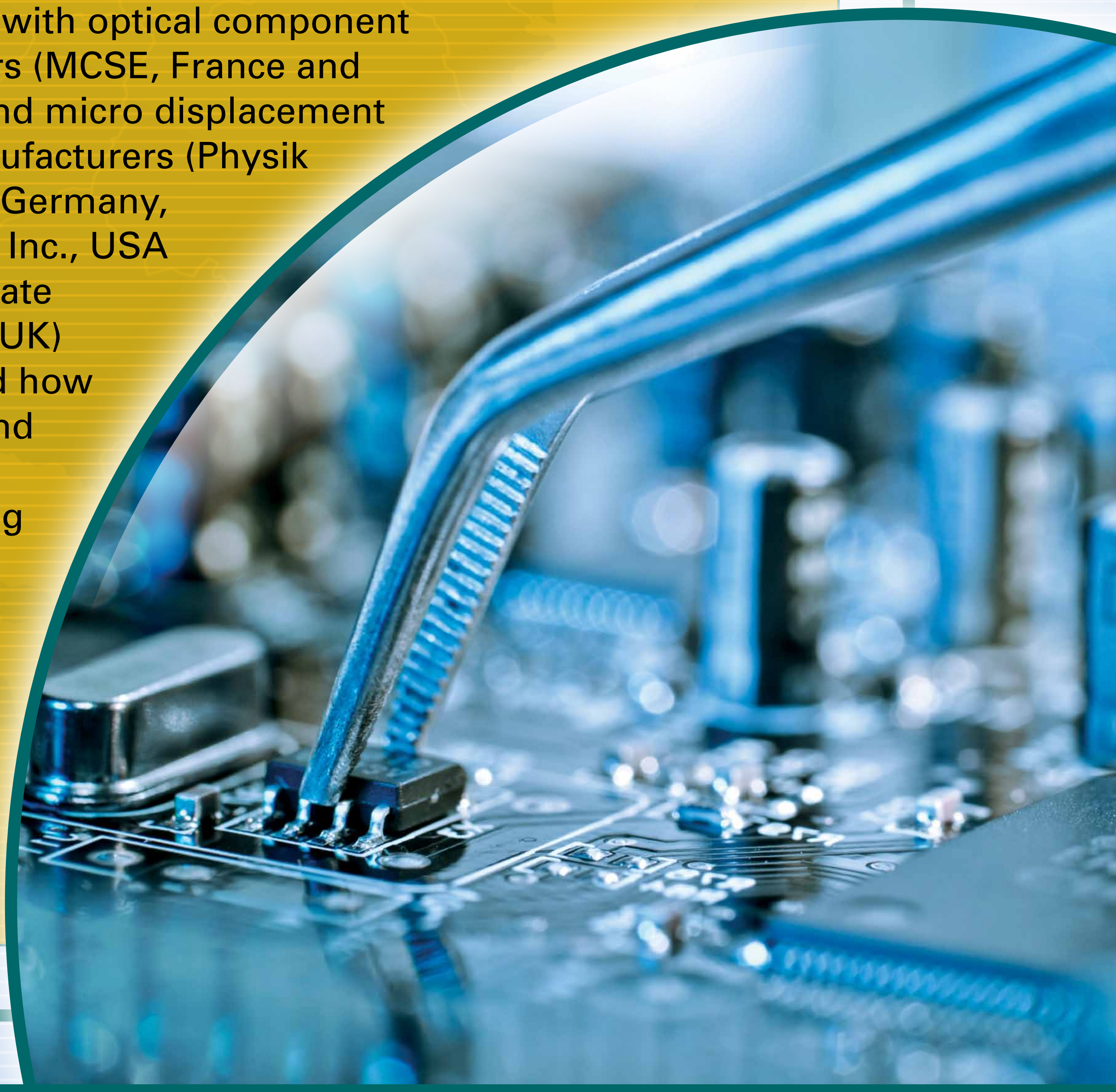
The x-ray interferometry facility will be available for measuring errors in optical interferometers and will be used to characterise instruments used in the semiconductor industry.

New transfer standard

Produced a new transfer standard (transportable actuator), which will be used for the validation of accurate displacement sensors such as interferometric, confocal and capacitive sensors, used in industrial measurements and for fundamental research.

Collaboration with manufacturers

Collaborated with optical component manufacturers (MCSE, France and SILO, Italy) and micro displacement actuator manufacturers (Physik Instrumente, Germany, Mad City Lab Inc., USA and Queensgate Instruments, UK) and identified how to improve and support their manufacturing processes.



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