

Semiconductor measurements

To stay competitive, electronics manufacturers are constantly developing smaller microchips, requiring greater manufacturing precision. Accurate measurement techniques for the nanoscale exist, but they are slow and unsuitable for manufacturing environments. Scatterometry offers fast nanoscale routine measurements, but lacks suitable reference materials. Developing new standards to link scatterometry to established measurement techniques will improve accuracy, supporting the development of smaller electronics.

Europe's National Measurement Institutes working together

The European Metrology Research Programme (EMRP) brings together National Measurement Institutes in 23 countries to address key measurement challenges at a European level. It supports collaborative research to ensure that measurement science meets the future needs of industry and wider society.

Challenge

Semiconductor devices - the foundation of modern electronics - continue to get smaller and more complex. *The International Technology Roadmap for Semiconductors* expects them to halve in size over the next six years.

Working at the nanoscale requires the production of sub-micrometre structures to build up sophisticated electronic circuits on silicon wafers. Other industries operating at micro- and nanometre scales, such as optics, medicine and biotech, face similar challenges.

Structures must be produced to extremely high accuracies, requiring small scale measurements which are hard to make. Techniques do exist to measure nano-structures, such as Scanning Electron Microscopy (SEM) and Atomic Force Microscopy (AFM), but they are relatively slow or require ultra-high vacuums, making them costly (SEM) or even unsuitable (AFM) for routine measurement.

Scatterometry, which illuminates a surface and detects the scattered light in reflections from it, provides an ideal way to measure small structures in a production environment. However, its adoption is held back by a lack of standards. Providing standards which link scatterometry to established techniques such as SEM and AFM would reduce uncertainties, provide confidence in measurements, and so make the technique viable for routine nanometre industrial measurements.

Solution

The EMRP project *Metrology of small structures for the manufacturing of electronic and optical devices*, has developed new reference materials to accurately calibrate scatterometry instruments.

Scatterometric systems were systematically investigated and compared to other techniques to assess relative performance. A scatterometry reference standard was designed and specified, which was then validated using trusted measurement techniques. These included existing microscopic methods such as AFM and SEM, which have established calibration routes for measuring critical dimensions at nanoscale. The reference standard can now be used to calibrate scatterometry systems.

The final reference standards and a corresponding calibration service based on the methods used are now available for scatterometry instruments. This improves traceability and accuracy of scatterometry by making it comparable to other trusted measurement methods, enabling its use for routine measurements of sub-micrometre features.

Impact

Advanced Mask Technology Center (AMTC) a joint venture of GLOBALFOUNDRIES and Toppan Photomask is developing EUV photomasks to accurately expose circuitry onto silicon wafers. A specific goal is supporting its parent companies - to enable 7 nm technology and below for next generation silicon chips. Access to advanced photomasks is key to achieving this.

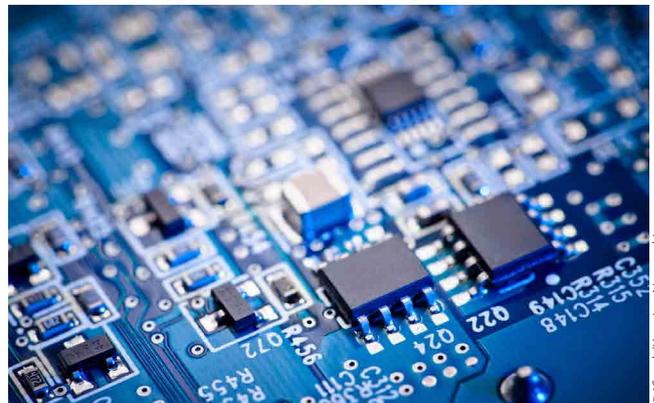
Through the project, AMTC is now able to accurately certify dimensions and uncertainties of their reference photomasks. Using these internal reference photomasks, and calculations developed in the project, they will be enabled to calibrate their metrology systems.

Being able to confidently use calibrated metrology systems will help AMTC to successfully produce EUV masks for 7 nm technology and beyond with features down to ~10nm on the next generation of silicon wafer circuits. They aim to make these technology available by mid-2018. This will play an important role in reducing the size of semiconductor devices, keeping the *International Technology Roadmap for Semiconductors* size reduction schedule on track, and improving the competitiveness of the semiconductor industry.

Metrology for manufacturing electronic and optical devices

The development of miniaturised optical and semiconductor components to meet the International Technology Roadmap for Semiconductors requires accurate dimensional measurement of micro-structures. Scatterometry measurements are relatively fast compared to the traditional methods of Atomic Force Microscopy and Scanning Electron Microscopy, but poor traceability and problems in handling the vast data sets is hampering uptake.

The EMRP project *Metrology of small structures for the manufacturing of electronic and optical devices* developed validated reference standards for all three measurement methods. For the first time, scatterometry calibrations can be compared to those of the other more established dimension measurement techniques. The new data handling methods and improved uncertainty analysis developed are making scatterometry a viable technique for use in the semi-conductor and optics industries where accurate micro-structure measurements are essential.



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