European Metrology Research Programme

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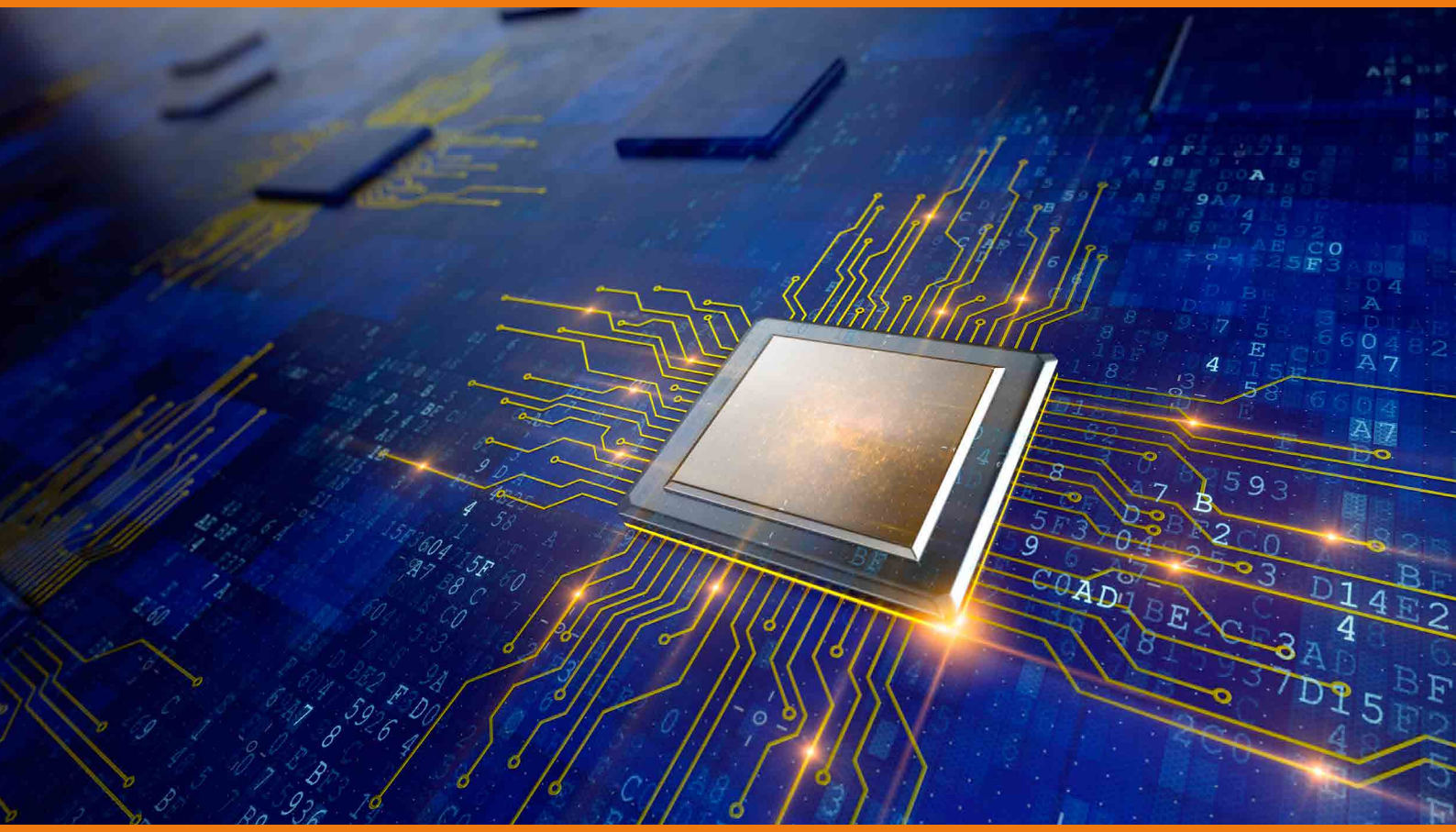


Investigating nano-defects

As electronics get ever smaller, detecting defects during quality control becomes more difficult. NSMM, a scanning microscopy technique, offers a new way to spot defects by measuring electromagnetic properties and has potential for investigating new materials for faster chips. For it to be viable for either of these, traceable calibration methods are needed so ultrafast electronics manufacturers' have confidence in its use.

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

Ultrafast electronics must be manufactured with high precision. Many of the features of complex nanoscale circuits are built up on wafers using EUV masks, which can develop cracks, leading to circuit defects. As electronics get smaller and operate at higher frequencies, there is a need for more accurate ways of checking for such defects.

A technique with potential for this application is Atomic Force Microscopy-based near-field scanning microscopy (NSMM). NSMM introduces an electric field into the material and, by measuring field disturbances, can determine the material's electromagnetic properties.

Microchips' electromagnetic properties relate to their geometries. NSMMs can verify whether chip properties are as designed, or identify the size of any defect on it by comparing the expected and measured disturbance. NSMM can also be used in research to characterise electrical properties of materials, such as those being investigated to replace silicon.

Uptake of this technique is limited by a lack of traceable calibration. At such small scales, manufacturers need to be sure that responses which indicate defects are not due to instrument performance effects. More reliable calibration methods are needed to give confidence in NSMM use in both research and quality control for the next generation of high speed electronics.

Solution

The EMRP Project *Electromagnetic characterisation of materials for industrial applications up to microwave frequencies* developed traceable reference materials and methods which enable calibration of NSMM instruments. The project also developed improved models and algorithms which offer much greater accuracy to NSMM instruments opening up a new method for materials characterisation in ultrafast electronics and communications applications.

The project reference materials consist of silicon chips with silicon nitride windows onto which precise nano meter scale gold features are added to generate known disturbances in the instrument's electrical field. Their size and location is known with great accuracy, so they produce an extremely well defined electrical response. For the first time it is possible to traceably calibrate the electromagnetic response of NSMM.

Impact

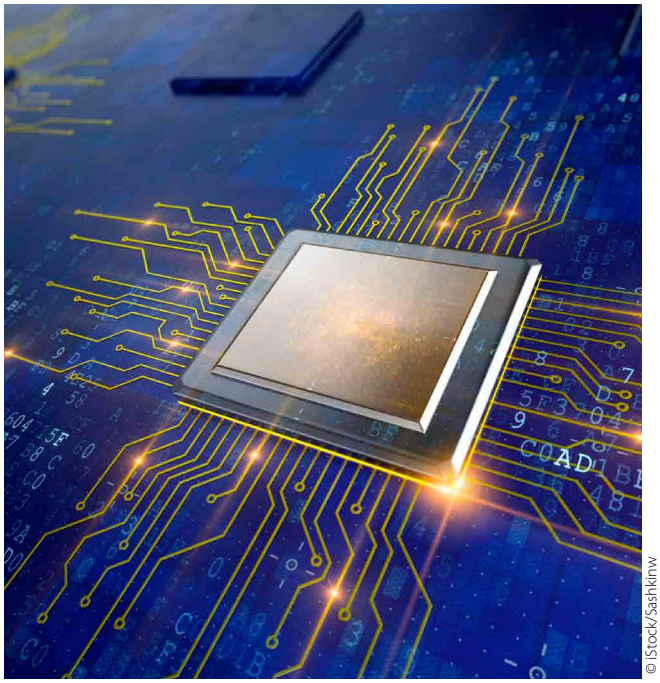
Project partner Keysight Technologies Inc, a major manufacturer of test and measurement equipment, assisted the project in the evaluation of prototype NSMM calibration standards using their state-of-the art research instruments. Through this interaction, Keysight gained a valuable insight into how customers use NSMM to make rigorous assessments of a materials electromagnetic properties - particularly important to the ultrafast electronics industries search for candidate materials to replace silicon.

Using the projects reference materials and methods, Keysight has been able to generate a traceable calibration route for its NSMM instruments. Upgrades to their analysis software are also being implemented to incorporate the project's models and algorithms providing improved accuracy to their instruments analytical results. These improvements, are helping Keysight to deliver higher NSMM accuracy giving improved confidence to their customers.

Increasing the traceability of NSMM as a measurement and characterisation tool, will enable the technique to play an important role in materials development and quality control in the electronics industry, as faster and smaller circuits are developed for the next generation of high speed communications and computers.

Metrology for advanced electronics materials

To develop faster electronics and effective microwave communication systems, developers need to understand the electromagnetic performance of materials at radio and microwave frequencies. The EMRP project *Electromagnetic characterisation of materials for industrial applications up to microwave frequencies* developed a range of tools for the accurate measurement of key electromagnetic properties, which provide valuable information on the capacitance, conductivity and permittivity of materials. These tools will support the electronics industry to improve the performance of existing materials and enable the uptake of new materials needed for ultrafast applications.



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