Información del proyecto

METRO4-3D

Identificador del acuerdo de subvención:
688225

Financiado con arreglo a
H2020-EU.2.1.1.

Presupuesto
general
€ 3 349 813,75

Aportación de la
UE
€ 2 689 035

Fecha de inicio
1 Febrero 2016

Fecha de
finalización
31 Enero 2019

INTERUNIVERSITAIR MICRO-ELEKTRONICA CENTRUM
Belgium

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N.° 86, OCTUBRE 2019
One driver of the semiconductor industry growth is the sustained realization of “Moore’s Law leading to fast technological developments, including increased process and material complexity, as well as reduced tolerance levels for process excursions. It increases the need for a more controlled manufacturing environment necessitating equivalent improvements and developments in metrology. In response to these needs novel metrology approaches have been developed and implemented as emerging metrology concepts by several equipment manufacturers. Among the barriers to achieve a full commercialization of these tools is the lack of adequate documentation on their performance when applied to a wide range of technological problems. In particular to demonstrate the technology readiness level (TRL) of these concepts one needs access to properly characterized devices with relevant dimensions and properties which is frequently beyond the capabilities of many (small) equipment manufacturers. If they have access, reporting of the results is often restricted by confidentiality clauses from the sample suppliers.

This project covers three new metrology concepts addressing specifically the processing challenges linked to semiconductor 3D-structures and devices. It ranges from probing basic layer properties (composition, electrical properties) in FEOL to control of metallization and isolation in BEOL up to issues linked to 3D-die stacking.

Due to the specific processing steps which need to be addressed, three separate tools will be assessed:

- a TOFSIMS system (ION-TOF) with built-in Scanning Probe stage and FIB column for true 3D-composition profiling in confined and structured devices of failure analysis;
- a completely automated microHall and sheet resistance measurement tool (CAPRES) addressing similar structures but sampling their electrical properties
- and a GHz scanning acoustic microscope (PVA TePla) with a frequency range up to 2 GHz (PVA TePla) for probing various defects in the BEOL layers like cracks, delamination, defectivities (such as voids), through Si vias (TSV’s) and micro-bumps, as well as voids or cracks in stacked dies and wafers.

The work in this project is divided in three main technological parts corresponding to the three assessed instruments. Towards the end of the project, the scope of the metrological solutions developed will be further enlarged by combining the results of several of these solutions together.

Assessment of IONTOF TOFSIMS for 3D-structure
The workpackage devoted to the TOFSIMS instrument performed in this reporting period is divided in three sub-section.
First, a thorough assessment of the instrument performances has been performed. Second, tests have been performed on actual systems: crater depth measurement using the AFM module, as well as topographical and chemical information were combined in order to provide a 3-dimensional image of epitaxially grown SiGe structure.

Third, the evaluation of non-conventional AFM measurement modes has been evaluated. Assessment of Capres microHALL-A300 for 3D structure

The second main workpackage is centered around the microHALL-A300 tool of Capres. This fully automated in-line tool implements two techniques, namely micro four-point probe and microHall. The purpose is to evaluate the tool on both semiconducting and metallic materials.

For semiconducting materials, we test first the tool on the materials and structures (blanket or micron-scale pad geometry) of Si, Ge, SiGe and III-V semiconductors. It included a new software taking the current confinement in small pads. Next, we evaluate the potential extension of the tool capabilities towards more relevant nanoscale semiconducting volumes: In structures involving Si and III-V materials in a long fin-like geometry, where the tool has shown to be very successful in determining the resistance in fins with width as low as 20 nm.

In the next part of this workpackage, we evaluated how the tool performs on ultra-thin metal films.

Assessment of PVA TePla GHz Scanning Acoustic Microscope

The assessment of acoustic microscopy in the GHz-band for non- and semi-destructive inspection of 3D-relevant technologies in microelectronics is the focus of the third large workpackage. Extending the acoustic frequency into the GHz-band allows for a significantly increased spatial resolution compared to conventional SAM. Furthermore, the use of acoustic lenses with large numerical apertures enable the excitation of additional wave modes and thus extend the value and potential of this non-destructively operating inspection technique.

This workpackage focusses on three main subtasks: First the assessment of GHz-SAM for failure analysis and metrology tasks for BEOL materials and structures. Second, the assessment of GHz-SAM for failure analysis and metrology tasks for 3D-relevant systems and structures. The third task focusses on the validation and verification of the acoustically obtained results and the implementation of the GHz-SAM inspection technique into complex metrology and failure analysis work flows.

Avances que van más allá del estado de la técnica e impacto potencial esperado (incluida la repercusión socioeconómica y las implicaciones sociales más amplias del proyecto hasta la fecha)

The basic scientific concepts underlying the different instruments assessed in this project are already known for many years. However, the introduction of novel components, enhanced technologies and their implementation in more automated instruments targets to raise their performance level at par with the applications to be encountered in next generation technologies. For instance, adding an in-situ AFM and FIB-column to the TOFSIMS concept opens the perspective towards a true 3D-TOFSIMS capability. Similarly, the full wafer scale automatization of the micro Hall concept from CAPRES will allow the application of the technique at full wafer level and its use in production line control. Extending the scanning acoustic microscopy to the GHz frequency domain will not only allow the detection of smaller defects in thinner films or smaller structures, but also creates the opportunity to study failure mechanisms that could not be assessed up to now.

In each case it is fair to state that the tools and metrology concepts pursued within this project contain
a high degree of innovation and enhanced performance and can be described as having transitioned from the “idea to application” level towards the “lab to market” phase. One important expected impact from this project is to regain market share, maintain manufacturing base and innovative product development by SME’S as well as to prepare industry for future development of the electronic landscape.

At the manufacturing level, metrology is a key player in reducing the lab to market time lapse and thus the proposed assessment of new metrology will directly contribute to this and keep European industry performant at the world wide scale. Providing manufacturers a platform and opportunity to demonstrate and document the validity, performance and added value of their solutions in respect to the needs of the next generation technologies is a key enabler in maintaining this strength on the EU-level.

At the technological level, this project will help sustain the historical integrated circuit scaling cadence and reduction of cost/function, as advanced metrology is the key enabler to timely develop a mature technology and achieve high production yields. By solving material aspects at small dimension and 3D challenges, it will strengthen the interaction between design and technology development.

Ultima actualización: 18 Marzo 2021
Número de registro: 215106

Permalink: https://cordis.europa.eu/project/id/688225/reporting/es

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