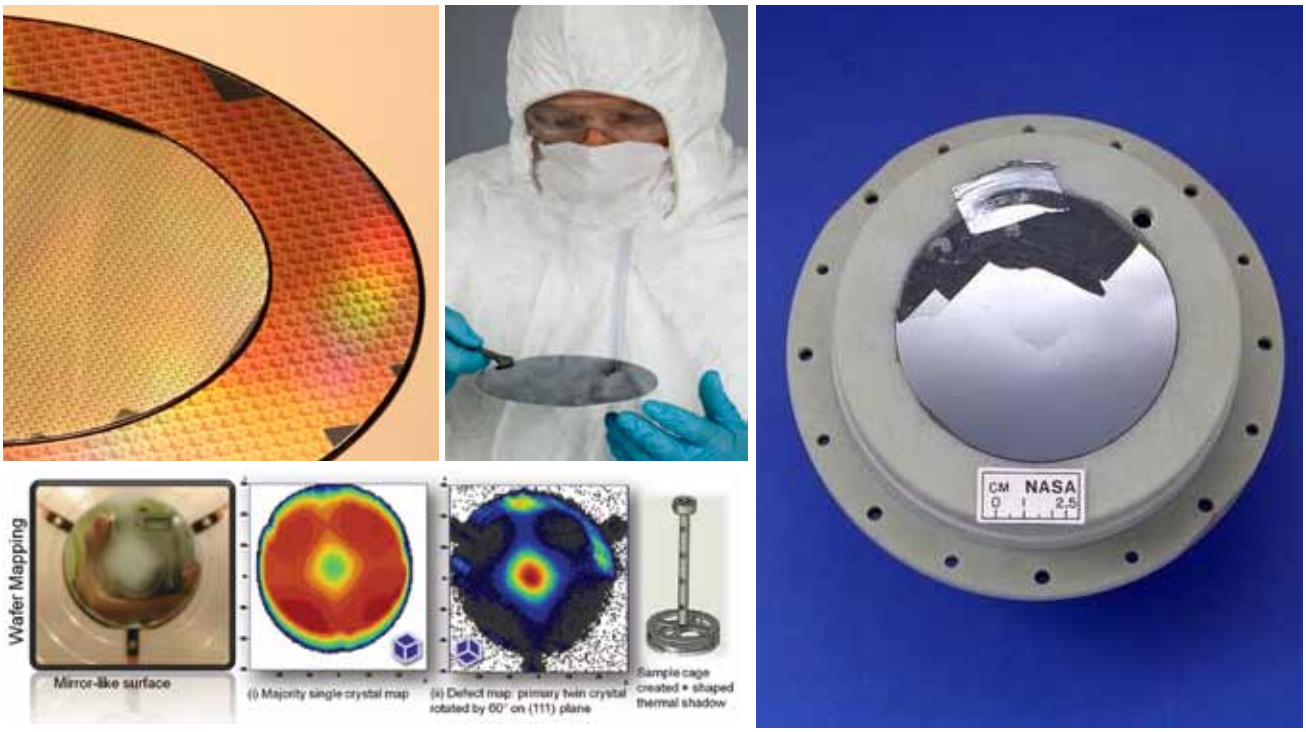
National Aeronautics and Space Administration

technology opportunity

X-ray Diffraction Wafer Mapping Method

A powerful, non-destructive measurement tool



NASA's Langley Research Center invites companies to license an innovative X-ray diffraction (XRD) method for determining twin defects in single crystals, poly-crystals, and crystalline structures at whole-wafer scale. This method will identify primary twin defects in wafers, benefiting wafer-level mass production of (111) plane-oriented cubic semiconductors such as silicon (Si), germanium (Ge), or SiGe on trigonal crystal substrates and enabling the fabrication of twin-free, rhombohedral single-crystalline SiGe layer regions. This innovation further benefits NASA's rhombohedral super-hetero epitaxial semiconductor materials technology in which various cubic semiconductors (group IV in diamond, group III–V and II–VI in cubic zinc-blende structure) can be atomically aligned and grown on the c-plane of trigonal crystals. This unprecedented epitaxy technology produces new types of high-quality epitaxial layers, suitable for fabrication of various noble electrical and optical devices.

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Benefits

- **High spatial resolution:** Scans from a few nanometers to a few millimeters with a nearly isotropic and uniform XY scan
- **Whole wafer:** Characterizes whole wafers with XY spatial resolution
- **Non-destructive:** Permits non-destructive evaluation of each rhombohedrally aligned cubic semiconductor wafer, including SiGe/sapphire wafers
- **Error correction:** Expands with two variables to compensate for the common misalignment of the sample holder in an XRD machine
- **Optimal conditions:** Determines conditions for the best growth parameters
- **Increases reliability:** Identifies defects with a specific quantitative twin-defect density

Applications

- Mass-production, semiconductor wafer processing
  - Quality monitoring
  - Quality control

Technology Details

Silicon-on-sapphire (SOS) and SiGe on sapphire have many superior electrical and thermal properties. However, the epitaxial growth of these structures is hindered by the formation of twin domains and micro-twin defects because of crystal structure differences between the epitaxial layer and the substrate or stacking fault during growth. This non-destructive analysis and monitoring method detects twin defects using advanced XRD technology.

How It Works

When a cubic material layer is grown on the c-plane of trigonal or hexagonal crystal substrates, the epitaxial layer often contains primary twin defects that are rotated 60 degrees on the (111) plane.

This new technology measures whole wafers with XY spatial resolution, using a point or line X-ray source with a narrow beam-mask or a crossed slit to detect the distribution of defect regions and single crystal regions on the wafer. While the wafer moves in the X and Y direction, a narrowly defined X-ray source illuminates the sample and the diffracted X-ray beam is monitored by the detector at a predefined angle.

This XRD method can be used to determine optimal conditions and the best growth parameters using iterative improvements that can be integrated during epitaxial growth with the in-situ X-ray diffraction machine. It also can be used for quality monitoring and quality control of final products. Individual wafers can be evaluated non-destructively and identified with a specific quantitative twin-defect density (0~50%), removing defective wafers and greatly increasing customer confidence that their products will be reliable.

Why It Is Better

This new method is the first of its kind. The X-ray diffraction-based wafer mapping technology can characterize a whole wafer with micrometer-to-millimeter resolution and with part-per-million sensitivity. Previously, only destructive microscopic defect evaluation, such as transmission electron microscopy analysis, was available. Macroscopic characterization over whole wafers was not possible, and twin defects measured with electron microscopy characterized only a small region of the wafer. Now, quality can be greatly improved and defective wafers can be eliminated.

Patents

NASA has secured a patent for this technology (U.S. Patent No. 7,558,371) and has filed a second patent application.

Licensing and Partnering Opportunities

This technology is part of NASA's Innovative Partnerships Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing this X-ray Diffraction Wafer Mapping Method (LAR-17044 and LAR-17554-1) for commercial applications.

For More Information

If you are interested in more information or want to pursue transfer of this technology please contact:

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