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Full scale semiconductor wafer chemical composition scanner by capillary focused X-ray microbeam

Introduction

During the growth of compound semiconductor crystals, both deviations from composition are observed, resulting from microscopic changes (for example due to the segregation coefficients) as well as microscopic scale (non-uniformity , precipitates, etc…). These composition changes have drastic effects on the characteristics of the materials and consequently on the performance of the devices. The standard version of the instrument is able to measure with a resolution of typically 20 µm the X-ray excited fluorescence lines of the chemicals, without any physical contact on a full scale wafers by scanning.

Besides semiconductor wafers, the instrument can be used to analyze with a high local resolution any solid surface.

Principle of the method

X-ray fluorescence is a widely used technique for chemical composition analysis. The fluorescence is generally excited through a shielded X-ray beam or an electronic microscopy. The shielding reduces drastically the beam intensity, whereas the electronic microscope needs vacuum operation.

Here, no vacuum is necessary and the X-ray beam is no longer reduced in size by shielding but through a computer calculated capillary, as developed in house. In this manner, not only small beam sizes (typically 20 µm in diameter) but also high gains in intensity compared to conventional methods (the gains are between 50 and 100).

The instrument consists essentially of the following parts (Figs 1 – 4):

- an X-ray generator coupled to
- a capillary, based on critical angle full reflectivity of the photons
- a computer controlled X6Y displacement system
- an X-ray spectroscopy line operating at RT with high resolution using a dispersive semiconductor detector
- a PC based software

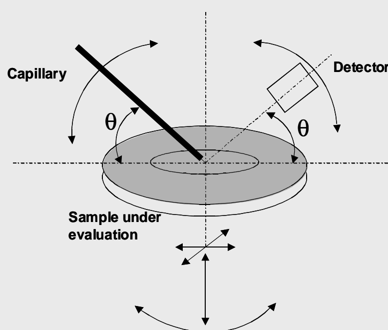

Fig. 1. Principle of the method

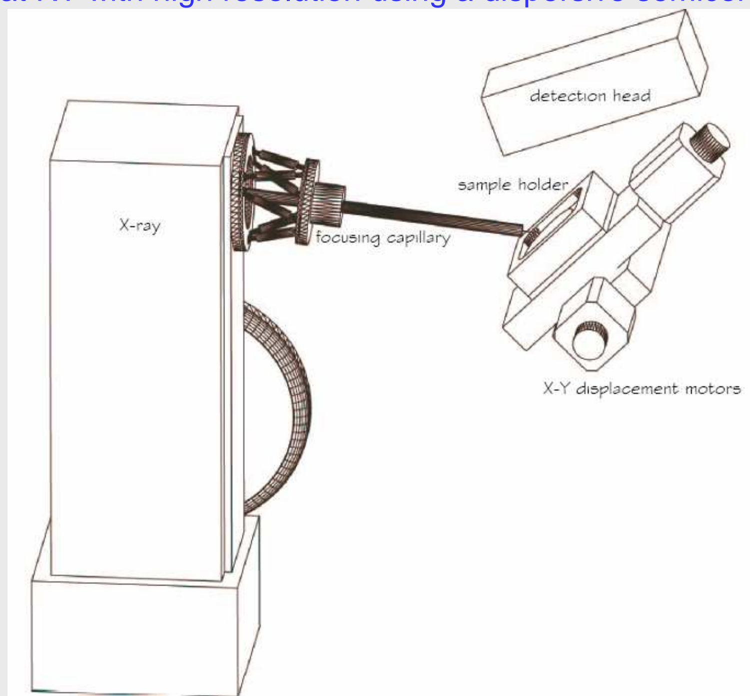

Fig. 2. Technical scheme of the system

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Results

To illustrate the possibilities of the instrument, CZT (CdZnTe) wafers have been analysed cut both perpendicularly and parallel to growth direction. The results are given on Figs 5-8.

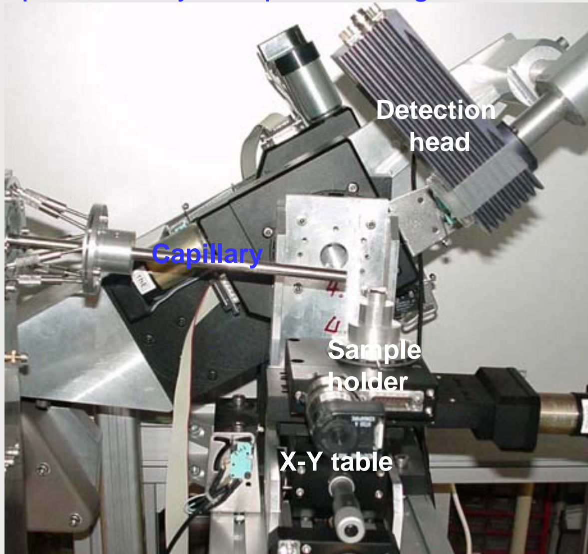

Fig. 3. General view of the EUROX-SCAN system

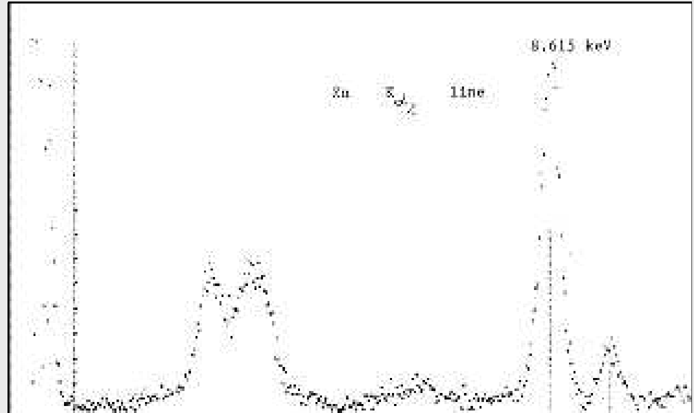

Fig. 4. X-ray fluorescence spectrum of CdZnTe obtained With a micro beam of 20 μm in diameter able to scan a whole wafer step by step. The spectrum displays the Zn $K_{\alpha 2}$ energy region

[Zn] mapping in pseudo-color on CdZnTe wafers

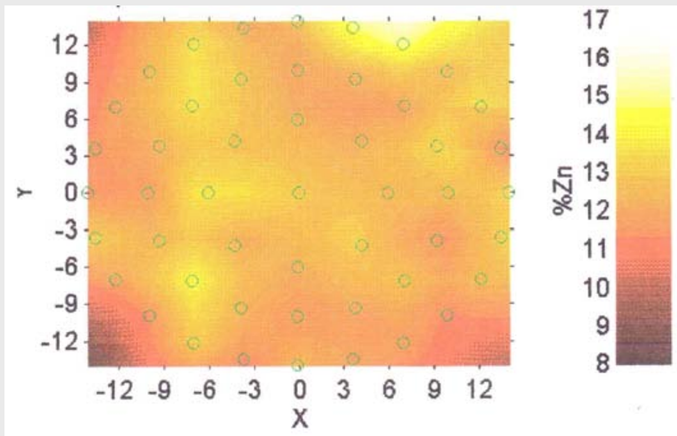

Fig. 5. Beginning of the CdZnTe ingot

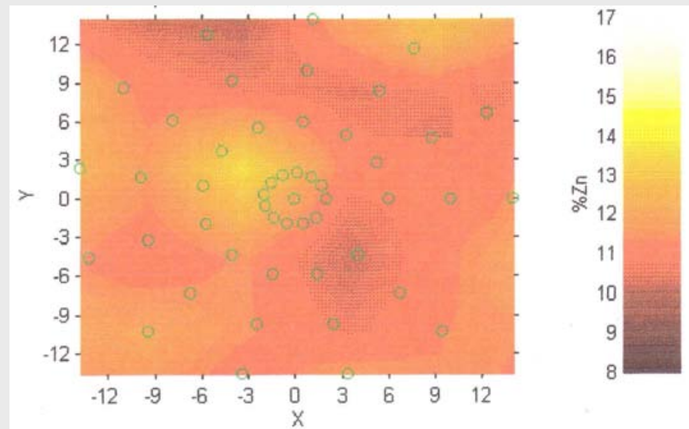

Fig. 6. Middle of the CdZnTe ingot

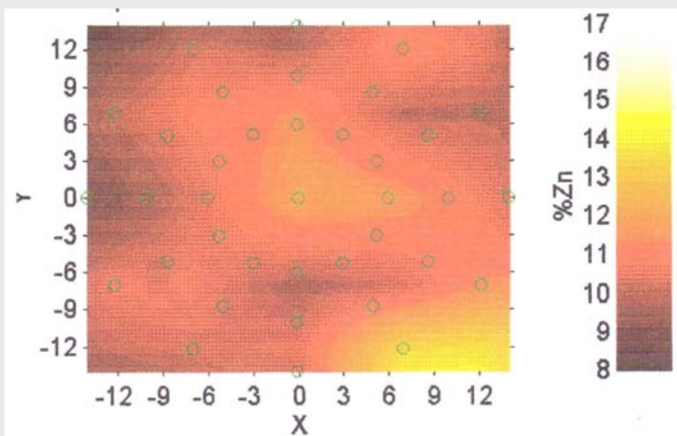

Fig. 7. End of the CdZnTe ingot

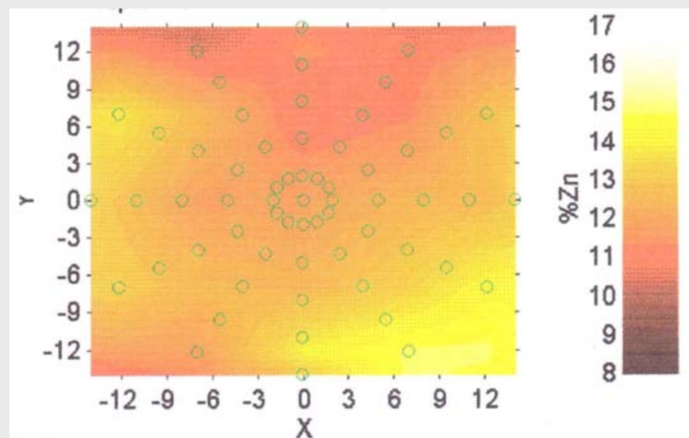

Fig. 8. Transversal wafer of the CdZnTe ingot

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