Bundesanstalt für Materialforschung und -prüfung

CERTIFIED REFERENCE MATERIAL for surface analysis

BAM-L002 / XXX

Nanoscale strip pattern for length calibration and testing of lateral resolution

ausverkauft / out of stock

CERTIFIED VALUES

Characteristic	Certified Value	Expanded (k=2) Uncertainty U_{CRM}
Calibration length L (centre to centre)	964 nm	35 nm
Strip width in grating 1	288 nm	16 nm
Strip width in grating 2	74 nm	6 nm
Strip width W5	145 nm	9 nm
Strip width W6	478 nm	25 nm

The expanded uncertainty $U_{CRM} = k * u_{cert}$ with k = 2 corresponds to a level of confidence of about 95%. u_{cert} is the combined uncertainty including the uncertainty of the certification procedure and the inhomogeneity of layer thickness across the wafer.

NON-CERTIFIED VALUES

for information only

Strip width W1	(48 ± 5) nm [1)]
Strip width W2	0.5 nm [2)]
Strip width W3	(5 ± 1) nm [1)]
Strip width W4	(48 ± 5) nm [1)]
Strip width W7	0.4 nm [2)]
Strip width W8	5 nm [2)]

[1)] measured value with rough uncertainty estimate

[2)] nominal value

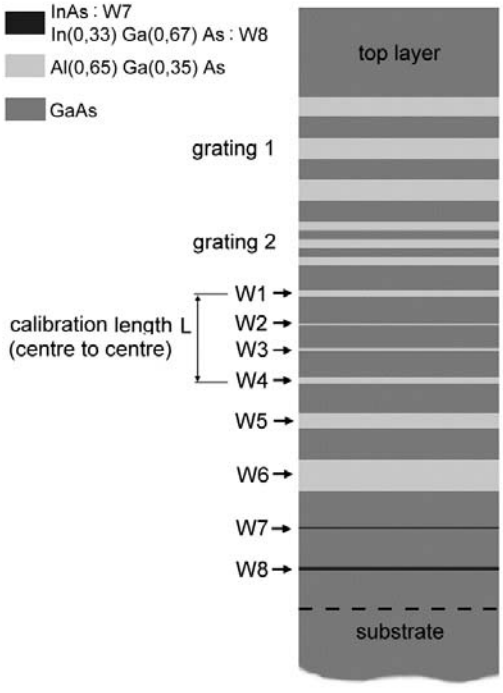

Fig. 1: Scheme of the strip pattern

CERTIFICATION PROCEDURE AND HOMOGENEITY

The certified values were determined from the inner part of a 2-inch wafer (dark and pale grey areas in fig. 2) and are valid for all samples taken from this area. They were provided by Transmission Electron Microscopy (TEM) using a JEOL 4000FX at an operating voltage of 400 kV and a magnification of 39 000 :1. The magnification of TEM was calibrated by means of a certified magnification calibration sample (MAG*I*CAL™ from Norrox Scientific, Canada) which again was calibrated with respect to the (111) lattice spacing of silicon.

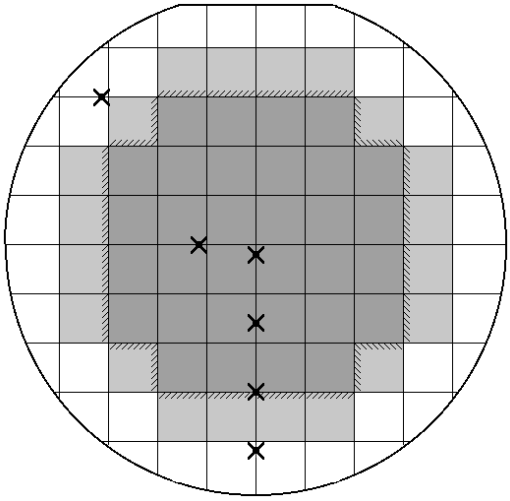

Fig. 2: 2-inch wafer with the cutting lines for the 5 mm ∗ 5 mm platelets. The dark and pale grey areas indicate the usable part of the wafer and the crosses mark the position where the TEM lamellae were prepared.

The certified values are means of 4 measurements made at different TEM lamellae taken from different positions of the inner part (dark grey in fig. 2) of the wafer. Two measurements at TEM lamellae from outside the dark and pale grey area yield a significant deviation of layer thickness from that measured at TEM lamellae from the inner part. The pale grey platelets were prepared in such a way that only the hatched edges were used to provide the strip pattern.

The combined uncertainties for the certified values are calculated from two components: The first one is caused by the inhomogeneity of the wafer and the random error of TEM measurement and is represented by the standard deviation of the values measured for the inner part of the wafer. If this standard deviation is smaller than the estimated uncertainty for the determination of the corresponding length on the TEM negative film, it is replaced by the latter. The second component is the uncertainty of the calibration of TEM magnification, which was estimated to be 1,6%.

The certified value for the calibration length L = (964 ± 35) nm was confirmed by the result of an inter-laboratory comparison for the measurement of lateral structures in the nanometre range with secondary ion mass spectrometry (SIMS). The participants measured 16 different

samples from the certified wafer yielding a mean of 956 nm. The value within the interval of (964 ± 35) nm, was determined by 12 of 16 participants.

STABILITY

$Al_xGa_{1-x}As$ - $In_xGa_{1-x}As$ – multilayers are long-term stable systems. However, oxidation of the surface takes place. The formation of oxide layers is a common issue, which is usually solved in surface analysis by sputtering the surface before analysis.

Sputtering for cleaning or analysis yields a change of surface topography. This effect has to be considered by the user. The cross section of a layered system has the same lateral structure across the whole depth of the sample. Therefore it is possible to renew the sample surface by grinding and polishing.

The epoxy material which the semiconductor platelets are embedded in is stable up to 110°C (230°F).

DESCRIPTION OF THE SAMPLE

The sample is a block of conducting epoxy with dimensions of about (12 x 10 x 4) mm^3. In this block two GaAs platelets were embedded. The shorter platelet was coated by an $Al_xGa_{1-x}As$ - $In_xGa_{1-x}As$ – multilayer stack. The block was ground and polished perpendicular to the plane of the two platelets. As a result one surface of the block (see fig. 3) shows a cross section of the multilayer structure corresponding to the strip pattern of fig. 1.

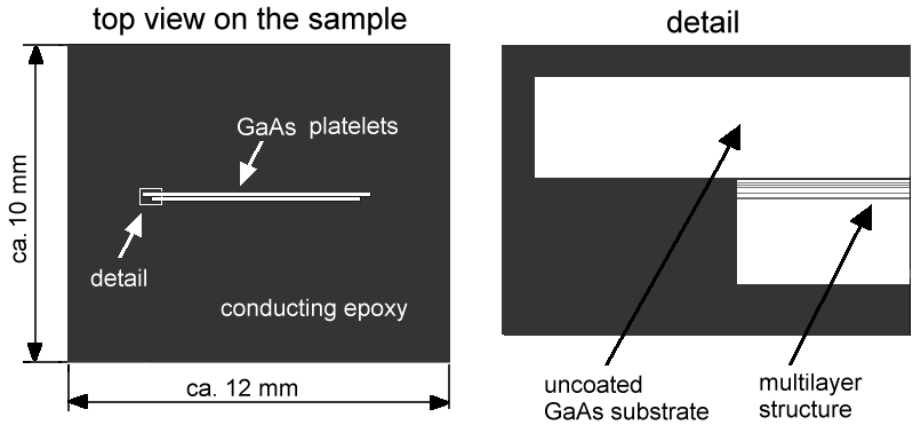

Fig. 3: Scheme of the sample

The epoxy material which the crystal platelets were embedded in is suitable for high vacuum, but it may be necessary to degas it in the vacuum chamber of a spectrometer. The minimum pressure obtained was $1 * 10^{-9}$ mbar.

APPLICATION

1. Length calibration

The calibration length L is the distance between the narrow strips 1 and 4. The certified value is the “centre to centre distance” and therefore it is independent on lateral resolution (beam diameter) of the instrument used.

2. Estimation of lateral resolution

Two gratings with different strip widths allow a direct estimation of lateral resolution during measurement and adjustment of the instrument.

3. Determination of beam diameter

The profile of the excitation spot can be analysed by measuring the profile of narrow strips (0.5 nm to 50 nm). If the width of the strip is small compared to that of the beam the measured profile is identical with the profile of the beam. The steepness of the rising edge of the excitation spot (16% to 84%) can be determined by measurement of a step transition at one of the edges of strip 6.

4. Determination of smallest detectable strip

Narrow strips with aluminium (0.5 nm, 5 nm, 50 nm) and indium (0.5 nm, 5 nm) enable the estimation of the smallest detectable structure.

Federal Institute for Materials Research and Testing (BAM)

Berlin, Germany

Department VIII
Materials Protection;
Non-Destructive Testing

Laboratory VIII.23
Surface and Thin Film Analysis

……

Dir. and Prof. Dr. W. Paatsch
Head of Department

……

Dr. W. Unger
Head of Laboratory