ICS 77.040
CCS H 21

NATIONAL STANDARD OF THE PEOPLE'S REPUBLIC OF CHINA

GB/T 43894.1-2024

Practice for determining semiconductor wafer near-edge geometry - Part 1: Measured height data array using a curvature metric (ZDD)

半导体晶片近边缘几何形态评价 第1部分:高度径向二阶导数法(ZDD)

Issued on: April 25, 2024 **Implemented on: November 1, 2024**

Issued by: State Administration for Market Regulation;
Standardization Administration of the PRC

Table of Contents

0 Place in the series

GB/T 43894 is planned in four parts, each attacking near-edge geometry from a different measured region and by a different calculation. This first part uses the second radial derivative of height. The second is to use edge roll-off, the third the local flatness of a sector-shaped region, and the fourth the local flatness of the incomplete region at the edge. So far only this first part has been published.

The introduction notes that the series is aimed at silicon wafers in the first place, but that the way it divides the wafer up and calculates can be carried over to wafers of other semiconductor materials.

3 Terms and definitions

Near-edge curvature is defined as the quantity described by the second radial derivative of a series of Z coordinates perpendicular to the median plane of the wafer, obtained from the array of wafer height data. Beyond this the terms of GB/T 14264 apply.

4 Principle of the method

The wafer is divided into sector-shaped regions by radius and central angle. Within each sector the array of height data is taken and the second derivative along the radius is worked out point by point, giving the near-edge curvature as a function of radius, and from that a

quantitative measure of near-edge geometry.

A note adds that the data array comes from a single surface, front or back, or from the wafer thickness.

5 Interferences

The positioning accuracy of the measuring equipment bears on where the measurement is actually taken and so on where the sampling points fall, which can make the result wrong.

Too few points in the height data array used for the calculation, too coarse a spatial resolution, wrong positioning and noise all bear on the result, as do the row spacing of the array, the way the sectors are cut, the method of calculating curvature and the definition of height.

Roll-off at the wafer edge makes the result change quickly as the radius grows, so that where the nominal edge exclusion is set too small the output becomes unstable; the nominal edge exclusion is to be set to suit the actual need.

Where the locating notch, the laser marking, or the clamping fixture falls inside the region from which the height array is taken, or where the front or back surface of the wafer intersects the fixed quality area, the array is collected wrongly, and those regions are to be set for exclusion beforehand. Wafer cleanliness may add noise to the scan and so bear on the result.

6 Test conditions and apparatus

Measurement is carried out at 23 +/- 3 degrees Celsius, at a relative humidity of 40 +/- 10 per cent, and in air no worse than class 5 of GB/T 25915.1-2021.

The geometry measuring system has to deliver a height data array with a height resolution no coarser than 1 nm; carry out calibration and edge exclusion and recognise and discard invalid data; work at a spatial resolution suited to the spacing of the height array, that spacing being no greater than 0.5 mm in both the X and the Y direction across the wafer surface; calculate the second radial derivative from the array and deliver results including summary statistics; and collect an array covering the whole wafer surface, so that the derivative can be calculated at every radius outside the excluded regions, with at least one measured point on each radius. The data processing system delivers results, summary statistics included, calculated as this document lays down.

8 Test procedure

The radii at which the second derivative is to be reported are set first, the largest of them being the nominal radius less the nominal edge exclusion. A note explains that the typical roll-off at the wafer edge makes the value rise quickly as that radius grows, and that the

largest radius that can be reported is limited by the minimum edge exclusion of the equipment.

The number of sectors is then chosen and the central angle of a sector follows from 360 degrees divided by that number. The document recommends 72 sectors, giving a central angle of 5 degrees, but leaves the number open to agreement between supplier and customer.

Regions to be excluded are set on the equipment: the edge exclusion; the laser marked area, which for a 450 mm wafer without a notch takes in the marked locating datum; any area inside the collection region that may be masked, such as that hidden by a clamp or by the locating notch; and any further region the parties agree on. The setting of an excluded region in polar and in rectangular coordinates is illustrated in an informative annex, four parameters fixing its position and size in each system. The position and least area of wafer identification marks and datum notches follow GB/T 16596 and GB/T 34479 or are agreed between the parties, and the position and actual size of the excluded region may carry a margin for the tolerance of the particular system.

Last, the statistics that have to be reported for each wafer are fixed; they are to include at least the maximum, the mean, the range, the standard deviation and the 95th percentile.

9 Treatment of test data

The wafer is divided into the chosen number of equal sectors. For each sector the anticlockwise boundary angle is one half of the central angle beyond the start of the sector, and the clockwise boundary angle one half of the central angle before it, both counted from the multiple of the central angle that the sector index gives.

Where the excluded area of a sector passes 20 per cent of the area of that sector, the sector counts as invalid and is left out of the statistics.

The height data array is interpolated onto the polar grid of each valid sector, at a point spacing matching that of the scan array and taking in the boundaries of the sector; a note records that the boundary data are produced by interpolation. At each radius, inside the sector and on its boundaries, the height values are averaged, giving the mean radial profile of the sector in polar coordinates.

The second derivative of that mean profile with respect to radius is then taken at each radius, giving the value that the document abbreviates as ZDD, in nanometres per square millimetre. Repeating over all sectors gives the mean radial second derivative of the whole wafer at each of the chosen radii.

Where the measurement is repeated, statistics are calculated over the repeats as well as for the single run, and are to include at least the maximum, the mean, the range, the standard deviation and the 95th percentile. Where the number of sectors is small, fewer

than one hundred for example, the 95th percentile may be left out.

10 Precision

Three polished silicon wafers and two epitaxial silicon wafers, 300 mm in diameter and 760 µm to 790 µm thick, were each measured five times for thickness in three laboratories. The relative standard deviation within a single laboratory did not exceed 4 per cent and that across laboratories did not exceed 5 per cent.

The same five samples were each measured five times for front surface height and for back surface height in four laboratories. The relative standard deviation within a single laboratory did not exceed 6 per cent and that across laboratories did not exceed 8 per cent.

11 Test report

The report gives at least the date and time of the measurement; the operator; the measuring and computing equipment, with maker, model and software version; the spatial resolution and the data point spacing; the batch number and wafer number, the wafer size and the nominal edge exclusion; the central angle of the sector; and, for each wafer, the maximum, mean, range, standard deviation and 95th percentile of the second derivative, together with the statistics at each radius and anything else asked for. The number of this document is also given.