

Peak Growth - Producing scanning probe tips using electron beams positioned with nano precision



Peak growth

NanoTOOLS GmbH is the global market leader for the production of special sensors for scanning probe microscopes. In cooperation with Olympus Soft Imaging Solutions the company has transformed a Scanning Electron Microscope (SEM) into a fully automated production apparatus for ultrafine scanning probes. Positioned with a precision of better than 10 nm, the electron beam causes the tips of the future probes to grow. This makes aspect ratios possible that had been unattainable until now. Within the framework of this joint effort with NanoTOOLS, Olympus Soft Imaging Solutions has developed the „WaferNavigator“ software package. „WaferNavigator“ takes any scanning electron microscope and turns it into an automated processing and measurement tool.

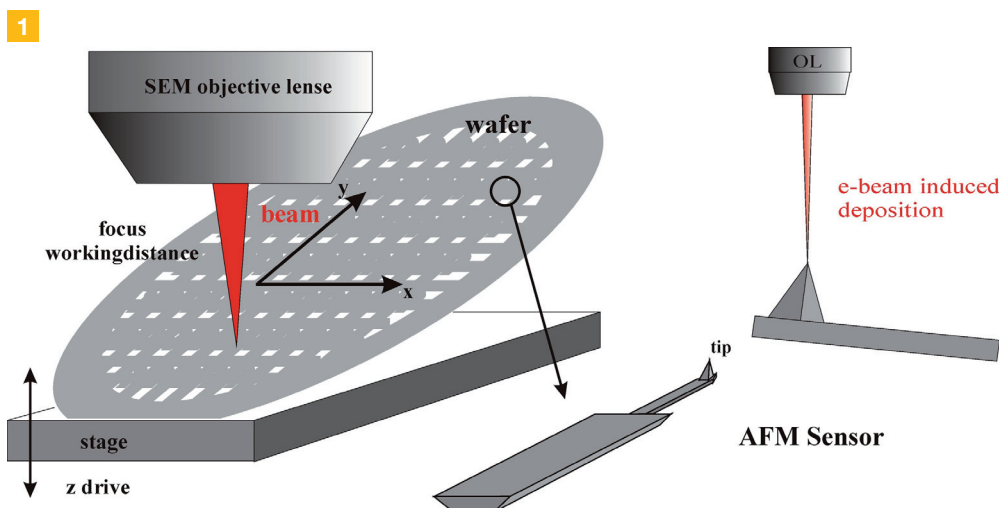
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One to ten and better

Scanning probes for Atomic Force Microscopes (AFMs) are very fine tips, which need to fulfill specific requirements in accordance with the object being scanned. As an example, we will look at the ultrafine AFM scanning probes used for process monitoring in semiconductor chip manufacturing. These tips must be thinner than 50 nm and have an aspect ratio (diameter:length) that is better than 1:10. NanoTOOLS GmbH in Munich is the global market leader for special sensors for scanning-probe microscopes. These probes are produced using unprocessed silicon tips. After the initial manufacturing process, they are refined using electron-beam induced deposition. An electron beam is aimed at the highest point of an unprocessed tip. The interaction of the beam, gas in the chamber and the tip results in molecules being deposited there. Depending on the gas composition within the SEM, these molecules polymerize to ultrafine, peak-shaped structures that are either carbonaceous, diamond-like or metallic.

Thirty parameters all under control

Approximately 30 process parameters must be monitored during production in order to maintain a consistent level of quality for the AFM probes. This is really only feasible when production is fully automated. A standard scanning-electron microscope (SEM) serves as the basic equipment. This is then converted for the deposition process and adjusted such that it can be operated automatically from an external source. The unprocessed silicon AFM probes are on a four-inch wafer, which is affixed to a motorized stage in the SEM. Automating this refinement process was tackled jointly with Soft Imaging System. This company, headquartered in Münster, Westphalia, Germany is a specialist with regard to digital image analysis and digital image management and has years of experience automating analog and digital SEMs. The goal of our joint effort was to develop a system that allowed the positioning of the SEM electron beam on three-dimensional semiconductor structures with a precision better than 10 nm.



This is how ultrafine tips are made: a four inch wafer with 400 unprocessed silicon tips is mounted in a scanning-electron microscope (SEM) with a motorized stage. The electron beam is targeted at the highest point of each individual tip and induces the deposition of certain molecules there. A needle-shaped structure grows upwards little by little with a diameter of 50 nm, for example. Olympus Soft Imaging Solutions software Scandium Solution „WaferNavigator“ and their ADDA II interface take care of the automatic control of the electron beam, of the motorized stage and of the entire production process. The entire process is documented by the software and a report is automatically generated.

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Ultrafine and very pointy: the primary characteristics determining the quality of a probe tip of a scanning probe microscope are its diameter and aspect ratio (diameter : length). The tip shown has a thickness of 50 nm and its aspect ratio is better than 1:40..

Type **M* 8 - 40**
Length 8µm, aspect ratio better 1:40,
Available on a wide range of cantilevers



1 µm

Localize it, position it, focus it, document it

The automation software developed by Olympus Soft Imaging Solutions is embedded in their SEM software environment Scandium and uses their ADDA II interface. This software controls and monitors the position of the motorized stage in the SEM and the electron-beam parameters relevant to production. Among other parameters, the software monitors and controls the following processes:

- moves the stage to the positions of the unprocessed AFM tips on the wafer
- localizes the three-dimensional, generally pyramidal structure of the unprocessed AFM tips via pattern recognition
- positions the electron beam with a precision better than 10 nm
- focuses the electron beam onto the highest point of the respective object
- keeps a record of beam parameters in situ during the deposition process
- documents the position the stage is moved to both before and after deposition via image acquisition and image archiving
- generates a complete production report with all relevant data on the finished batch

Before the production run, the operator can define which areas of the wafer are to be processed, the structures in those areas and what the abort criteria are to be.

100% guarantee

For the deposition process, the relevant parameters (eg, such as beam position, beam exposure time) can be defined as desired according to the type of probe being produced. This software also offers the option of producing different kinds of probes within the same batch. The production report indicates the positions where the special refinement was successful and where it wasn't. Defective probes can be sorted out immediately and the customer can be given a 100% guarantee for the product. Furthermore, the reasons for any possible defects during deposition can be determined via the recorded process parameters.

Other application fields

Within the framework of the joint effort with NanoTOOLS, the automation software was fully developed by Olympus Soft Imaging Solutions for market release. This software is now available as the Scandium Solution „WaferNavigator“ software package. It is suitable for operating SEMs automatically for measuring and material processing of any kind. It also offers the entire range of image analysis and image management functions available within Scandium.

Another application field for „WaferNavigator“ is automatically measuring Critical Dimensions (line widths) on wafers and lithography masks in the semiconductor industry, for example

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