NanoWizard® AFM integration with the Olympus LEXT OSL4100 and BioMaterials Workstation

JPK Instruments recently developed a new modification of their Biomaterials Workstation (BioMAT™) for use with the Olympus LEXT OSL4100 3D laser measuring microscope. The BioMAT enables the unique combination of research grade optical upright microscopy (bright-field, fluorescence, laser-scanning confocal etc.) and AFM on opaque samples without compromising the performance of either technique. In a sequential measurement scheme, the sample is exchanged between the two instruments using a mechanical ridged shuttle stage to access the same sample area for both techniques.

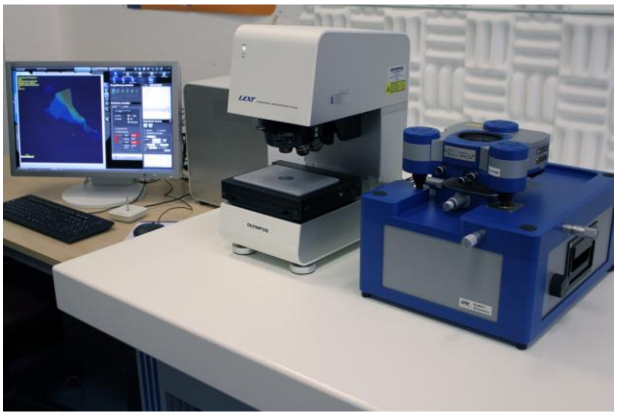

Fig. 1: *The JPK NanoWizard® on the BioMAT™ in combination with LEXT OSL4100 from Olympus*

Olympus LEXT OSL4100

The LEXT confocal laser scanning microscope (CLSM) from Olympus utilizes optical metrology enabling non-contact surface roughness measurements to be obtained. It provides high-resolution 3D surface profile observations and measurements in real-time in contrast to scanning electron microscopy (SEM) in which no precise height information can be obtained. Furthermore, no extensive sample preparation such as the conductive coating of the specimen is needed to avoid electrostatic charging.

The LEXT uses a short wave-length violet semiconductor laser (405 nm) in a fast and precise 2D scanning system (fast axis MEMS, slow axis Galvano mirror) to achieve a high lateral resolution of about 0.12 µm. A superior height resolution 10 nm is achieved by a dual confocal system where the objective-lens is moved along the z-axis to detect the change of light intensity yielding an I-Z curve per pixel. Olympus CFO (calculated focus operation) detects the maximum brightness value along the z-axis which defines the height of an image pixel. The dual confocal system corrects efficient for differences in sample reflectivity.

Integration

Adapting the LEXT OSL4100 to be used along the BioMAT™ Workstation is straight forward and requires no mechanical modification of the optical microscope (Fig.1). An adapter plate as a precise bearing for the shuttle stage is added to the motorized sample-stage of the LEXT. The initial reference calibration needed to synchronize the AFM and LEXT field of view is fully supported by the LEXT software.

Field of applications

Applications include high resolution AFM imaging with parallel, high resolution measurement of additional sample properties such as mechanical stiffness, conductivity, surface potential and magnetism on the nanometer scale guided by the precise 3D surface profile accessible by the LEXT CLSM. Typically, the AFM with its extraordinarily high spatial resolution beyond the nanometer scale, it suffers from limited access volume which complicates high resolution imaging on heterogeneous, highly corrugated samples. Now, target features on the specimen can be quickly located within the reliable, high resolution 3D profile before investigation by AFM.

Application examples

A macroscopic read/write head of an hard-disk combines a microscopic GMR (giant magneto-resistance) sensor structure (read device) with a two pole magnetic write device shown in Fig.2 (a). This is located at the very edge of the macroscopic read / write head and difficult to see by standard optical microscopy. Thanks to the large accessible scanning area of the LEXT combined with its

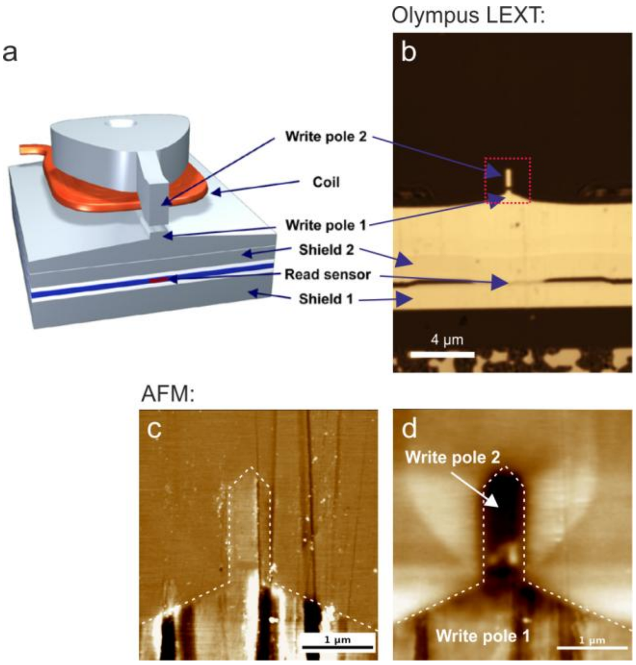

Fig. 2: *Scheme of GMR sensor with write device used in hard-disks (a) and optical reflectance image of the sensor structure acquired by LEXT (b). The red marked area in (b) was imaged directly by AFM yielding topography (c) and magnetization (d).*

high spatial resolution, the GMR structure can be easily located in the reflectance channel of the LEXT. After transfer of the sample to the AFM, topography and MFM (magnetic force microscopy) images (Figs.. 2, b & c) of the write poles of the device were taken directly without the need for large and slow overview AFM-scans. The write poles 1 & 2 are clearly resolved. Furthermore, the sensor's structure is planar and therefore almost invisible in the AFM topography and only just visible in the AFM's MFM channel.

As a second example a structured, doped (p-n) semiconductor sample was surveyed on a large scale using the LEXT (Fig. 3, a) to confirm the structure's uniformity. The inspection of the 3D surface profile acquired by the LEXT yields an average depth of the trenches (Δz = 180 ± 20 nm) in perfect agreement with the depth measured by AFM topography shown in Fig. 3 (b).

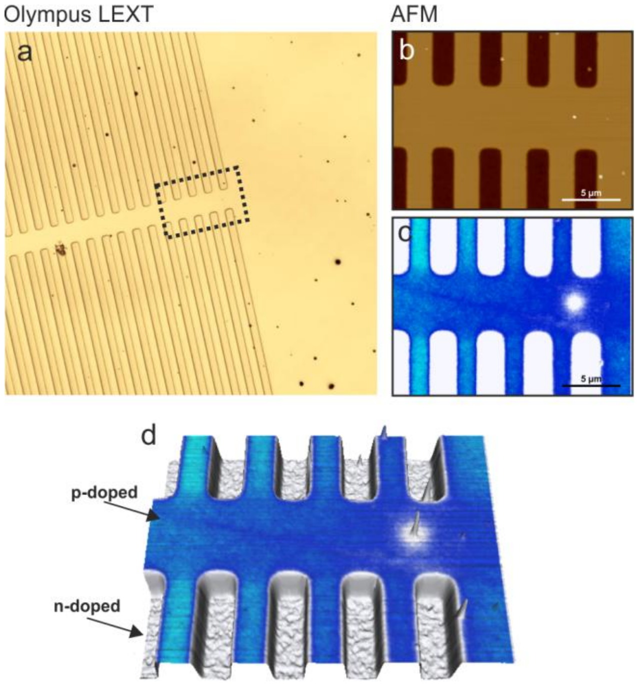

Fig. 3: *Overview 3D profile of doped (p, n) semiconductor structure (a) acquired by LEXT. Corresponding AFM topography (b) and EFM image (c) of the marked region in (a). Overlay of 3D AFM topography and EFM (d)*

Furthermore, the uniformity of the structure's doping was tested in parallel to the AFM-topography imaging by recording EFM images (electrostatic force microscopy) as shown in Fig. 3 (c). The overlay of the 3D AFM topography and EFM image shows a perfect match of the spatial structure and the doping. The trenches are n-doped while the plateaus are p-doped.

Conclusion

The combination of cutting edge optical microscopy, such as the Olympus LEXT OSL4100, with high resolution AFM employs novel, experimental schemes in which quick and precise sample surveys may be combined with nm scale, quick testing of geometry and secondary sample properties such as mechanical, electrical and magnetic characteristics.