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C. Wystup / M. Stubenrauch / M. Hoffmann

‘Black Silicon’ Adjustment Chips – A Nanointerface for the Conditioning of Multifunctional AFM Scanning Tips

Conditioning of multifunctional AFM cantilevers

A new quality in nano analytics is targeted within the sub-projekt A8 of the Sonderforschungsbereich SFB-622 (Nanopositioning- and Nanomeasuring Maschines), having a smart tool for the integration of various AFM cantilevers with different measuring principles on one standard platform for fast exchange as one key interest. The alignment of AFM tips with a high precision in correlation to the AFM laser beam and a long term stability on an AFM exchange platform within the NPM (nano-positioning and nano-measuring machine) is vital for the overall precision of the machine.

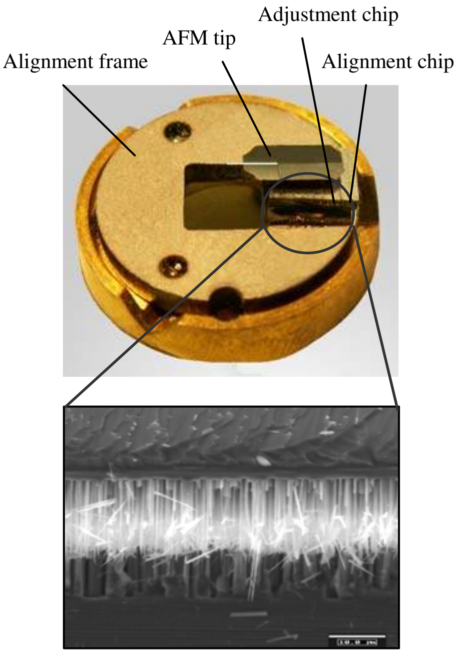

Figure 1:
AFM exchange plug with nano analytics

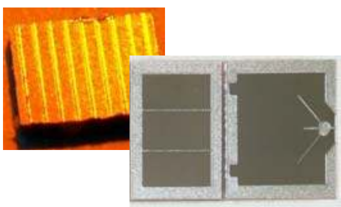

Figure 2:
AFM alignment chips

A new approach for the direct coupling of silicon work pieces is the ‘Black Silicon’ bonding which has been developed and established at the TU Ilmenau [1]. Needle-like surface structures with diameters between 300-900 nm on two silicon work pieces interlock during the process. Thus, a mechanically stable interface is formed.

A special setup consisting of alignment chips with nano structured ‘Black Silicon’ surfaces can exploit the Velcro® effect on solid state materials. Different AFM cantilevers can be aligned with high precision onto a standard platform (Figure 1). At first, the AFM cantilevers are glued to adjustment chips and the alignment frames are glued to alignment chips as a conditioning step. Subsequently, the pre-assembled components are accurately adjusted to each other in an align fixture and interlocked using the ‘Black Silicon’ functional surfaces. Finally, a polymer encapsulation protects the nano interface. The combinatorial effect of the polymer encapsulation of the Silicon Velcro® also inhibits drift and creep, minimizes the influence of external effects onto the interface and simultaneously protects the environment from the emission of nano particles from the interface. Areas without ‘Black Silicon” are required for the precise and non-destructive handling of the 3 x 2.6 x 0.4 mm^3 alignment and adjustment chips during the conditioning process. These areas serve as hub for handling tools (e.g. vacuum tweezers). For the implementation of such patterned mesa structures, a new process has been developed protecting the areas for the later nanostructured surface during a lithography and a subsequent deep etching step. The etched-back silicon surface is protected with a metal layer in order to generate the 'Black Silicon' on the desired areas only.

The optimized design of the functional surfaces on the chips enables a full encapsulation of the bond interface using capillary and surface tension forces. It also allows an exact dosing of small polymer solution volumes (< 0.5µl). Disturbing outgassing of monomers as well as over dosage can be avoided.

On the backside, special surface pattern inhibit hydroplaning of the chips during the fixation in the pre-assembly step (Figure 2).

Evaluation of the polymer encapsulation

For the determination of different quality parameters, e.g. mechanical toughness of the interface or the evaluation of the encapsulation, a visualization of the bonded silicon chips is required.

So far, the huge absorption coefficient of the nanostructured silicon surface (wavelength up to the IR range) constricted a non-destructive imaging of the interface. In contrast to normal polished silicon surfaces (which are transparent in IR light), the 'Black Silicon' could be seen as a totally black area only.

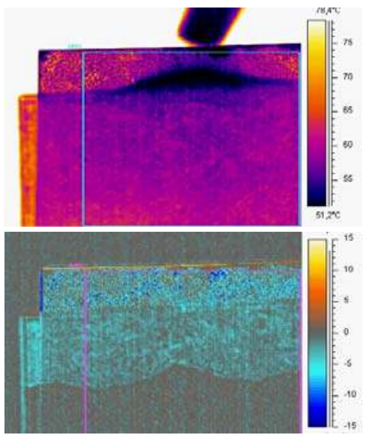

Figure 3:
Nondestructive inspection of a nano interface(IR transmission)

By means of a special transmitting light setup with a MIR infrared sensor we could get radiation through the bond interface. Thus, it is possible to visualize the two interlocked functional nano surfaces. The nanostructured silicon is highly transparent in the middle infrared range. The surface features are small enough not to induce too much scattering. The resolution is sufficient for the identification of surface defects which can lead to a negative impact on the mechanical stability (Figure 3).

This method enables an easy way to check each nano interface even after assembly.

The new inspection method is additionally suitable for experiments and studies of the spreading of low viscous liquids inside a 'Black Silicon' interface.

References:

[1] Stubenrauch M., Fischer M., Kremin C., Stoebenau S., Albrecht A., Nagel O.: Black silicon – new functionalities in microsystems, Journal of Micromechanics and Microengineering 16/6, S. 82-87.

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