Gluing micro-spheres on cantilevers in aqueous solution

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Introduction

A new procedure was developed, which is suitable for gluing silica micro-spheres (e.g. Ø = 5 µm) with high accuracy on a tipless CSC12 AFM-cantilever (Mikromasch, Tallinn, Estonia). As most steps are performed in aqueous solution, the benefits are: (1) applicability even in presence of strong adhesive forces between support and micro-sphere (e.g. capillary forces) and (2) possibility to correct the micro-sphere position on the cantilever (resulting in sub-µm positional error) until the glue is cured via UV-radiation.

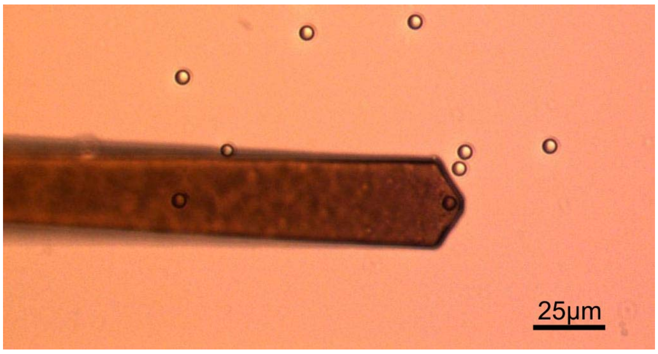

Fig. 1: Tipless cantilever in water with 5 µm micro-spheres

Techniques to glue micro-spheres to tipless cantilevers are commonly performed in air (for detailed information see technical report jpk-tech-spheres-on-tip.doc [1]). In this context, approaches that employ thin filaments to place the micro-sphere on the cantilever are often accompanied by a discontinuous movement / jump of the micro-sphere from the filament to the cantilever. This problem is caused by capillary forces (arising between the sphere and the cantilever) and makes it often difficult to achieve a central micro-sphere position on the cantilever beam. To increase the positional accuracy, other approaches try to catch and lift up a micro-sphere (laying on a glass-slide) directly with a glue-covered cantilever. However, these procedures become unfeasible if there are strong adhesion forces between support and micro-sphere. Here, we present a new approach which eliminates both effects as most of the steps are performed in solution. Using this procedure it is possible to position the micro-sphere with approximately 500 nm accuracy on the cantilever beam.

Protocol

<u>The following steps have to be performed in the sequence indicated:</u>

(1) At first two glass-slides have to be cleaned with the help of an RCA 1-treatment [2,3]. This treatment is recommended to avoid sphere contamination.

(2) In the second step a thin filament or a needle is used to put a line of the UV-curable and hydrophobic adhesive *NOA68 (*Edmund Optics GmbH, Karlsruhe, Germany) on a clean glass-slide. It is recommended to create the line perpendicular to the orientation/long axis of the cantilever beam.

(3) With the help of the JPK NanoWizard® AFM-piezos, the front of the cantilever is immersed 1µm into the adhesive. After 1 second of indentation, the cantilever is retracted. A small drop of glue remains on the bottom side of the front of the cantilever.

(4) 1 ml of a solution of distilled water and micro-spheres (0.006 wt. %) is pipetted on a second clean glass-slide. Because of the RCA 1-cleaning, the solution spreads over the whole slide, so that most of the micro-spheres inside the solution get separated. In the solution the micro-spheres lay on the ground, but they do not adhere. After pipetting a drop of distilled water on the cantilever, the AFM-stepper motors are used for driving the cantilever into the solution.

(5) When catching a single micro-sphere it is important to use low tip-velocities (~1 µm/s) close

to micro-sphere, because the micro-sphere could be moved away from its former position due to the induced flow.

(6) When the glue-covered end of the cantilever beam is over the micro-sphere, the z-piezo is used to press the micro-sphere into the adhesive with a force of 5 nN for ≥ 5 s. Small adjustments of the position of the micro-sphere can be achieved via cantilever-movement with the help of the x- and y-piezo.

(7) Now the micro-sphere weakly adheres to the tip and the cantilever can be retracted from the surface.

(8) It is now important not to pull the cantilever out of the water, because the surface-tension could either detach the micro-sphere from the cantilever or relocate it on the cantilever. For this reason a portable UV-lamp (*UVGL-25* for wavelengths of 254 and 365 nm (VWR, Darmstadt, Germany) is used for curing the adhesive in solution. Despite of the UV-absorption in water, enough radiation reaches the cantilever, so that the glue starts curing. Usually, this takes 7 minutes at 254 nm wavelength and a distance of approximately 10 cm between lamp and cantilever. After this first curing it is save to pull the cantilever out of the water. Afterwards, the curing-process has to be completed with the UV-lamp or another stronger UV-source.

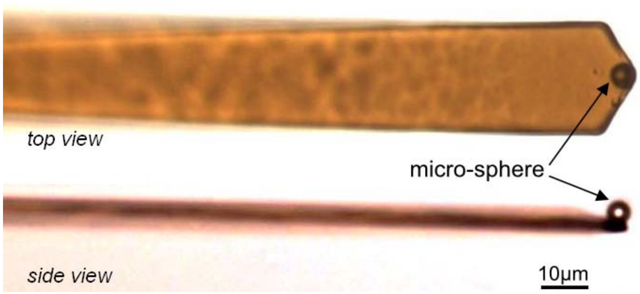

Fig. 2: Cantilever with 5 µm micro-sphere attached at the end of the cantilever beam. Using the new deposition procedure, the location of the micro-sphere can be easily adjusted until the central position is reached. This results reproducibly in sub-µm positional error.

Literature

[1] JPK technical report: Attaching microspheres to cantilevers using the NanoWizard® Life Science stage and AFM head. http://www.jpk.com/jpk-tech-spheres-on-tip2.download.a7e6fc3981828b6eefb1cbb0557a886a.pdf

[2] W. Kern and J. Vossen, Eds., *Thin Film Processes*, Academic Press: New York, 1978, Ch V-1.

[3] W. Kern, Ed., *Handbook of Semiconductor Cleaning Technology*, Noyes Publishing: Park Ridge, NJ, 1993, Ch 1

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