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High throughput tips manufacturing for active piezocantilevers with xenon ion beam with mass control

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Microcantilevers equipped with orthogonal tips are basic tool in many scanning probe microscopy (SPM) techniques, especially in atomic force microscopy (AFM). Tips are medium for transferring interactions between surface and appropriate transducers, their durability determines life span of a tool. However, it is possible to preserve the tool by regeneration of the tip. While original tips are manufactured with use of mass production methods, regenerated tips require unitary approach. Therefore throughput of regeneration method becomes valid parameter.

For regeneration of tips focused ion beam (FIB) family of techniques can be used. It allows both for removing (milling) and building (depositing) the material. With use of nanomanipulators auxiliary materials can be applied [1]. Manufacturing the tip requires time, as required amount of material has got to be moved. To increase the throughput of process inert gas plasma beam can be utilized. Plasma beam offers greater currents than liquid metal sources or gridless ion sources. Furthermore, use of heavy element such as xenon greatly improves processing speed, as Xe ions have higher sputtering yield (2.3 atom/ion on silicon on normal incidence) than e.g gallium (2.05) and also lower penetration depth (mean 11,1 nm versus 12.2 nm for gallium) [2].

To get a hold on rapid process, external measuring circuit is applied. Active cantilever is actuated at the resonant frequency and it can be viewed as a simple harmonic oscillator (SHO). Material deposition delivers mass to the SHO, therefore reducing its resonant frequency; material milling during process raises resonance. Vibrations are observed with help of amplifying circuit on the oscilloscope, where in situ assessment of process' result is possible with measurements of mass

In this setup conductive diamond tips were delivered onto active piezoresistive cantilevers. We present used setup with results in form of sharpened tips.

[1] E. Gacka, P. Kunicki, A. Sikora, R. Bogdanowicz, M. Ficek, T. Gotszalk, I. Rangelow, K. Kwoka; *Focused ion beam-based microfabrication of boron-doped diamond single-crystal tip cantilevers for electrical and mechanical scanning probe microscopy*; Measurement (**2022**), 1

[2] R.P. Webb, I.H. Wilson; *Problems using the Sigmund formula for the calculation of sputtering yields*; Vacuum (1989), 1163

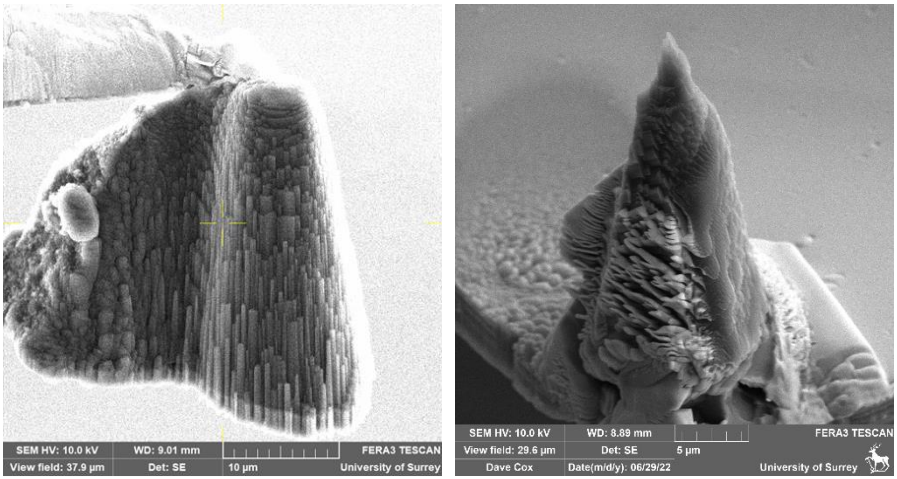

Fig. 1: Diamond tip before mounting, carried with nanomanipulator (left) then mounted and sharpened (right)

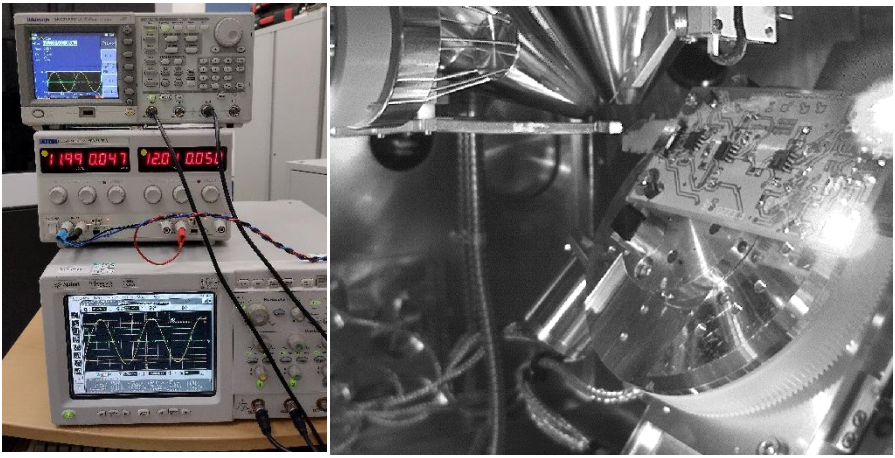

Fig. 2: Tip placement control setup consisting of: power source, function generator, oscilloscope outside chamber (left) and circuit board of amplifiers inside the chamber (right)