PREPARATION OF SB DOPED SnO_2 SPM TIPS AND THEIR USE AS TRANSPARENT PROBES IN STM INDUCED LIGHT HYBRID MICROSCOPY.

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Development of various kind of sharp needles has been in focus of investigators since their application as sensors in scanning probe microscopy (SPM). As transparent SPM probes, metal coated SiO_2 needles have found the use in near field (SNOM) studies. By now different methods based on melt pulling or etching of silica fibres have been developed for production commercial sensors. By a crude division two different kind of tips, aperture and apertureless, are designed for use as SNOM probes. Surprisingly metal oxides have found very limited attention as sensor materials, although they have many interesting and potentially valuable properties like extremely high strength in the case of HfO_2, electrical conductivity simultaneously with optical transparency in the case of doped SnO_2, high-yield fluorescence in the case of rare-earths doped TiO_2, etc.

We have made many efforts for finding possibilities to sharpen such metal oxide fibres down to nanometer scale needles and use them as SPM probes. In our first paper we presented a technology to prepare Sb^{3+} doped SnO_2 tips from thermally degraded $Sn(OBu)_4$ with tip radius less than 50 nm [1]. Afterwards we found that suitable precursors for tips can be obtained by slow addition of water to $Sn(OBu)_4$. Then we improved universality of the method and prepared sharp needles from TiO_2 [2]. In our recent paper we focused on luminescence generated by tunnelling current when operating the tips in STM mode and applying voltages higher than certain threshold between the tip and surface [3,4].

In current study we have focused mainly for the phenomena of tips formation. Typical shapes of SnO_2 tips prepared from viscous stannoxane solutions are shown in Fig.1. Optimum pulling speed for tips preparation were found to be around 1cm/s that forms tips with tip angle 7-10 degrees and tip radii from 10-20 nm from the precursors with viscosities from 300 to some thousand poises. Lower speeds led to larger tip angles and lowered reproducibility of the tip shapes. Although higher speeds led to sharper tips, they were typically bent and mechanically unstable.

Phenomena of converging of sol jet during the pulling are essential for understanding the mechanism of tip formation. In principle the fibre brakes in a region where its viscosity is the lowest. Viscosity depends on complicated interplay of several phenomena like polymerization of the fibre surface caused by water vapour in air, dynamics of the orientation of the molecules in moving jet, etc. Creation of an exact model remains for future studies.

References:

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[4] V. Jacobsen, Ph.D. thesis, University of Mainz (2004).

Figures:

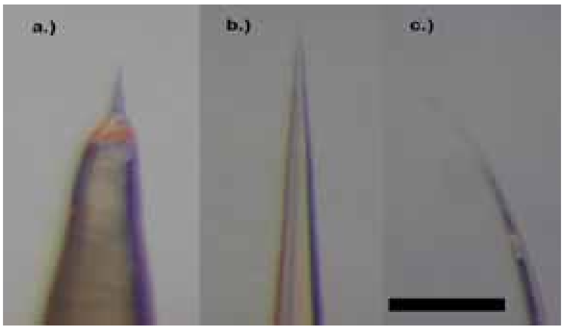

Fig.1 Typical images of fibres pulled at a) 0.25 m/s, b) 1.05 m/s and c) 3.20 m/s from solution with viscosity of 500-2000 poise. The scale bar on the images is around 0.1mm.

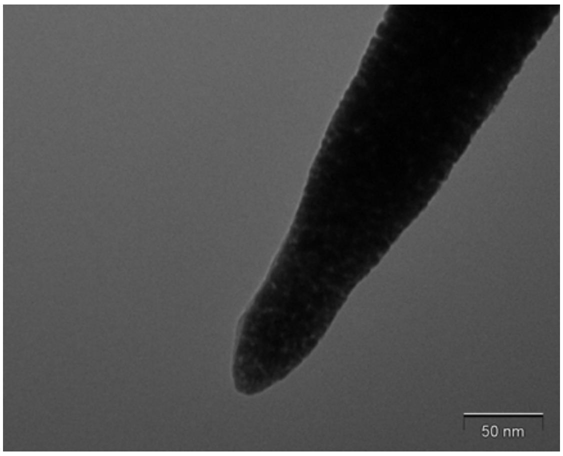

Fig.2 TEM image of tip prepared by pulling speed 1.05 m/s from the stannoxane solution with viscosity of 500-2000 poise.