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Quantitative understanding of ink transport in Dip-pen Nanolithography

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Motivation of the work

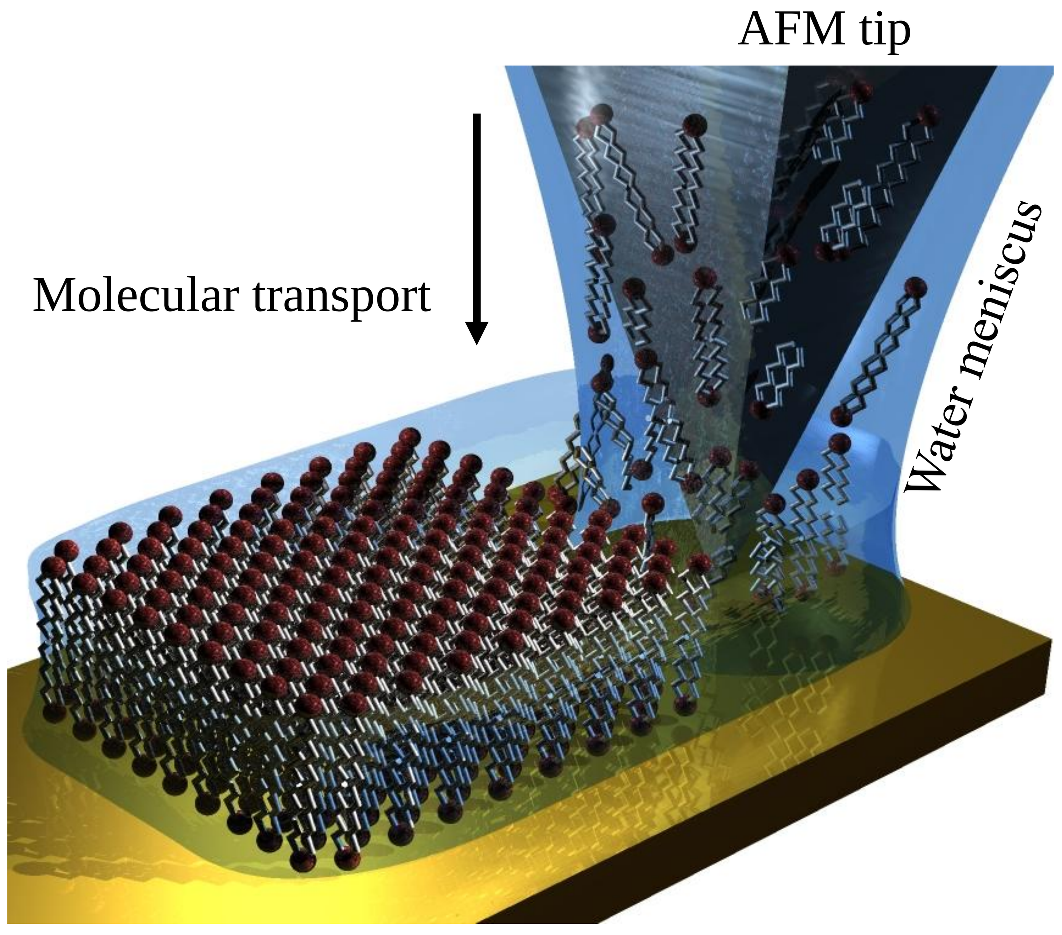
❖ Dip-pen Nanolithography (DPN), based upon an atomic force microscope (AFM), has evolved as a unique tool for nanotechnology.

❖ DPN in particular offers the unique potential of ultrahigh throughput and materials integration when carried out in parallel with phospholipids inks [1].

❖ Though DPN has been extensively used before for patterning surfaces, it is important to mention here that there is still no complete understanding of the ink transport mechanisms.

❖ In order to control the patterns one should understand the process properly [2].

❖ In this work, we try to understand the ink transport in DPN using atomic force spectroscopy.



Schematic of the DPN-writing with lipids [3]

Basic concept

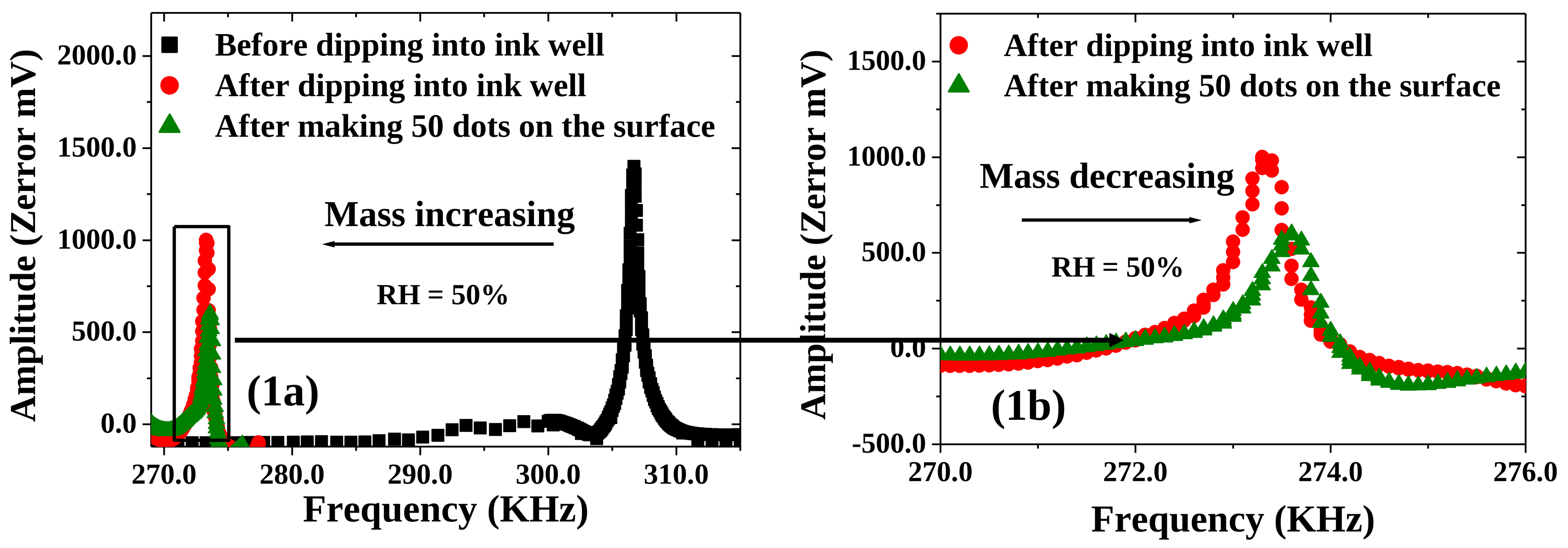
When an AFM cantilever is vibrated, the resonance frequency f of the cantilever is given by

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{M}}$$

where k is the spring constant and M is the effective mass of the cantilever. When the resonance frequency shift Δf occurs due to mass change, mass change Δm is calculated using

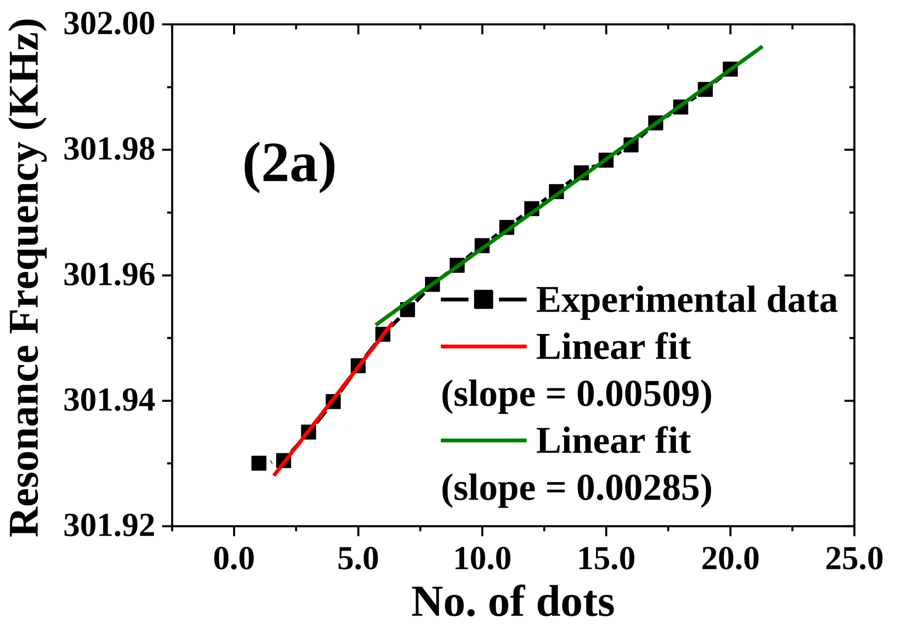
$$\Delta m = -2\frac{m}{f}\Delta f$$ [4]

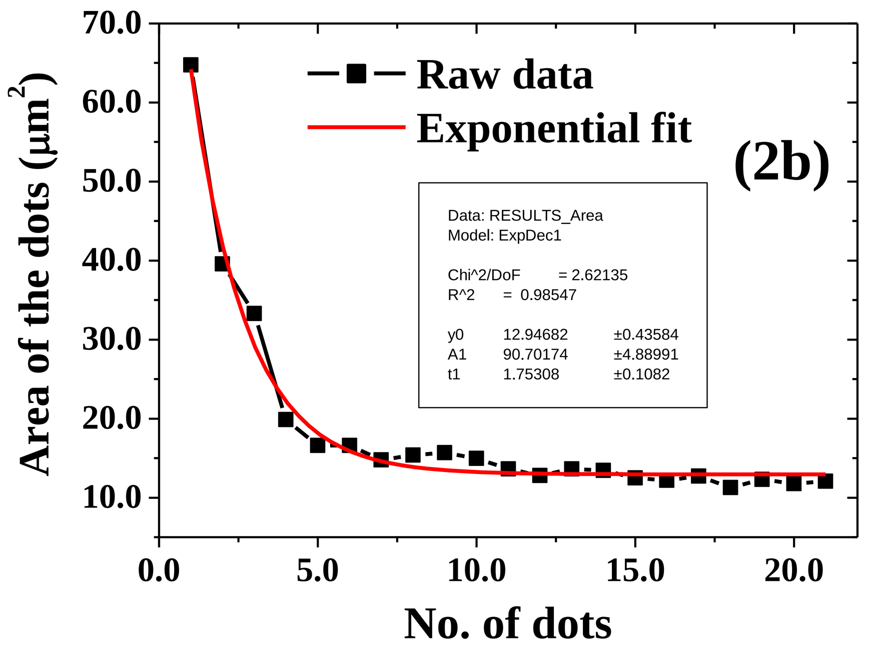
where m is the mass of the cantilever.

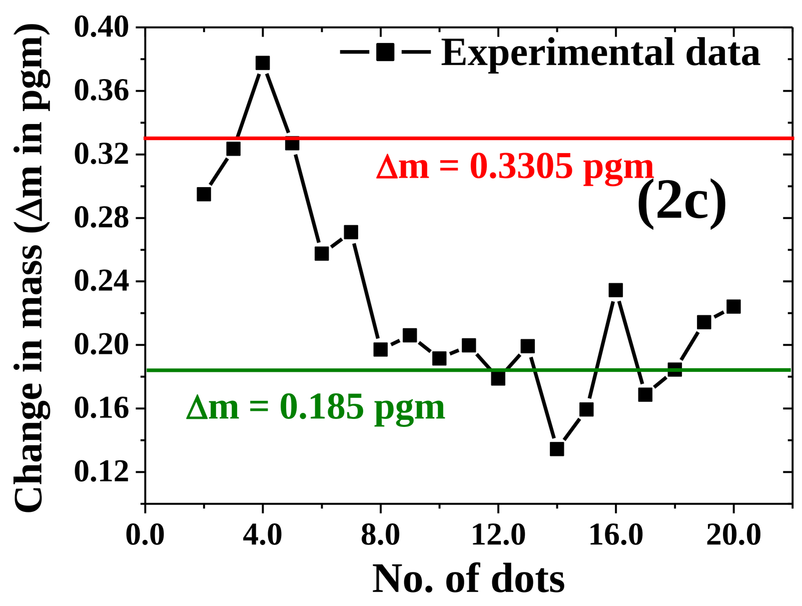


Frequency spectra of the cantilever in air before coated with ink (DOPC+Rho.), after coated with ink and after making 50 dots on the surface. Figure 1(a) and (b) show that resonance frequency of the cantilever increases with the decrease of the effective mass of the cantilever.

At RH 65%

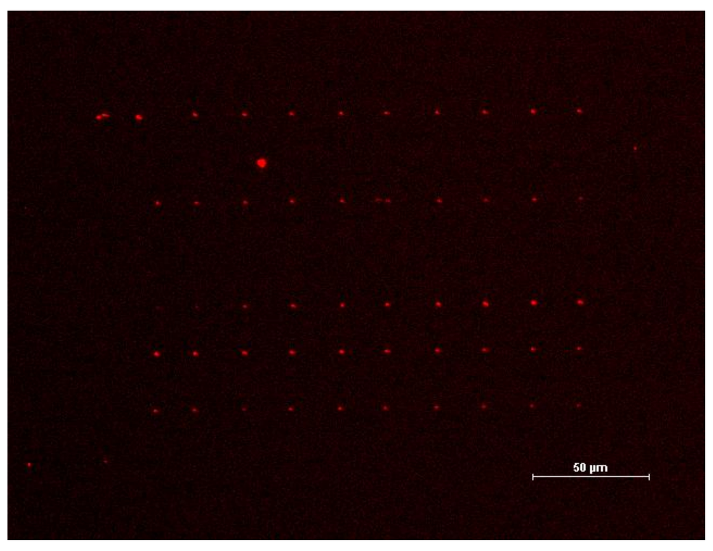




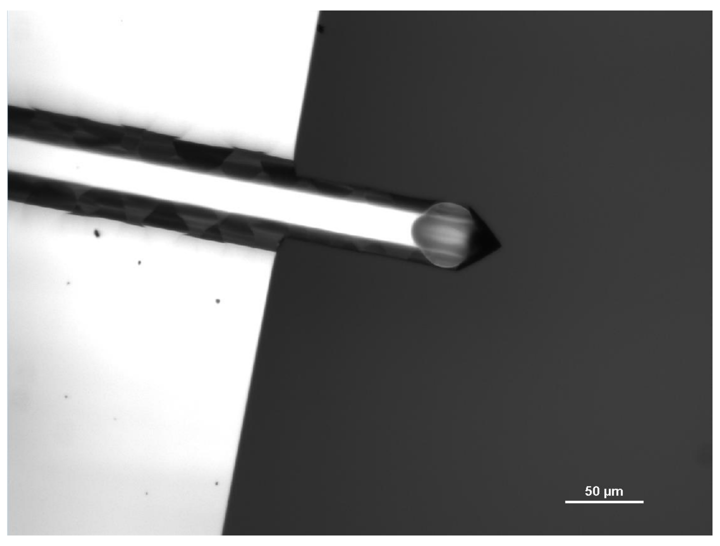


2(c) Amount of ink transferred to the surface is plotted as number. of dots. The average mass transferred to the surface corresponding to two different regions of the data in figure 2(a) have been shown by the red and the green lines in the graph.

2(a) There are two different rates of ink transfer to the substrate as can be seen from the graph. The average mass transfer corresponding to the red line and the green line are **0.3305 pgm** and **0.185 pgm** respectively. 2(b) The area of the dots decreases with the number of the dots.

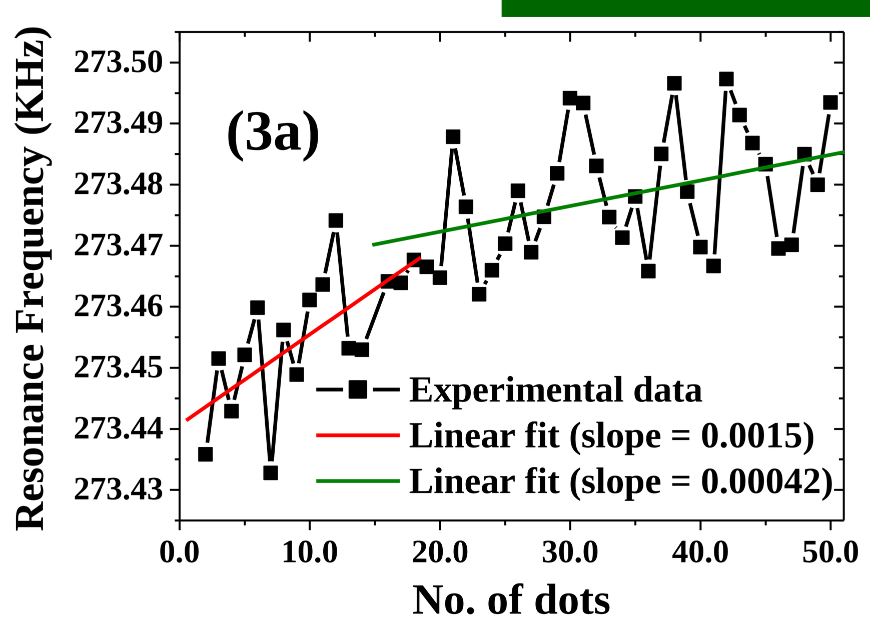


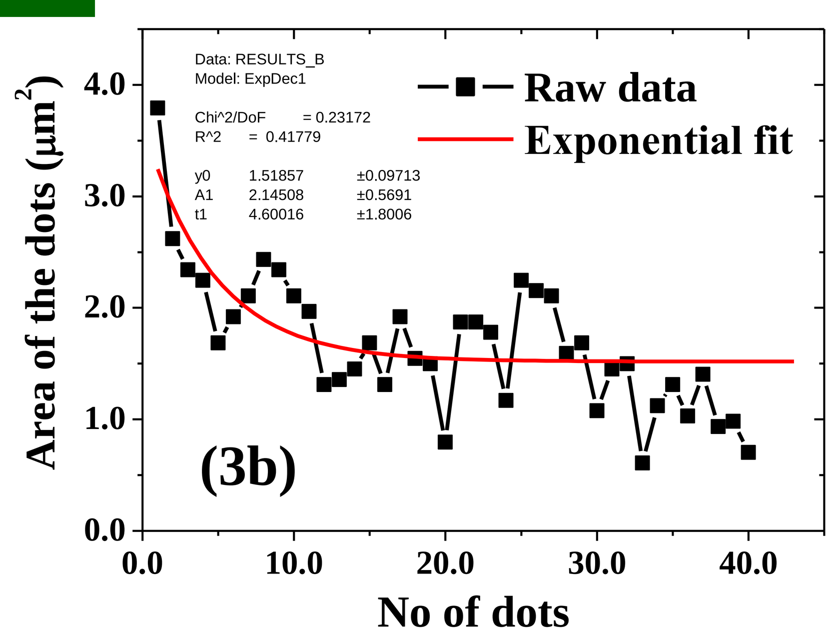
Fluorescently labelled dots made on plasma cleaned cover slip



Optical micrograph of the cantilever after coated with ink.

At RH 50%





Similar behavior has been observed for RH 50%. The only difference is that at lower humidity ink transport is less, so the data is more erroneous. In this case, the average mass transfer corresponding to the red line and the green line are **0.1106 pgm** and **0.031 pgm** respectively.

References

[1] S. Sekula et. al., *Small*, **2008,** 10, 1785.
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[4] H. Sone et. al., *JJAP*, **2004**, 43, 3648.