SNM
Work Package WP2
Deliverable: D2.7 ("Parallel operation of small cantilever arrays")

Addendum

Additional Person-months by partner for the Addendum										
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Criteria and Achieved Results	**Criteria of Achievement**					**Summary of Achieved Results**				
	See original deliverable report.					See original deliverable report.				

Description of the addendum

Addendum Parallel writing

30.03.2017

Since delivering the report, further progress has been made with the multiplexed probes. First parallel writing was achieved with the new multiplexing electronics and individual per-probe series resistors.

Setup and tuning of resistances

The first step for parallel writing was the selection of suitable series resistors. An individual probe typically uses 1.5 kOhm in series with the writer. The problem with a parallel circuit of probes on a single series resistor is the negative differential resistance of the writers above the intrinsic temperature. This leads to an uncontrolled increase in current, and failure of the writers.

To provide a single point where the current is measured, the probe array electronics retain the shared series resistor. The probe current is used for temperature calibration and, more crucially, topography imaging. In addition to the shared series resistor, each probe has an individual series resistor to limit the effect of the negative differential resistor, and thus

allow parallel operation above the intrinsic temperature. The two resistances need to be selected to balance the protection above the intrinsic temperature with the signal to noise ratio for the current and topography measurements.

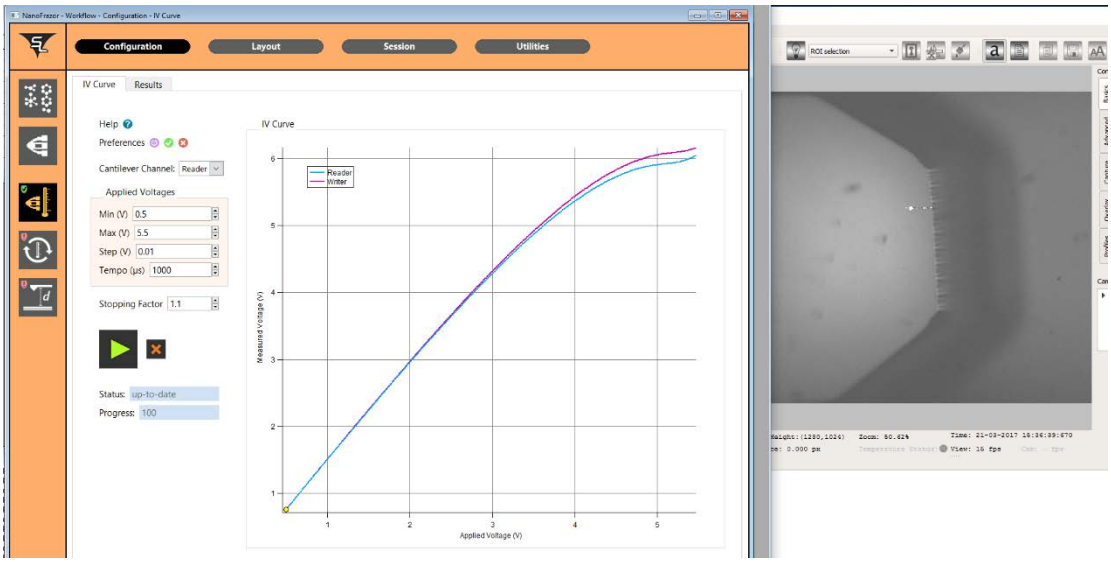

Figure 1:Individual IV curves of two writers

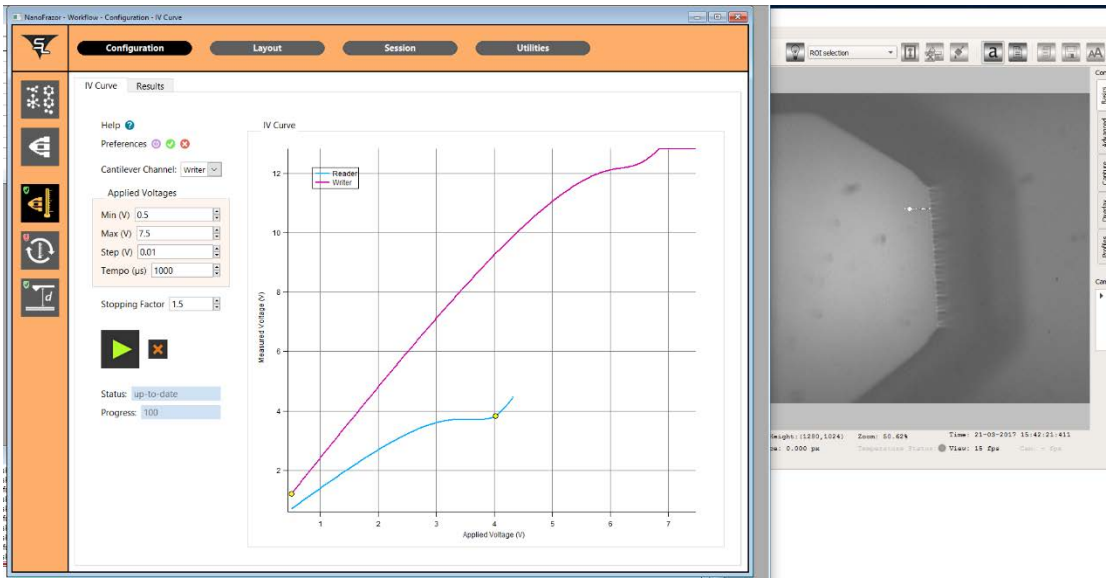

Figure 2: joint IV-curve of writers in Fig.13 (magenta). IV curve of one reader (blue)

Satisfactory resistors were found to be 500 Ohms for the shared current measurement resistor and 300 Ohms for each individual probe. 800 Ohms of series resistance is stable even when operating an individual probe, and still sufficiently low to allow current measurement with multiple probes in parallel with the corresponding increase in current.

Figure 13 shows individual I-V curves taken for two writers on the probe array. It is important that the resistors have similar resistances, so that the temperatures are

synchronous during parallel operation. This is the case, as both curves are close to each other.

Figure 14 shows the I-V curve of both writers in parallel switched to the same channel (magenta). For comparison, the I-V curve of a single reader is also shown in blue, corresponding to the approximate current levels from Figure 13. The current through two writer resistors in parallel twice as large, so the joint IV curve saturates the measurement amplifier. It is important to note that the maximum measurement voltage is significantly above the intrinsic temperature. Despite the saturation in the measured current, the resistance measurement can be deemed a success, as there is no destructive positive feedback.

Alignment of probes to the substrate

After selecting the series resistors, the alignment procedure for the probe array was carried out. The procedure is the same as carried out previously. The roll angle is adjusted in small steps until the snap-in is detected first on the respective other probe. Figure 15 shows the result of the alignment.

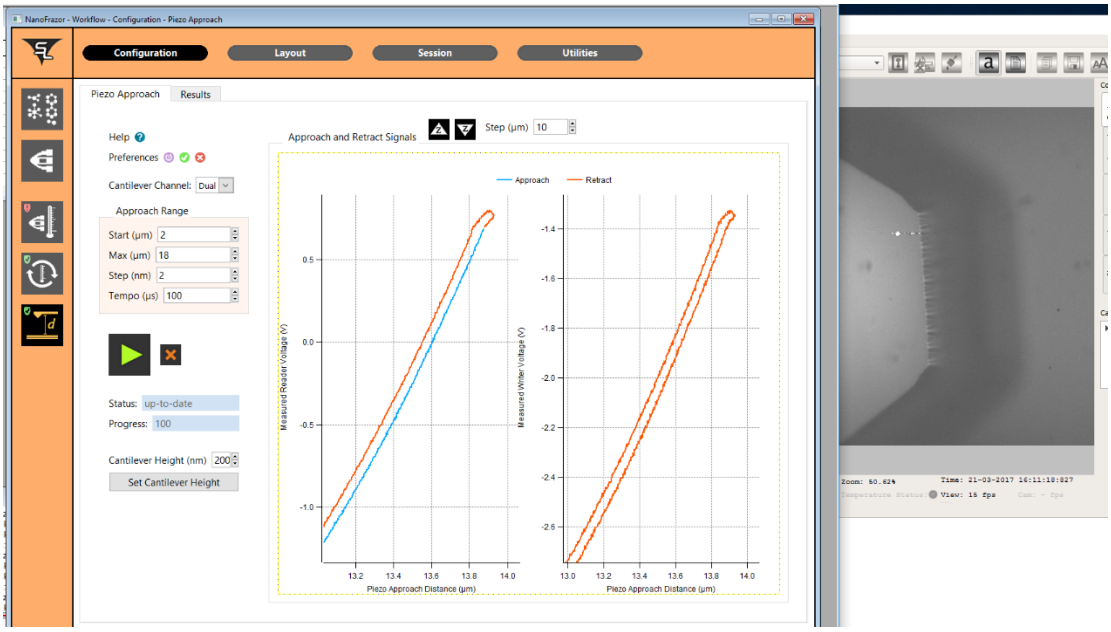

Figure 3: Simultaneous snap-in after alignment of the probes

In this measurement, probes of a new design were used. These exhibit a much weaker gradient change after snap-in compared to the original design. The sensitivity of snap-in detection is limited by the signal to noise ratio (and series resistance). In some cases, the software algorithms failed to detect the snap-in during some of the approach tests, and exceeded the contact point, so one of the tips was damaged (see write result).

Parallel Writing operation

After temperature calibration with the I-V curve, and roll-angle alignment with the substrate, parallel writing was carried out. Figures 16 and 17 show the writing result with

two probes simultaneously. Probes no. 1 and no. 9 were used, to show the accuracy of the roll angle alignment. These probes are spaced far apart, so height differences from mis-alignment are most pronounced.

Figure 16 shows the successful, high-resolution writing result achieved with probe 1. Figure 17 shows the writing result achieved with probe 9, which shows lower resolution and some pile-up, a consequence from the prior alignment procedure and the failed detection of snap-in.

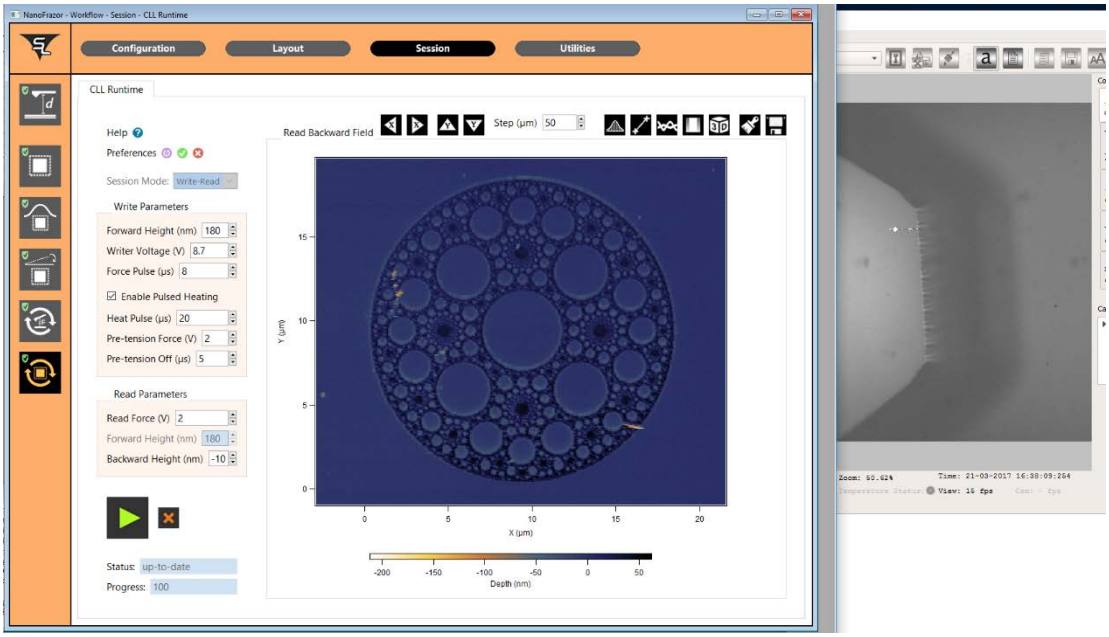

Figure 4: Parallel writing result probe 1

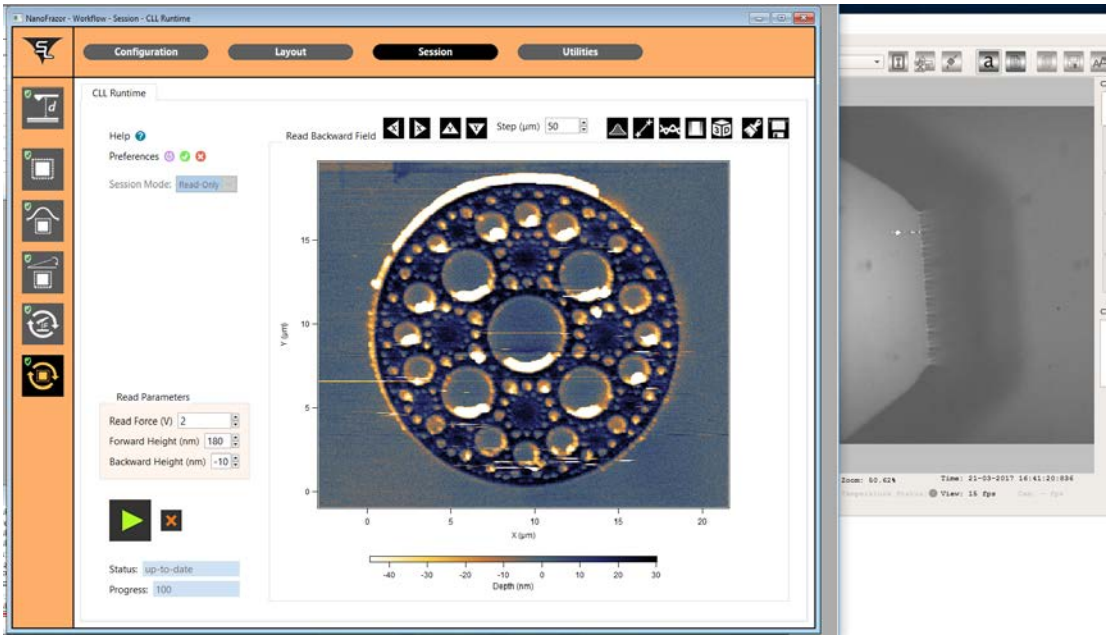

Figure 5: Parallel writing result probe 9

	## Further work The writing procedure will be trialled further, and better parameters will be found to make the procedures more robust. An improved version of the new probe design will be available in early May, which will alleviate the snap-in detection problem. In addition, a first trial version of dual-read software was written, and efforts will be made to get this running.
Explanation of Differences between Estimation and Realisation	
Metrology comments	