

Nanometer Internal Diameter Fused Silica Capillary Tubing >

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Synthetic fused silica capillary tubing continues to be a vital material in the separation sciences. In this application note, we present and discuss recent data on cutting edge, nanometer internal diameter capillary tubing.

Scientists employ fused silica capillary tubing routinely in a wide range of analytical applications, encompassing GC, CE, Capillary LC, and CEC. It has proven as an ideal substrate for interfacing in hyphenated techniques. As the separation sciences and related analytical technologies evolve, a general trend toward smaller bore capillary tubing is clearly evident. Polymicro Technologies™ capillary tubing leads the field in meeting this market demand by offering 25 standard products with internal diameters (i.d.) of less than 50 μm , with six of those having i.d. tolerances of $\pm 1 \mu\text{m}$. The next logical innovation is the sub-1 μm regime. For many years it was felt that nanometer i.d. capillary, or “Nano-capillary,” could not be produced as the open bore of the capillary would close shut during the manufacturing process. After innovative developments, Nanocapillary has been drawn several times in small quantities. In this application note we discuss details of a 1 km-long experimental run of polyimide coated, fused silica-based Nano-capillary.

EXPERIMENTAL

Nano-capillary tubing used in this study was produced on a standard Polymicro Technologies drawing tower using proprietary, optimized draw parameters. The fused silica employed was the same glass type used for similar small i.d. capillary. The objective was to produce tubing of $<1 \mu\text{m}$, but specific nanometer level targeting was not possible due to the delay between production sampling and SEM verification. Individual samples were measured using a Hitachi S4500, using a NIST traceable standard from Geller MicroAnalytical Laboratory.

During the draw, individual batches of capillary were collected in pre-determined lengths of 100 m. Each batch was further segmented and end measurement samples taken every 25 m. The i.d. of each sample was then determined by SEM yielding 5 data points every 100 linear meters.

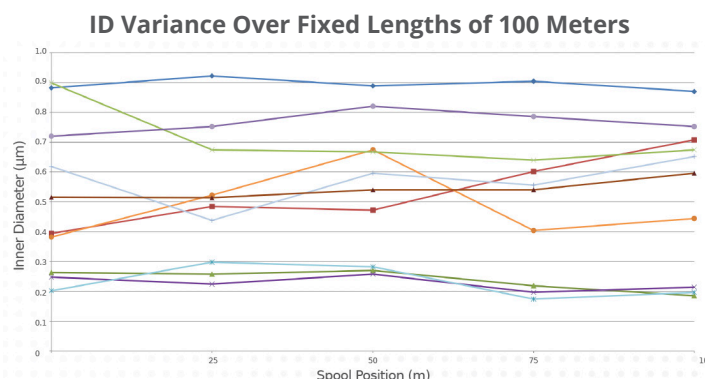


Figure 1: i.d. data for 100 m long batches from a 1 km draw of Nano-capillary.

RESULTS

A chart of i.d. data collected from the 10 batches produced is shown in Figure 1. The i.d. target of $<1 \mu\text{m}$ was met on all data points. The i.d. range within each 100m long batch varied from a low of 40 nm to a high of 314 nm, with six of the batches having ranges of $<125 \text{ nm}$. Table 1 shows a summary of the average i.d. by spool and the corresponding standard deviation. The i.d. initially trended downward from $\sim 900 \text{ nm}$ to nominally 200 nm and then slowly trended upward into the 800 nm range. A review of all collected data suggests that a higher frequency of measurement linearly is needed (i.e. every 10 m), which may allow for tolerances approaching $\pm 100 \text{ nm}$.

CONCLUSION

It is evident that through state of the art process control and metrology, providing Nano-capillary tubing is possible. Finished spool length and tolerances need to be defined. The data presented in this note represents one of several studies currently under way.

Table I: Average i.d., range & standard deviation for 10 batches of Nano-capillary

Spool	1	2	3	4	5	6	7	8	9	10
Average	0.893	0.532	0.239	0.228	0.231	0.485	0.572	0.541	0.711	0.766
Range	0.040	0.314	0.085	0.061	0.124	0.292	0.214	0.082	0.258	0.100
Std. Dev	0.020	0.123	0.036	0.025	0.056	0.118	0.083	0.033	0.106	0.038