

## NSCRIPTOR™ Active Pen™ Option

Dip Pen Nanolithography® (DPN®) is the process of writing nanoscale patterns of molecular "ink" onto a sample substrate via a coated SPM tip. NanoInk's NSCRIPTOR DPN System is a fully-integrated hardware and software system that is optimized for the DPN process. The *Active Pen™ Option* is a revolutionary technology designed to take DPN patterning to the next level of productivity and versatility. Active Pens use thermal bimorph technology to individually approach and retract pens from the surface via computer control, and their control is seamlessly integrated into NanoInk's InkCAD™ control software.

With Active Pens you can:

- Semi-automatically calibrate the tip-to-tip alignment between adjacent pens in order to use multiple pens to write into the same area with sub-100 nm registration.
- Write patterns with an inked pen and immediately inspect the area with an uninked pen, preventing smearing and contamination of DPN pattern features.
- Image a surface area using a clean tip, then write into that area with a DPN pen.
- Write nanoscale structures in one patterning job that consists of multiple functional ink materials, using coated active pens (i.e., instead of having to switch single pens for different inks).

The *Active Pen* option includes 2 main parts: electronics and interconnect modules, and the active microfabricated pens. Following is a short summary of features.

### Design Considerations

Referencing Figure 1 below, several changes were made to the 2<sup>nd</sup> Generation Active Pens:

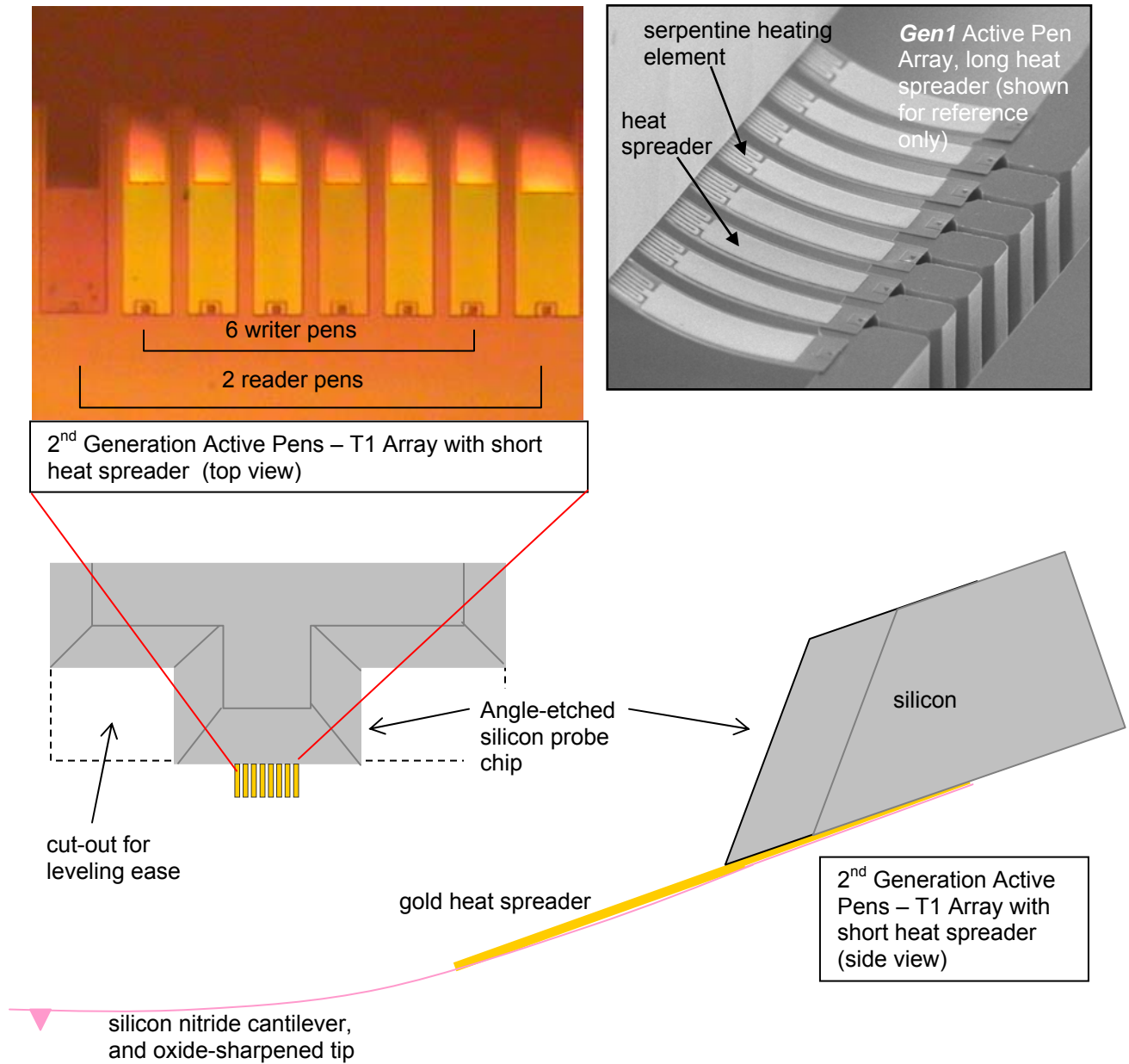
- The front corner edges of the probe chip were etched away to enable easier probe array leveling (and avoid rubbing the corners on the substrate during imaging or lithography)
- This etch was accomplished at an angle to enable easier laser alignment on the cantilevers.
- The heat spreaders were shortened substantially to reduce the tip temperature. The pens actuate via thermal bimorph, wherein the different coefficients of thermal expansion between gold and silicon nitride cause the cantilever to bend down when current is passed through the serpentine heater, and then conducted along the heat spreader.

**Table 1: Cantilever Specifications**

Probe Type	Writer <i>k</i> (N/m)	Writer width (μm)	Writer length (μm)	Writer-Writer pitch (μm)	Writer-Writer gap (μm)	Reader <i>k</i> (N/m)	Reader width (μm)	Reader length (μm)	Reader-Writer pitch (μm)	Reader-Writer gap (μm)
T1	0.18	30	150	40	10		40	150	45	10
T2	0.15	26	150	30	4		40	150	37	4
T3	0.11	18	150	23	5		30	150	29	5

Heat spreader distance from tip ~ 80 μm

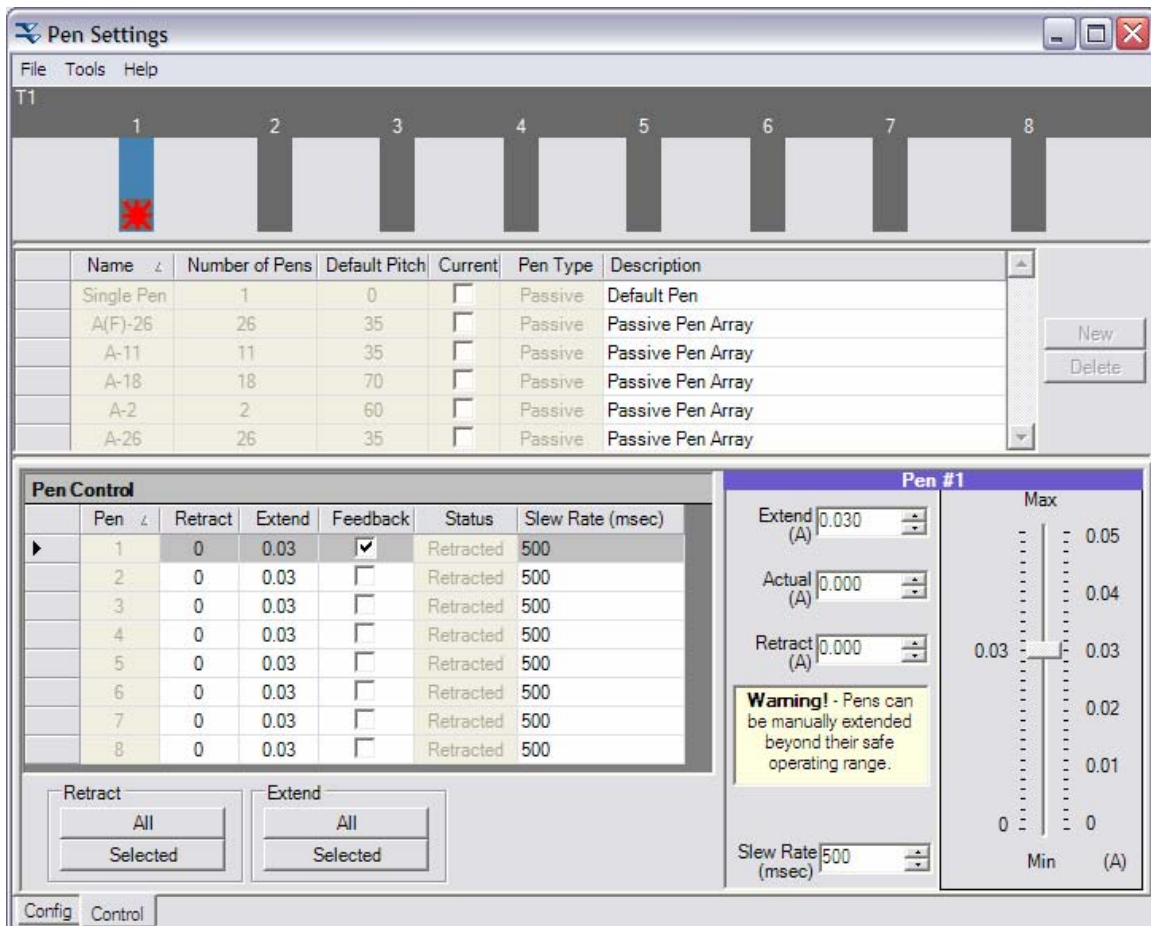
Figure 1



## Active Pen Software

The *Active Pen* option requires installation of InkCAD 3.2. This version offers:

- Software support for separate reader/writer operation - integrated control for writing with one pen and imaging with a different pen.
- Support for multilayer writing with separate pens. Each layer can be drawn with a separate pen. Multi-pen design is fully integrated into the InkCAD design environment.
- Selective parallel writing. Choose which pens to draw within a layer.
- Active Pen control dialog - individual pens can be manually manipulated and configured from this panel.
- Active Pen alignment wizard - the nanoscale positioning between pens can be determined with this wizard. Results are used for reader/writer operations and multilayer writing with separate pens so that the user doesn't have to do any calculations. Just select the pen to use for writing - all positioning offsets are accounted for.
- Active Pen inking - the ability to selectively ink groups of pens with inkwells.
- New tip lift option - it is now possible to select if the writing pen should lift between drawn objects using the scanner piezo or using thermal actuation.



## Active Pen Electronics

The *Active Pen* option requires additions and modifications to the NSCRIPTOR hardware that can only be carried out by NanoInk certified personnel. The electronic interface board between MEMS hardware and control software has the following features:

- Eight driver outputs are available in parallel.
- Two ADC inputs are present.
- Driver outputs type: Voltage to current configuration.
- Maximum output current per driver output: 55mA for loads < 40  $\Omega$ .
- Actuation slew rate: < 10  $\mu$ s.
- Total actuation latency (all eight pens): < 30ms.
- Pen to pen actuation latency: < 5ms.

Additionally, the Active Pen module comes with the Signal Access Module, and a digital multimeter to monitor Z piezo output (via the Z sensor).

## Active Pen MEMS hardware

- Operational actuation range: 500 nm to 10  $\mu$ m
- Maximum actuation range: 20+  $\mu$ m
- Recommended operating current: 15-40 mA.  
This is the usable current range; above 40 mA there is a risk of burnout, and below 15 mA there may not be sufficient actuation to differentiate from neighbor cantilever positions.
- Environmental temperature for operation: 20 - 30  $^{\circ}$ C
- Tip radius: 20 +/- 5 nm
- Actuation direction: Towards substrate
- Actuation mechanism and material: Thermomechanical metallic bimorph
- Cantilever material: Silicon-rich  $\text{Si}_3\text{N}_4$
- Cantilever modulus: 123 GPa +/- 10%
- MEMS integration: The pens are delivered fully mounted and electrically connected onto a flex circuit. Installation is as easy as installing a passive pen.

For more information including pricing, please contact NanoInk Sales Department at [sales@nanoink.net](mailto:sales@nanoink.net) or 1-847-679-NANO.

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