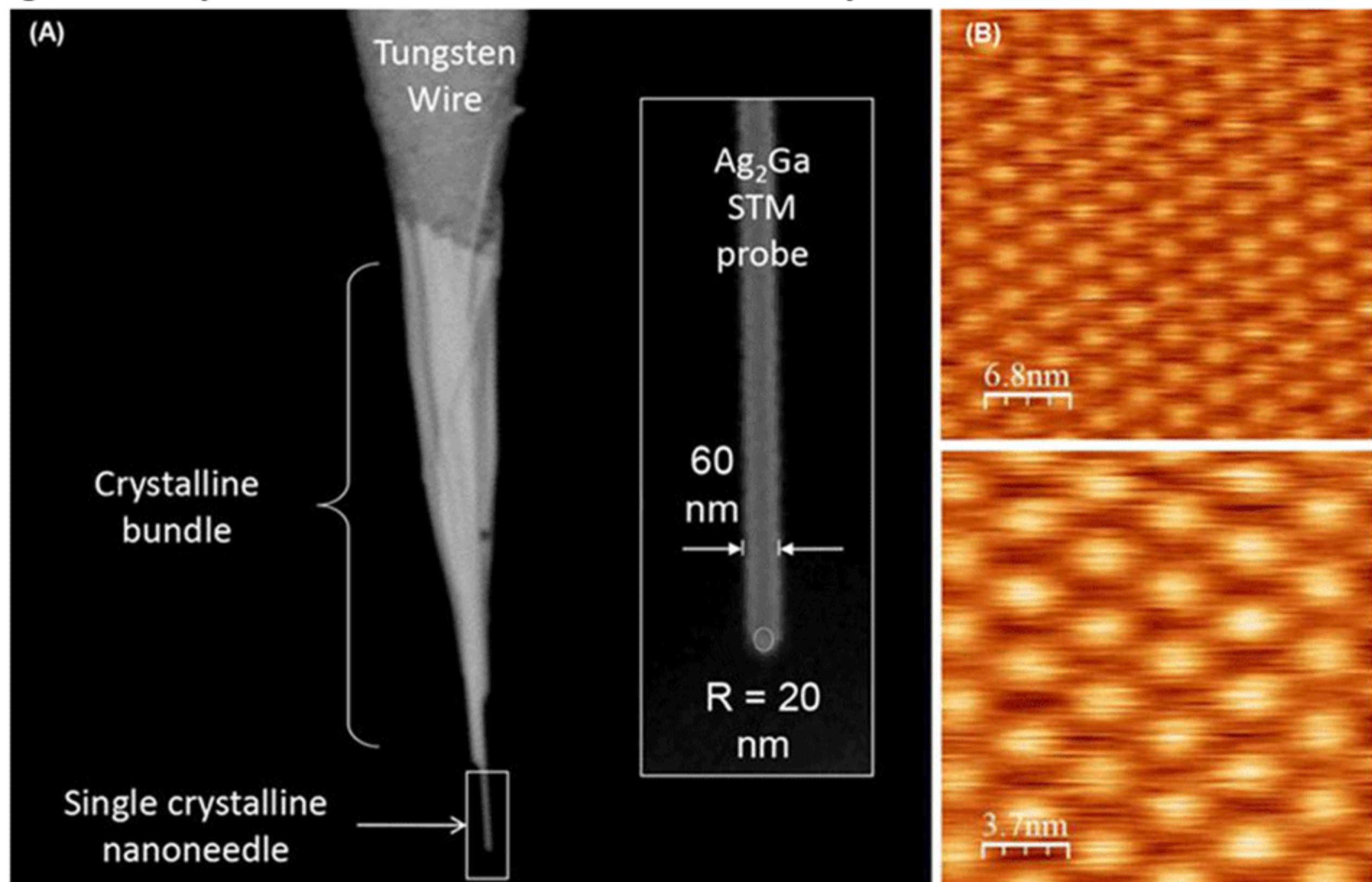


## NaugaNeedles' Ultra Sharp NanoProbe (USNP)

NaugaNeedles has developed a very unique nanofabrication technology to selectively grow individual metallic Silver/Gallium ( $\text{Ag}_2\text{Ga}$ ) nanoneedles at the end of standard tungsten probes. The  $\text{Ag}_2\text{Ga}$  nanoneedles have superior electrical, mechanical and chemical stability that significantly improve the performance of Micro-Probe-Stations, Nano-Manipulators and Scanning Tunneling Microscopy (STM) applications. **Figure 1** shows SEM images of an ultra-sharp NanoProbe (USNP). An  $\text{Ag}_2\text{Ga}$  nanoneedle 1-10 $\mu\text{m}$  long (per customer request), is grown on a standard tungsten probe, with a radius of curvature of  $\sim 20\text{-}50\text{ nm}$  at the tip. The nanoneedles are attached to the tungsten probe by a taper shape structure made of  $\text{Ag}_2\text{Ga}$  alloy that significantly enhances the mechanical stability of the nanoneedle.



*Figure 1: (A) SEM images of NaugaNeedles' Ultra Sharp NanoProbes (USNP). Courtesy of Sara E. Harrison (Stanford University) and Ron Reifenberger (Purdue University) (B) STM image of gold superlattice using USNP*



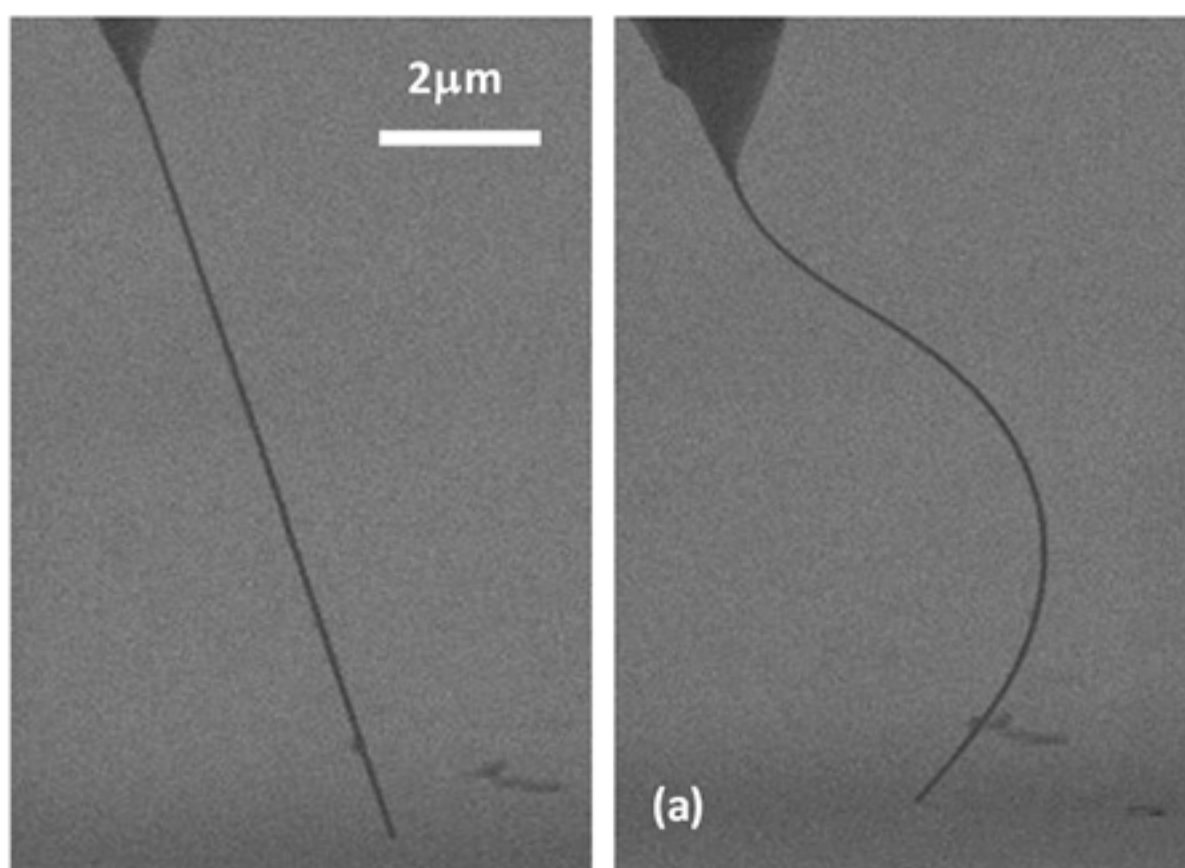
## Advantages:

- Highly conductive
- The most durable STM/NanoProbe in the market
- We can provide these tips with variety of coating (e.g. Pt, Cr, AG, Au) to enhance the performance
- The best probe for multi-probing with Zero taper angle
- Excellent mechanical properties with high elasticity
- Cylindrical shape single metallic crystal with atomically uniform diameter

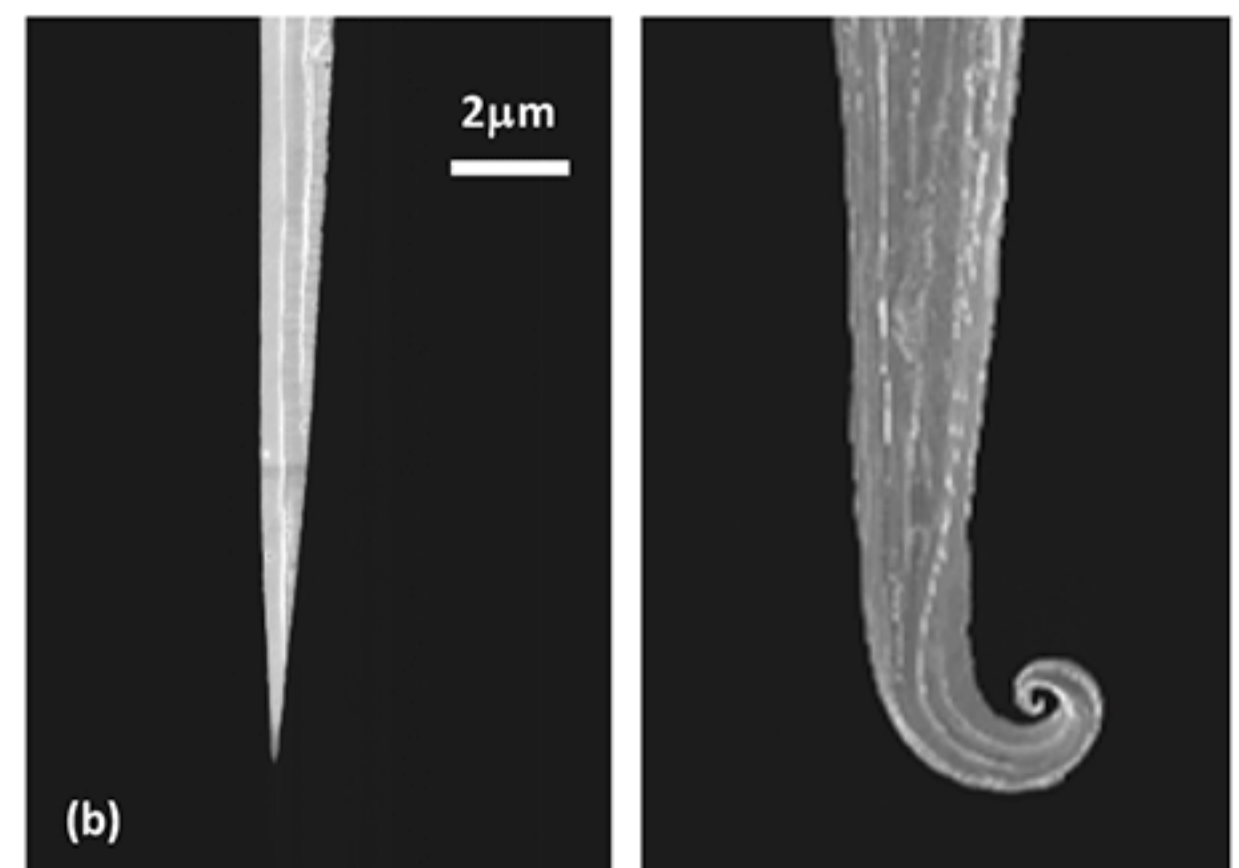
## A comparison between mechanical properties of the USNP and standard tungsten probes:

Due to crystallinity of their tip, the USNPs have excellent mechanical properties. [Figure 2a](#) shows the SEM images of a USNP as it is pushed against a silicon surface. Despite standard tungsten probes that are plastically deformed ([Figure 2b](#)), the USNPs can be elastically deformed up to 50% of their length and return to the original shape without any plastic deformation.

NaugaNeedles' ultra sharp NanoProbe (USNP)



Standard tungsten probes in the market



*Figure 2. Comparison between mechanical properties of (a) an USNP and (b) a standard tungsten probe.*





## Electrical properties of USNP:

Table 1 summarizes the resistance data taken from 9 USNPs with various Ag<sub>2</sub>Ga nanoneedles tip size when they brought in contact with a platinum coated substrate. For shorter (3 μm) nanoneedles the resistance is as low as 40 ohm and for the longer nanoneedles (18.5 μm), the resistance is as high as 2200 Ohm. Current as high as 0.5 mA can be passed through the shorter USNP (1 to 5 μm) without any damage to the nanoneedle. Based on these measurements, the electrical resistivity of Ag<sub>2</sub>Ga material is estimated at  $(13.5 \pm 3) \times 10^{-8} \Omega\text{m}$  that is can be categorized as a very good electrical conductor.

L (μm)	3	14	9.7	27.7	39	10	25	22	18.5
R (nm)	50	125	85	150	105	72	78	70	56
R (Ohm)	40	35	52	56	272	400	1400	1500	2200
$(\rho, \Omega\text{m}) \times 10^{-7}$	1.0	1.2	1.2	1.4	2.4	1.8	1.0	1.1	1.1

Table 1. Resistance measurement of individual USNP

Since the resistance of the contact point between the surface and the USNP was also a part of the resistance measurement, the real value for resistivity of Ag<sub>2</sub>Ga material should be smaller than the reported values above. All of the measurements here were done under ambient condition.

## Optical Evaluation of USNP, suitable for probe station probes:

Due to their crystallinity, even very thin (50 to 100 nm) Ag<sub>2</sub>Ga Nanoneedles are easily being seen under optical lenses.





Figure 3 shows an optical image of a nanoneedle grown on a tungsten wire. As it is seen in Figure 3, the brightness of the nanoneedle is even higher than the tungsten wire which makes it visible under relatively good optical lenses.

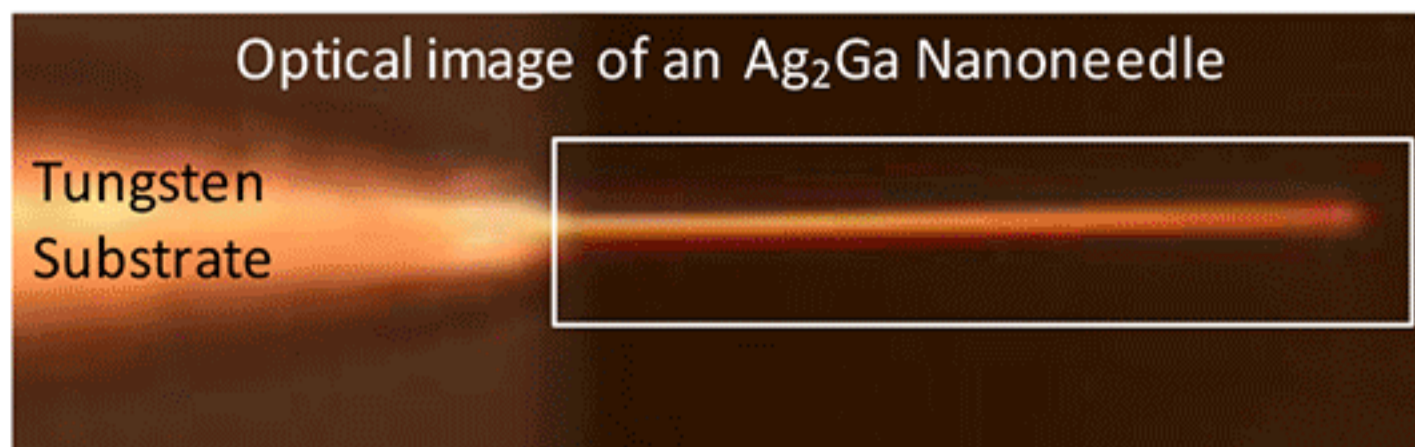
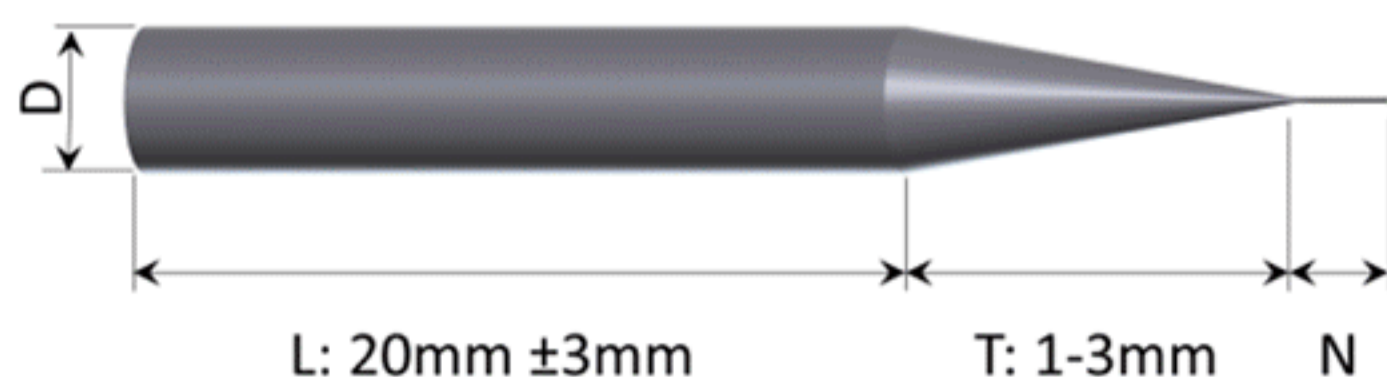
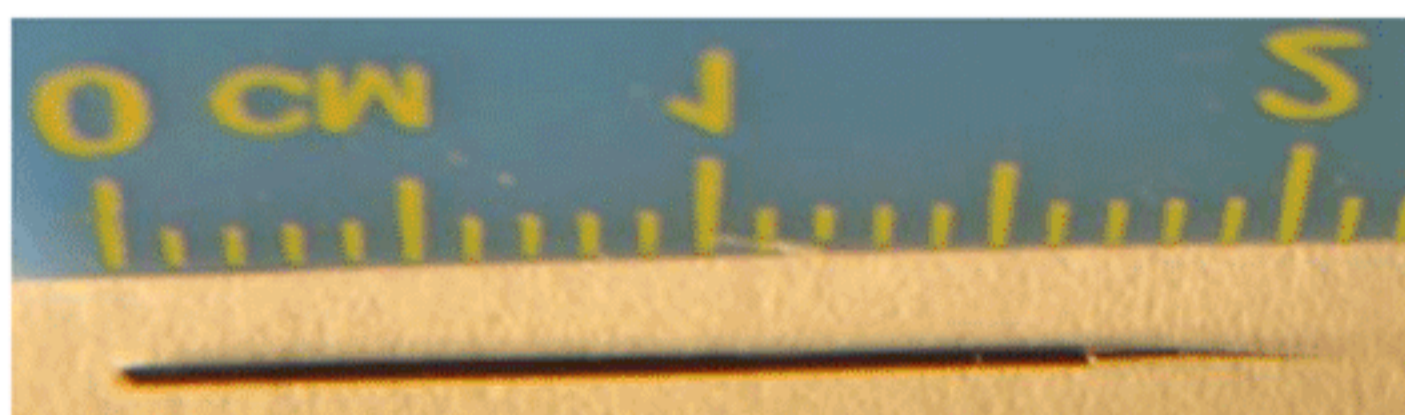


Figure 3: Optical evaluation of USNP

### Specifications:

	USNP-W100	USNP-W250	USNP-W500
Tungsten diameter (D)	100 $\mu\text{m}$	250 $\mu\text{m}$	500 $\mu\text{m}$
Tungsten length (L)	20 mm $\pm$ 3mm (Different length available per order)		
Needle length (N)	1 $\mu\text{m}$ (1-3 $\mu\text{m}$ ) - 5 $\mu\text{m}$ (3-7 $\mu\text{m}$ ) - 10 $\mu\text{m}$ (7-12 $\mu\text{m}$ ) *		
Needle radius of curvature	25-50 nm		
Coating material	Pt - Cr - Ag - Au		

\*Longer needle up to 50  $\mu\text{m}$  available by special order. Please contact us for more detail.



# NAUGANEEDLES

11509 Commonwealth Dr., Suite 2 • Louisville, KY, 40299

Phone: (502) 619-5156

Email: [info@nauganeedles.com](mailto:info@nauganeedles.com)

[www.nauganeedles.com](http://www.nauganeedles.com)