



### 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 and Nano-Manipulators. Figure 1 shows SEM images of an ultra sharp NanoProbe (USNP). A 5  $\mu\text{m}$  long and 60 nm diameter  $\text{Ag}_2\text{Ga}$  nanoneedles is grown on a standard tungsten probe, with a radius of curvature of  $\sim 13$  nm at the tip. The nanoneedles is 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.

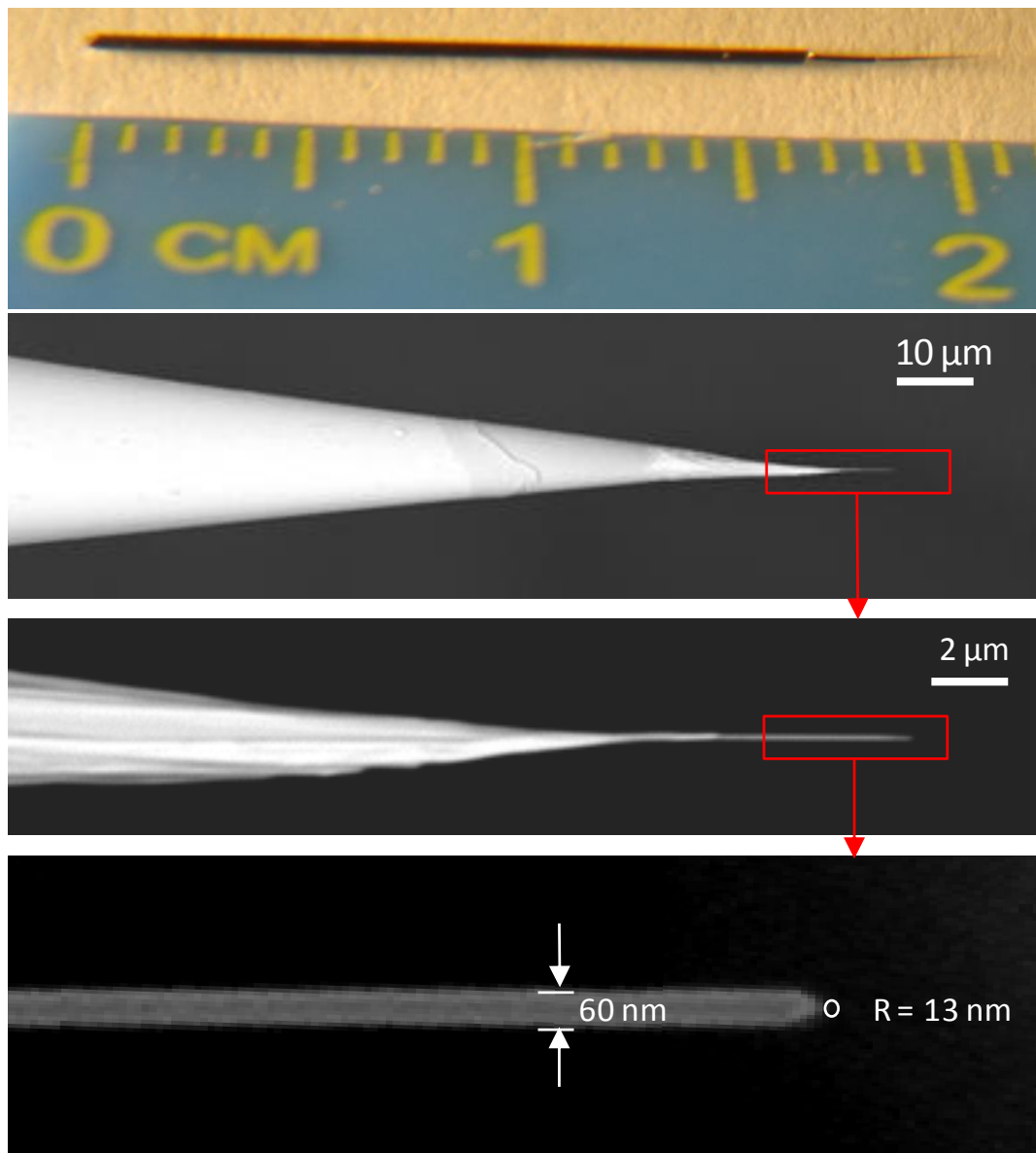


Figure 1: Optical (top) and SEM images of NaugaNeedles' Ultra Sharp NanoProbes (USNP)



**Advantages:**

- The smallest tip radius in the market
- The most durable NanoProbe in the market
- Platinum corrosion protection
- The best probe for multi-probing with Zero taper angle
- Highly conductive
- Excellent mechanical properties with high elasticity
- Cylindrical shape single metallic crystal with atomically uniform diameter

**Specification:**

Figure 2 shows schematics of different component of the USNP. The USNP are made of three parts; (1) A crystalline nanoneedle tip, (2) A polycrystalline tungsten wire, and (3) A probe shank.

(1) Specification for Crystalline Nanoneedle tip:

Tip radius of curvature:		25 to 50 nm
Nanoneedles length:	Category 1: 1 to 5 $\mu\text{m}$ ,	Category 2 : 5 to 10 $\mu\text{m}$
Contact resistance:	Category 1: $\leq 30$ Ohm,	Category 2 : $\leq 100$ Ohm

(2) Specification for polycrystalline tungsten wire

Diameter : $\sim 100 \mu\text{m}$ ,	Length : $\sim 5.0 \text{ mm}$ ,	Taper angle : $\sim 10^\circ$
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(3) Specification for Probe Shank:

Diameter : $\sim 0.25 \text{ mm}$ ,	Length : $\sim 15 \text{ mm}$ ,	Total probe length : $\sim 20 \text{ mm}$
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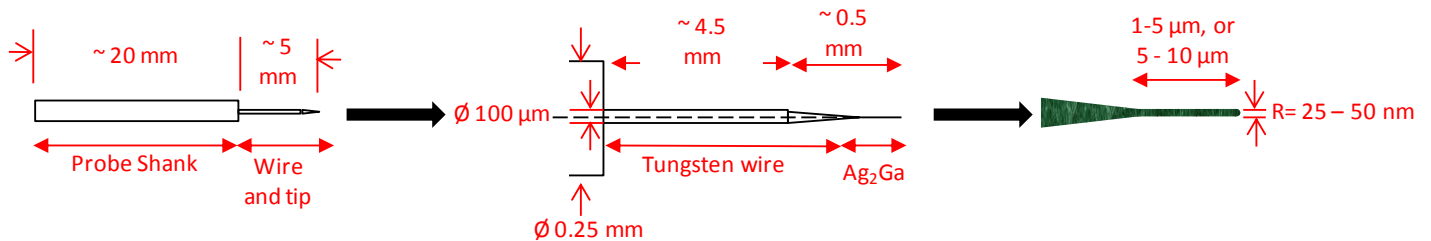


Figure 2: Schematic of different components of the USNP

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

Due to crystallinity of their tip, the USNPs have excellent mechanical properties. Figure 3a shows the SEM images of a USNP as it is pushed against a silicon surface. Despite standard tungsten probes that are plastically deformed (Figure 3b), the USSPs can be elastically deformed up to 50% of their length and return to the original shape without any plastic deformation.

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#### Standard tungsten probes in the market

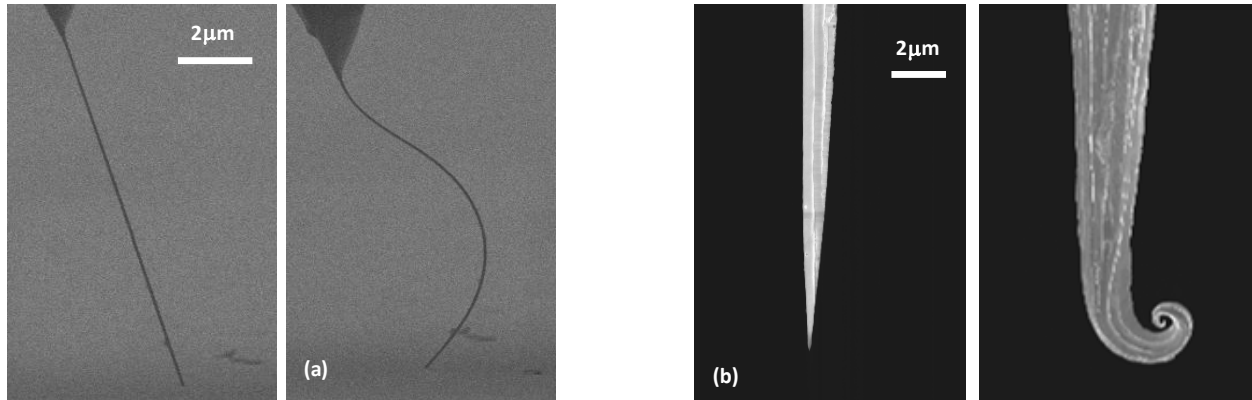


Figure 3. Comparison between mechanical properties of (a) an USSP and (b) a standard tungsten probes.

### Electrical properties of USSP:

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  $1.35 \times 10^{-7} \Omega\text{m} \pm 3 \times 10^{-8} \Omega\text{m}$  that is can be categorized as a very good electrical conductor.

Table 1. Resistance measurement of individual USNP

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
(ρ, Ωm) × 10 <sup>-7</sup>	1.0	1.2	1.2	1.4	2.4	1.8	1.0	1.1	1.1

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 USSP, suitable for probe station probes:

Due to their crystallinity, even very thin (50 to 100 nm)  $\text{Ag}_2\text{Ga}$  nanoneedles are easily being seen under optical lenses. Figure 4 shows an optical image of a nanoneedle grown on a tungsten wire. As it is seen in Figure 4, the brightness of the nanoneedle is even higher than the tungsten wire which makes it visible under relatively good optical lenses. We have been able to detect the nanoneedles with various types of optical lenses (e.g. Keyence, Navetar).



Figure 4: Optical evaluation of USSP