NaugaNeedles

NaugaNeedles' Ultra Sharp NanoProbe (USNP)

NaugaNeedles has developed a very unique nanofabrication technology to selectively grow individual metallic Silver/Gallium (Ag_2Ga) nanoneedles at the end of standard tungsten probes. The Ag_2Ga 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 µm long and 60 nm diameter Ag_2Ga nanoneedles is grown on a standard tungsten probe, with a radius of curvature of ~ 13 nm at the tip. The nanoneedles is attached to the tungsten probe by a taper shape structure made of Ag_2Ga alloy, that significantly enhances the mechanical stability of the nanoneedle.

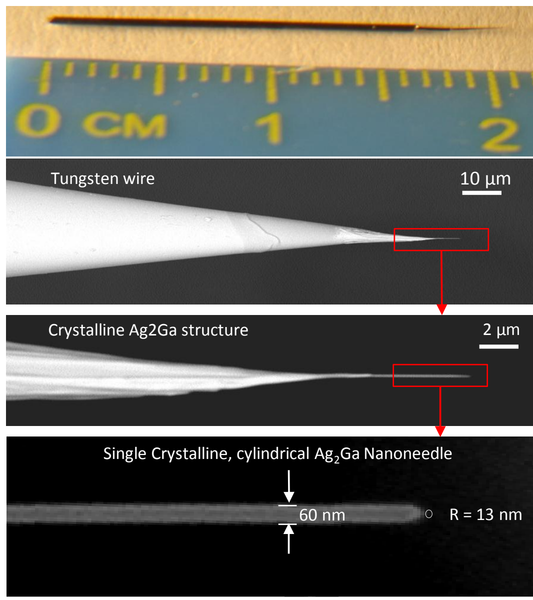

Figure 1: *Optical (top) and SEM images of NaugaNeedles' Ultra Sharp NanoProbes (USNP)*

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 µm,	Category 2 : 5 to 10 µm
Contact resistance:	Category 1: ≤ 30 Ohm,	Category 2 : ≤ 100 Ohm

(2) Specification for polycrystalline tungsten wire

Diameter : ~100 µm, Length : ~5.0 mm, Taper angle : ~ 10 o

(3) Specification for Probe Shank:

Diameter : ~ 0.25 mm, Length : ~15 mm, Total probe length : ~ 20 mm

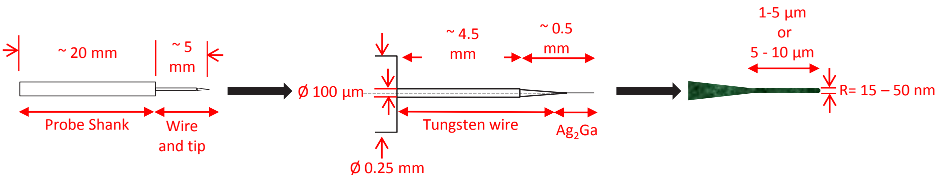

Figure 2*: Schematic of different components of the USNP*

NaugaNeedles' ultra sharp NanoProbe (USNP)

Standard tungsten probes in the market

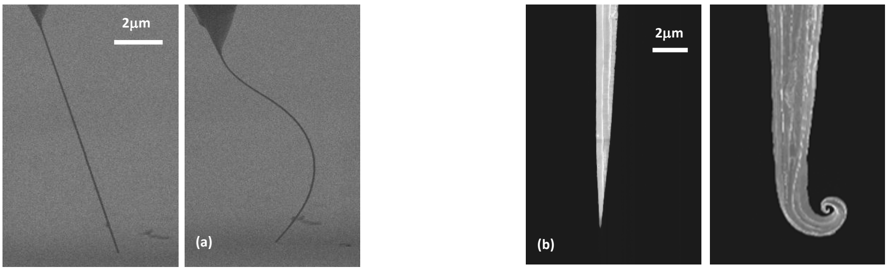

Figure 3*. Comparison between mechanical properties of (a) an USSP and (b) a standard tungsten probes.*

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 3*** a 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.

Electrical properties of USSP:

Table 1 summarizes the resistance data taken from 9 USNPs with various Ag_2Ga 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_2Ga material is estimated at 1.35×10 7 Ωm ± 3×10 8 Ωm 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
(ρ, Ωm)× 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 Ag2Ga 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) Ag2Ga 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).

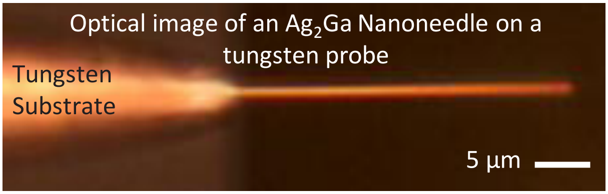

Figure 4: *Optical evaluation of USSP*

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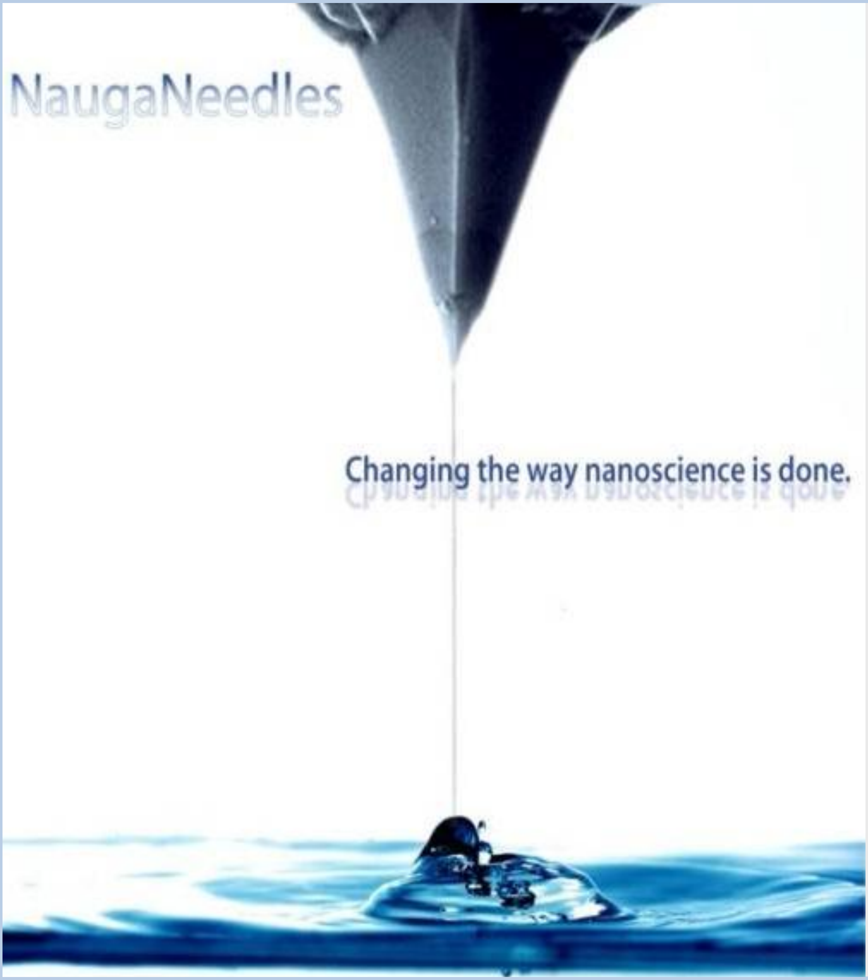

NaugaNeedles

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

Phone: (502) 619-5156

Email: info@nauganeedles.com

www.nauganeedles.com