

**NAUGANEEDLES**

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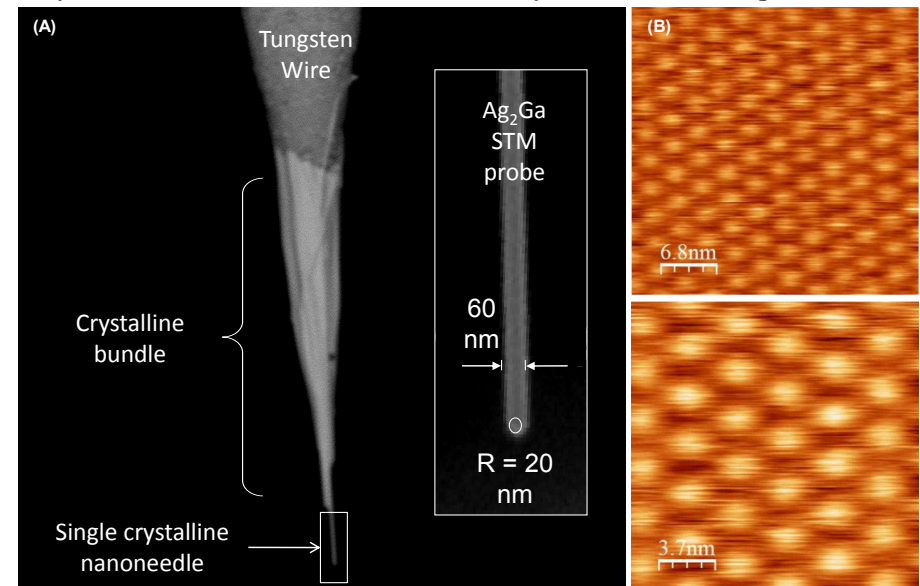
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**NaugaNeedles' Ultra Sharp STM Probe (USSTM)**

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 are suitable for scanning tunneling microscopy (STM) applications. *Figure 1A* shows SEM images of an ultra sharp STM (USSTM) probe. A  $2\ \mu\text{m}$  long and  $60\ \text{nm}$  diameter  $\text{Ag}_2\text{Ga}$  nanoneedle is grown on a standard tungsten probe, with a radius of curvature of  $\sim 13\ \text{nm}$  at the tip. The nanoneedle is attached to the tungsten probe by a taper shape structure made of  $\text{Ag}_2\text{Ga}$  alloy, that enhances the mechanical stability of the USSTM tip.



*Figure 1: Optical (top) and SEM images of NaugaNeedles' Ultra Sharp NanoProbes (USNP). Courtesy of Sara E. Harrison (Stanford University) and Ron Reifenberger (Purdue University)*

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**Figure 1B** shows STM images of a Moiré superlattice on a highly ordered pyrolytic freshly cleaved graphite (HOPG). The imaging were performed with a Nanotec Electronica air STM under dry nitrogen conditions using a USSTM.

**Advantages:**

- The smallest tip radius in the market
- The most durable STM probe in the market
- We can provide these tips with variety of coating (e.g. Pt, Cr, Au) to enhance the performance
- Highly conductive
- Long shelf time
- 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 USSTM. The USSTM 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:**

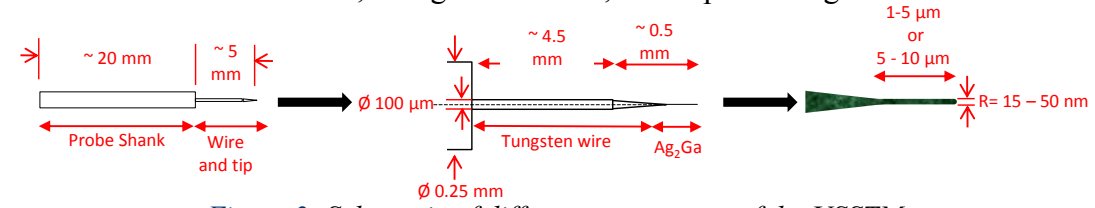
Tip radius of curvature: 25 to 50 nm  
 Nanoneedles length: Category 1: 1 to 5 μm, Category 2 : 5 to 10 μm  
 Contact resistance: Category 1: ≤ 30 Ohm, Category 2 : ≤ 100 Ohm

**(2) Specification for polycrystalline tungsten wire**

Diameter : ~100 μm, Length : ~5.0 mm, Taper angle : ~ 10<sup>-0</sup>

**(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 USSTM*

**Electrical properties of USSTM:**

**Table 1** summarizes the resistance data taken from 9 USSTMs 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 USSTM (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 1.35×10<sup>-7</sup> Ωm ± 3×10<sup>-8</sup> Ωm 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