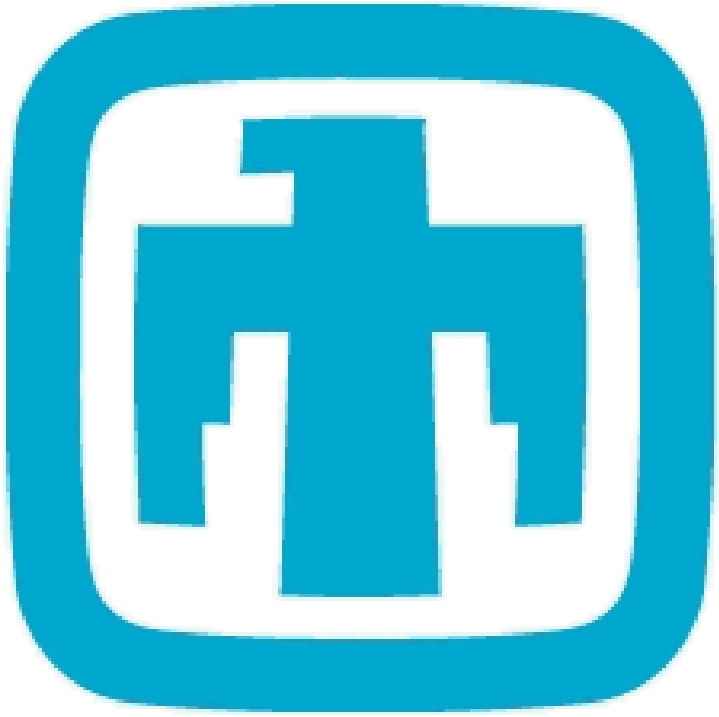
SAND2015-6929PE



Sandia National Laboratories

Carbon Nanotubes

Sumner Ogrydziak

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND NO. 2015-XXXX PE

Who Am I?

- 3rd Youngest (older twin)
- West Point ’17
- Born in Honolulu, Hawaii
- Home is Nederland, Texas

Carbon Nanotubes

(CNT)

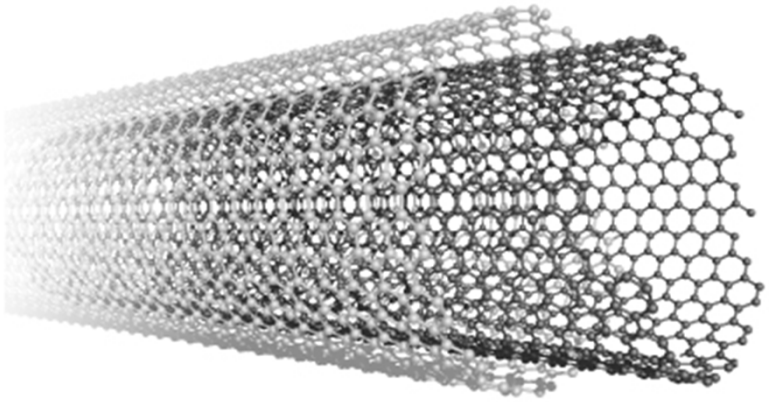
CNT are cylindrical tubes of carbon atoms

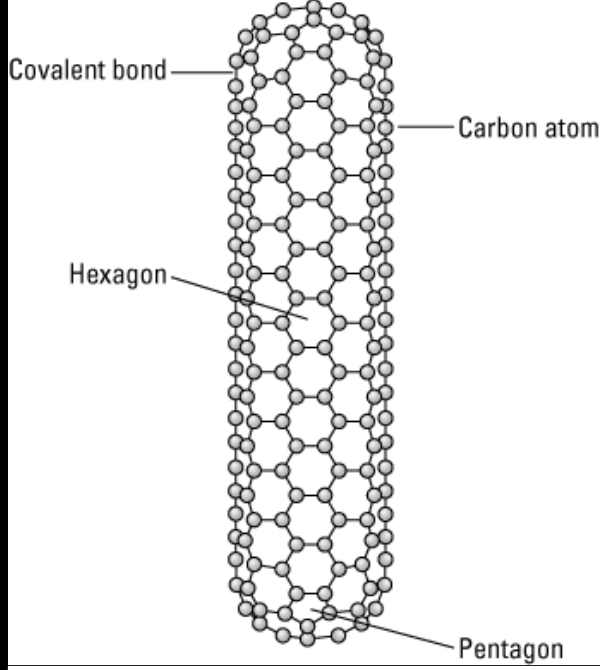
Properties:

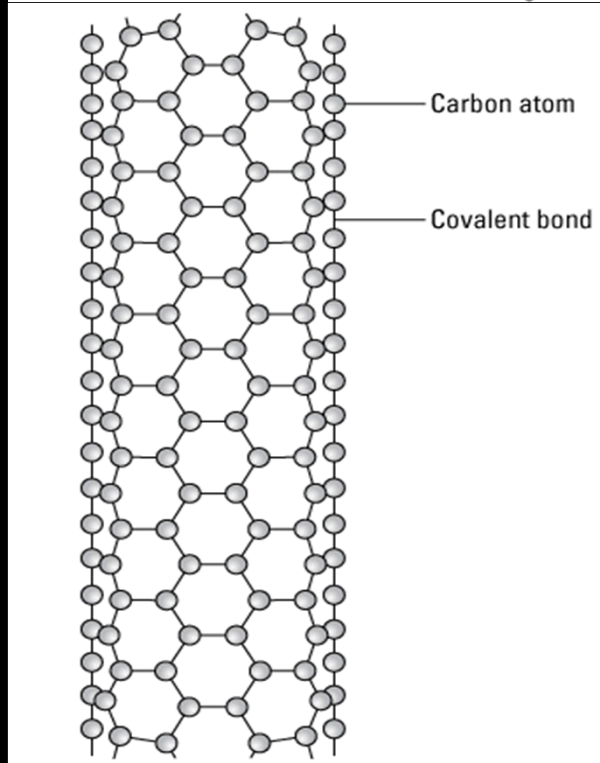
- 200X the strength of steel
- 5X the elasticity of steel
- 5X the electrical conductivity (depending on shape, may be semiconducting)
- 15X the thermal conductivity of copper
- 1,000X the current capacity of copper
- half the density of aluminum
- CNTs have almost none of environmental or physical degradation issues common to metals (thermal expansion and contraction, corrosion and sensitivity to radiation)

"Nanocomp Technologies | What Are Carbon Nanotubes?" Nanocomp Technologies | What Are Carbon Nanotubes? Nanocomp Technologies Inc., 2014. Web. 04 Aug. 2015.

"What Are Carbon Nanotubes?" What Are Carbon Nanotubes. Nanotechnology For Dummies (2nd Edition), n.d. Web. 04 Aug. 2015.







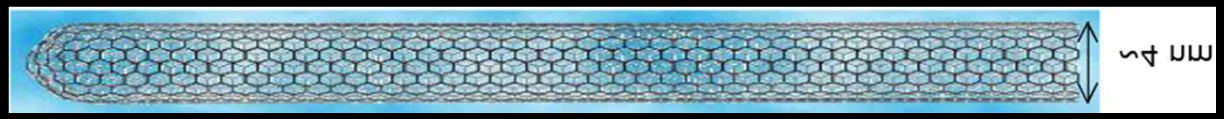
CNT Size

Diameter:
- 1nm to 50nm

Length:
- Several microns to over half a meter

Item	Diameter	Factor
Wrist	40 mm = $40X10^{-3}$ m	1000
Hair	40 μm = $40X10^{-6}$ m	

Item	Diameter	Factor
Hair	40 μm = $4X10^{-5}$ m	10,000
Nanotube	4 nm = $4X10^{-9}$ m	



Bhagat, Ram. "Nanotechnology and Clean Water: How Safe Is Our Drinking Water?" *10.05.02:*. Yale, n.d. Web. 03 Aug. 2015.

CNT Shape

Armchair

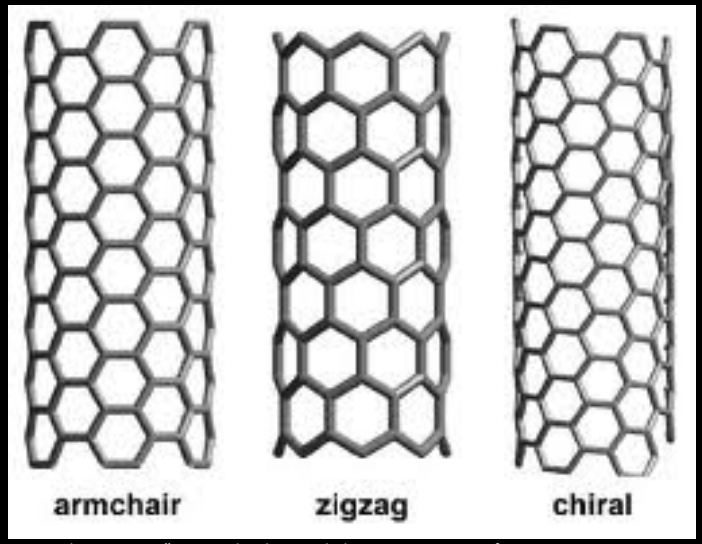
- Similar to metals
- Better conductor than copper or any other metal

Zigzag

- Semiconductor properties
- Only conduct electrical current when extra energy in the form of light or electric field is applied

Chiral

- Similar to Zigzag



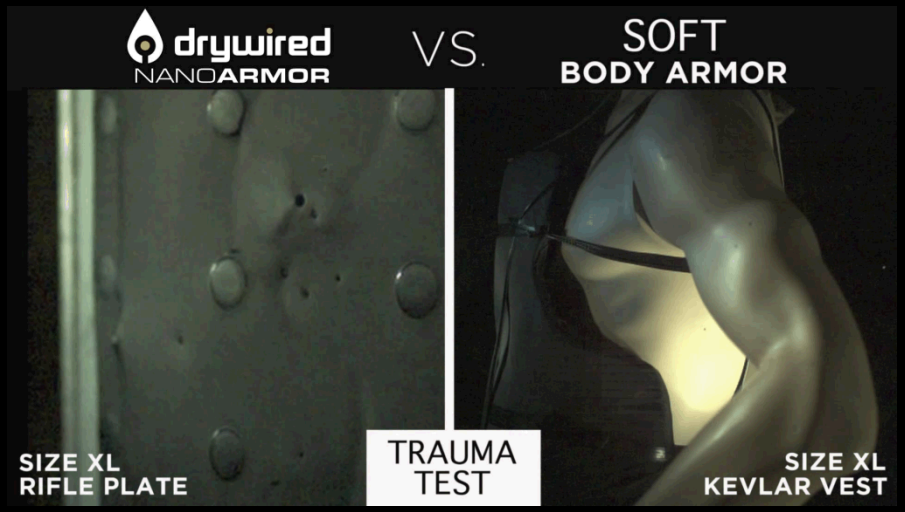
Bhagat, Ram. "Nanotechnology and Clean Water: How Safe Is Our Drinking Water?" *10.05.02:*. Yale, n.d. Web. 03 Aug. 2015.

Why Should We Care?

Application of CNTs are endless

- Body Armor (Stab, Trauma, Rifle)
- Transistors
- CPU
- Power Supply
- Metallic Composites

https://www.youtube.com/watch?v=HkQxAumEMH8

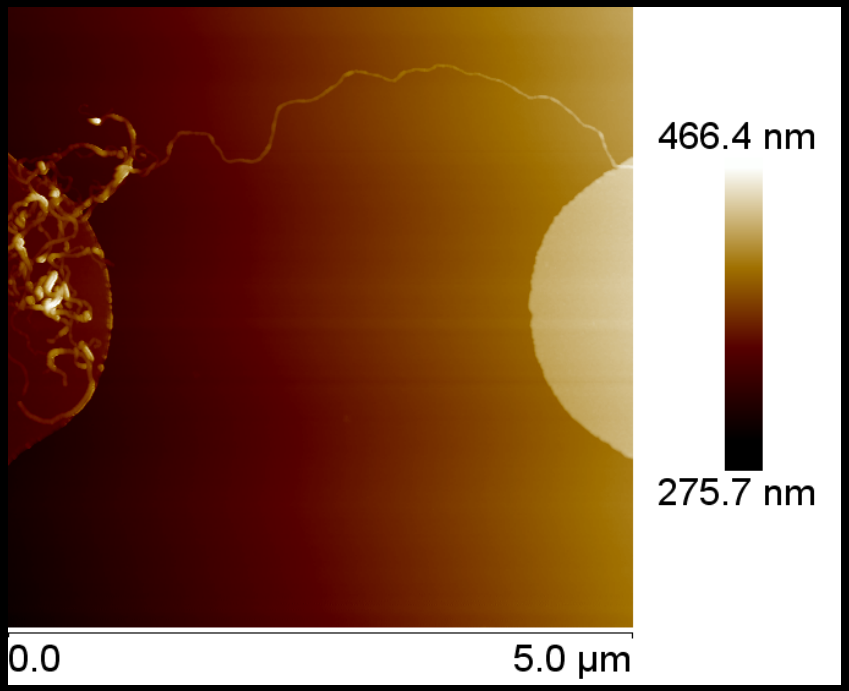


"DryWiredÂ® NanoArmor: Carbon Nanotube Body Armor." *YouTube*. YouTube, 25 Oct. 2014. Web. 03 Aug. 2015.

Lemind, Anna. "Japanese Company Promises to Build Space Elevator by 2050." *Learning Mind*. N.p., 16 Sept. 2012. Web. 03 Aug. 2015.

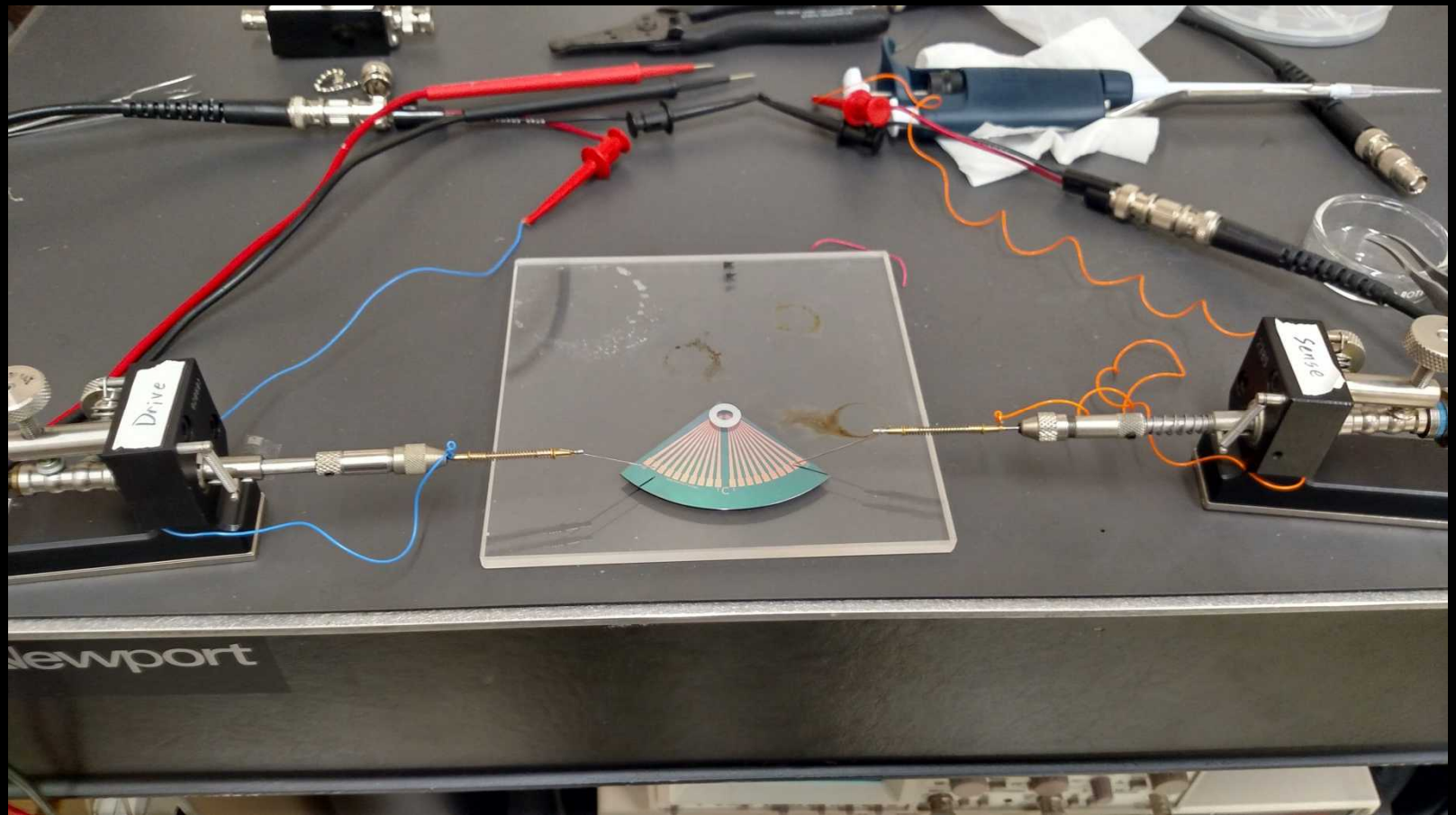
Project

BLUF: Use an AC electric field to induce the formation of aligned multi walled carbon nanotube networks between a pair of electrodes and begin to characterize their conductive properties.

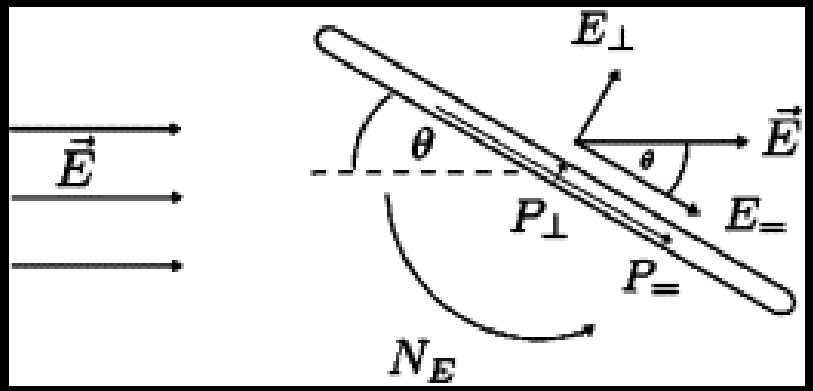


Difficulties

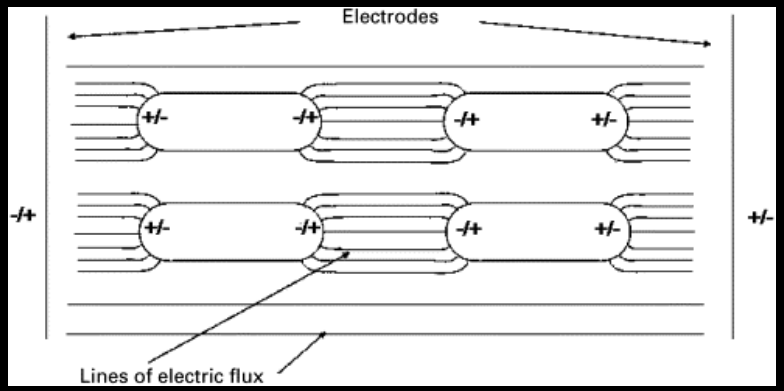
- Age of the CNT
- Sonication
- Concentration
- Time for each sample



How It Works



Martain, C. A., J.K.W. Sandler, A.H. Windle, M.-K. Schwarz, W. Bauhofer, K. Schulte, and M.S.P. Shaffer. "Download PDFs." *Electric Field-induced Aligned Multi-wall Carbon Nanotube Networks in Epoxy Composites*. Scrience Direct, 26 Jan. 2005. Web. 03 Aug. 2015.

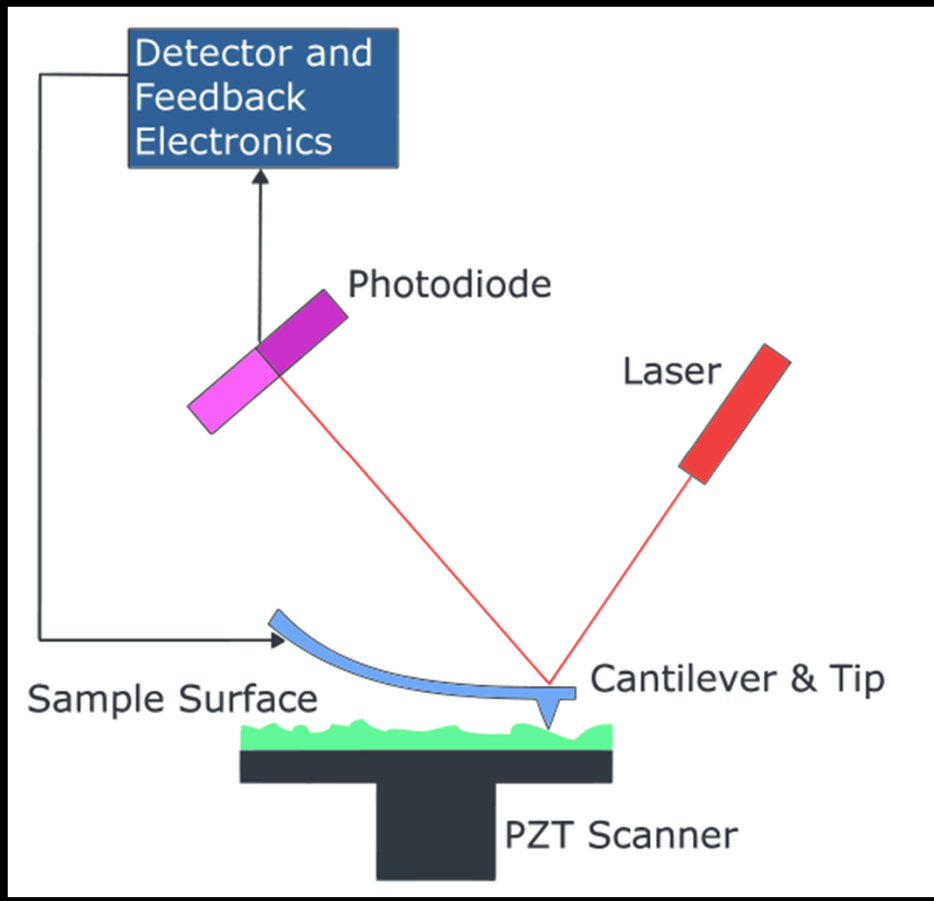


Martain, C. A., J.K.W. Sandler, A.H. Windle, M.-K. Schwarz, W. Bauhofer, K. Schulte, and M.S.P. Shaffer. "Download PDFs." *Electric Field-induced Aligned Multi-wall Carbon Nanotube Networks in Epoxy Composites*. Scrience Direct, 26 Jan. 2005. Web. 03 Aug. 2015.

Polarization leads to a torque in the direction of the electric field with set environment. Then the oppositely charged ends of the CNT will attract and hopefully form a single strand.

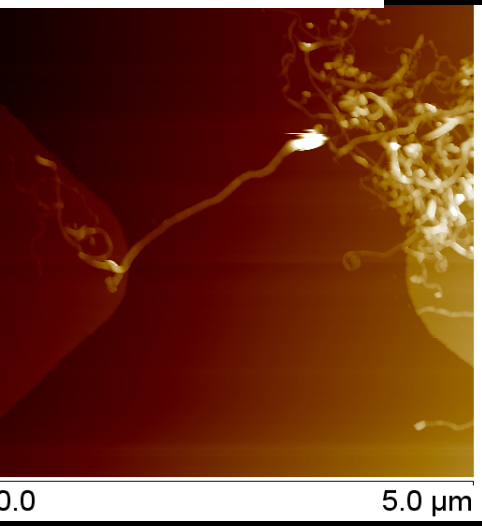
Atomic Force Microscope

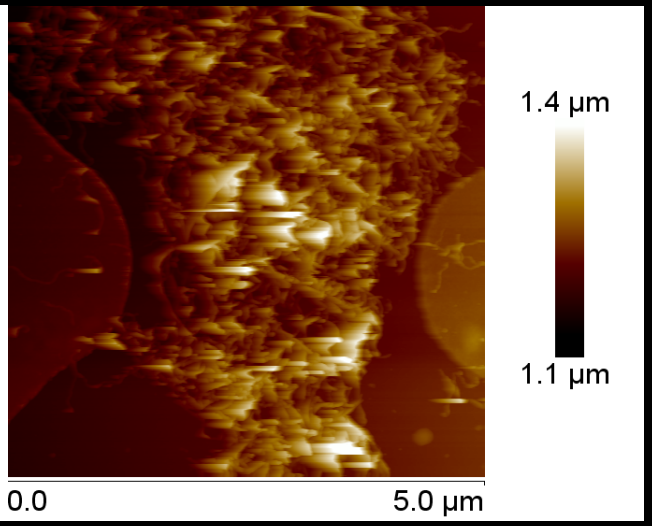
"Atomic Force Microscopy." *Wikipedia*. Wikimedia Foundation, n.d. Web. 03 Aug. 2015.

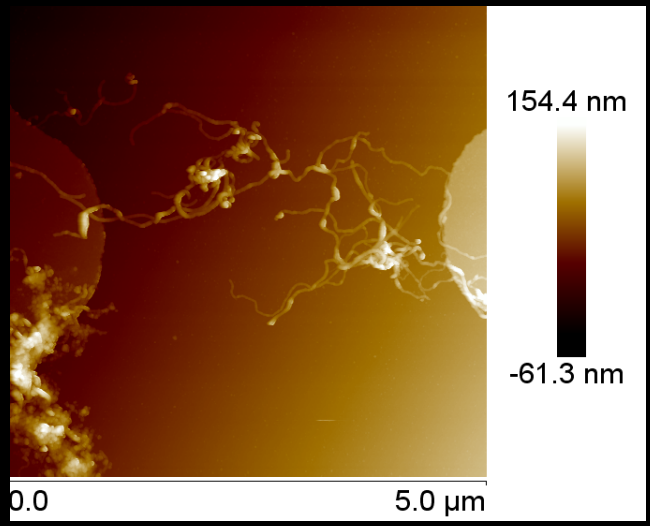


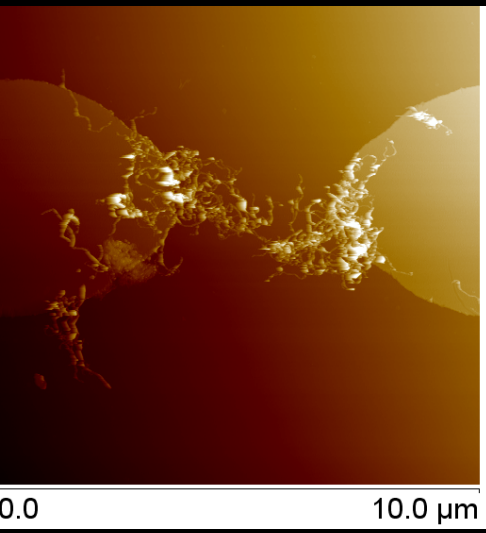
"Atomic Force Microscopy." *Wikipedia*. Wikimedia Foundation, n.d. Web. 03 Aug. 2015.

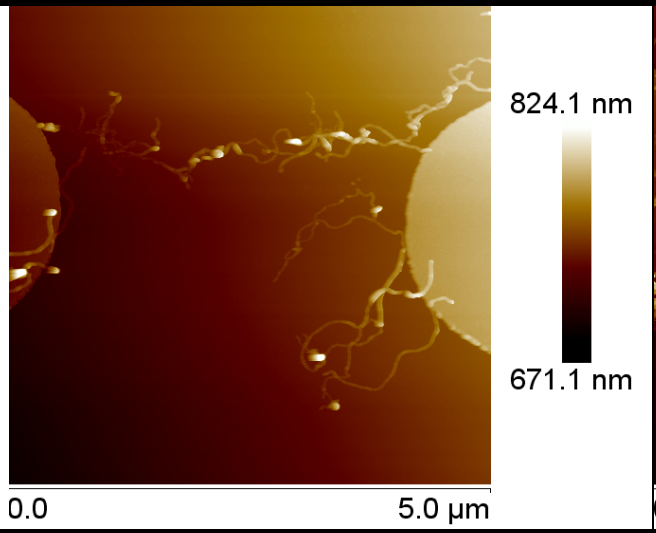
Results

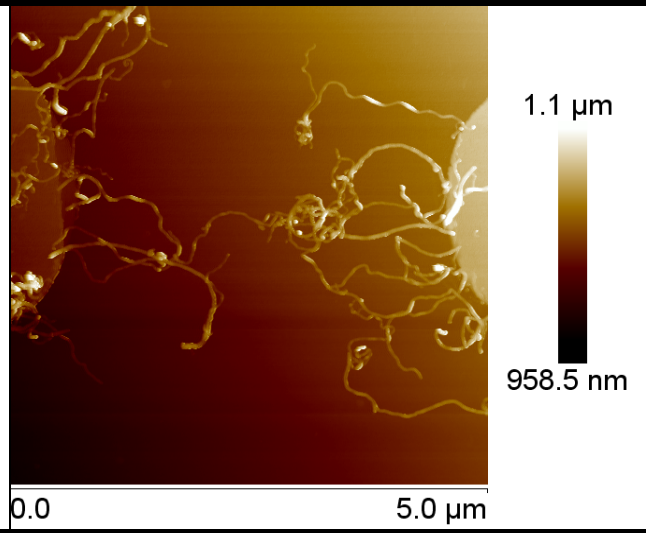

368.6 nm
95.3 nm
0.0
5.0 µm


1.4 µm
1.1 µm
0.0
5.0 µm


154.4 nm
-61.3 nm
0.0
5.0 µm


1.1 µm
781.2 nm
0.0
10.0 µm


824.1 nm
671.1 nm
0.0
5.0 µm

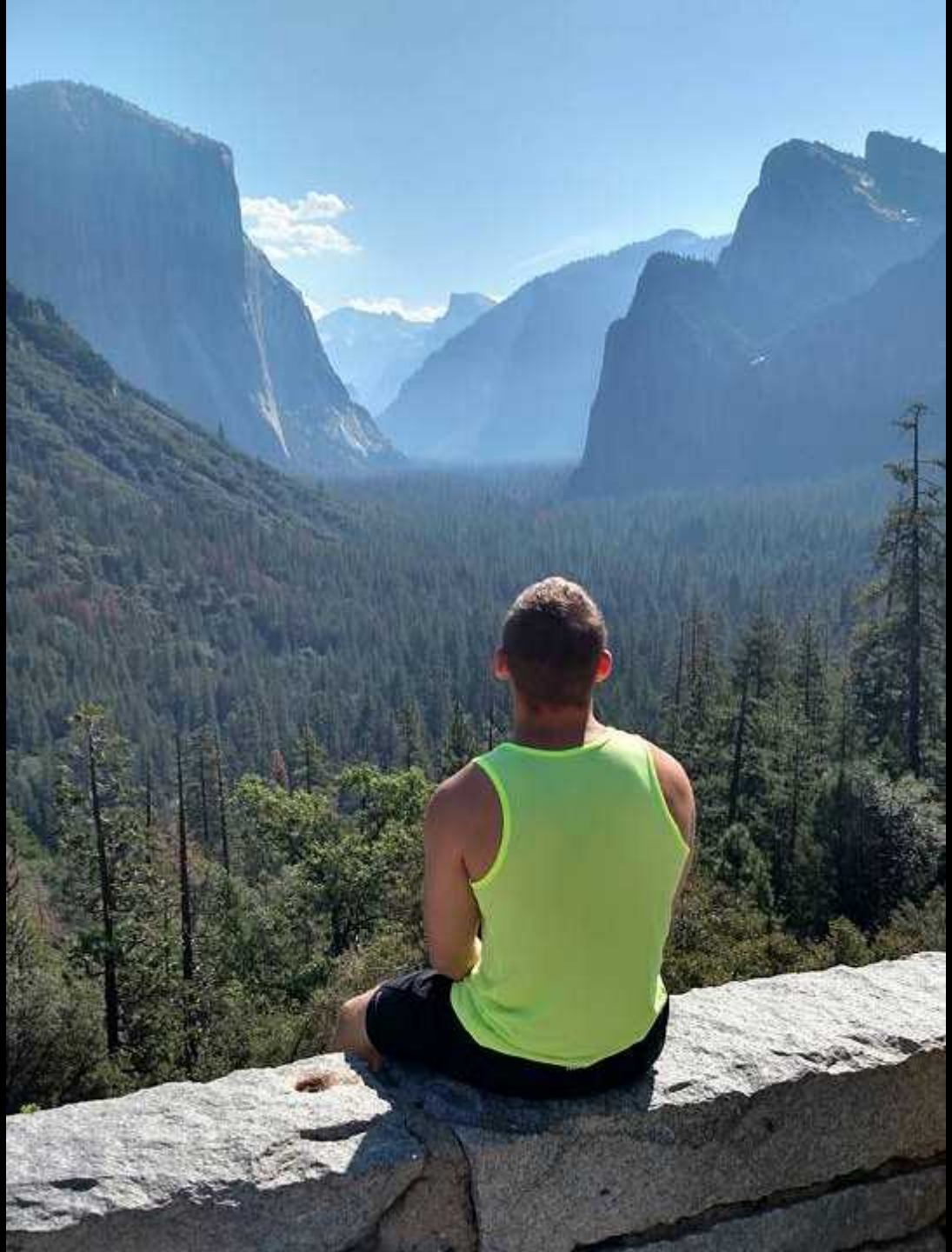

1.1 µm
958.5 nm
0.0
5.0 µm

Intern Rafting Trip

Biking the Bridge

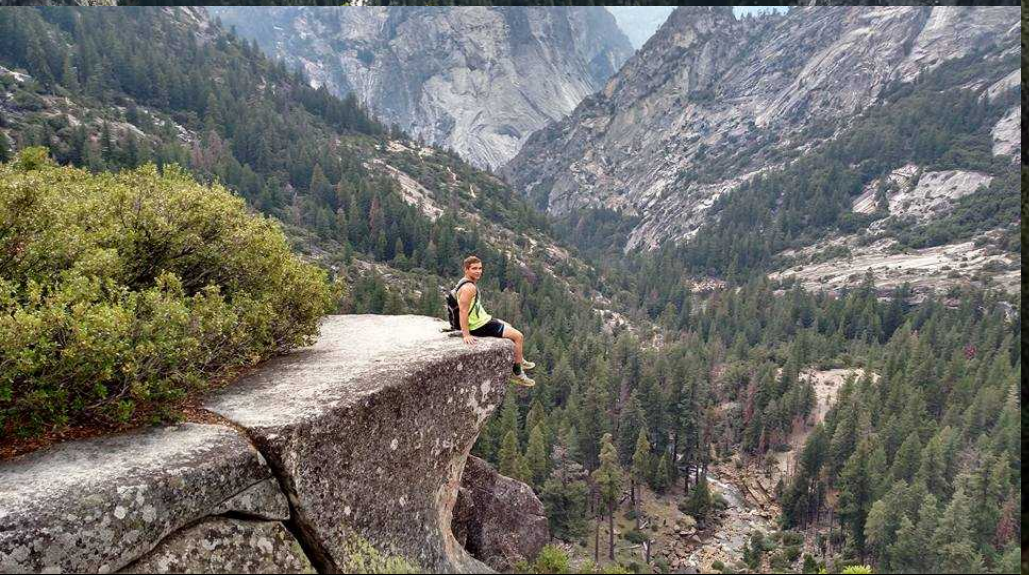
Biking the Bridge

Yosemite



Vernal Falls

Nevada Falls



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