

Remote Access Laboratory Guide



Silver Nanowire Synthesis and Characterization

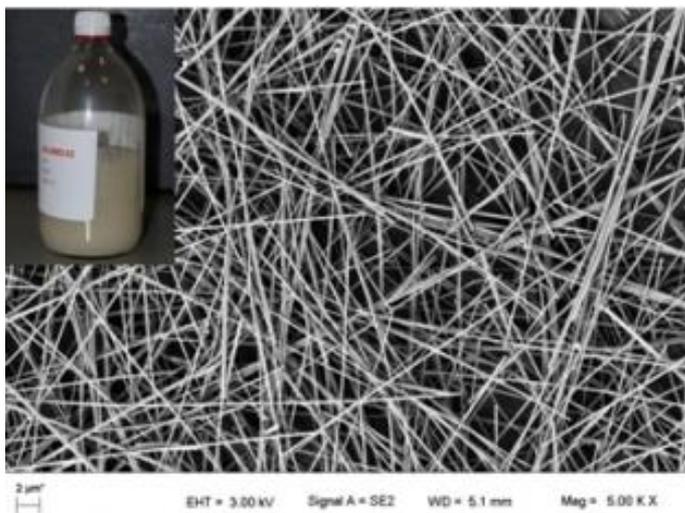
In this exercise, you will:

- Investigate the synthesis of silver nanowires.
- Gain experience in nanoscale characterization.
- Learn how substrate morphology affects nanostructure formation.



Background

Can you produce glass that conducts electricity? What about plastic? Surprisingly the answer to both questions is yes! Small silver wires billionths of a meter in size have made it possible to create glass and plastic substrates that are as conductive as copper wire. Silver nanowires have been used by scientists and engineers to create a mesh that is combined with glass and plastics, allowing these materials to conduct electricity. These developments could lead to remarkable improvements in consumer electronics, such as improved touch screens and possibly devices with flexible screens. This is just one example of many products that incorporate nanoscale materials, which have dimensions billionths of a meter in size. Nanotechnology involves the use of materials with dimensions 100 nm in size or smaller for practical applications. At these sizes, unique electrical, mechanical, and optical properties are observed. The chemical synthesis you will conduct in this experiment will introduce you to the realm of nanotechnology.



<http://nanotechweb.org/cws/article/lab/61516>

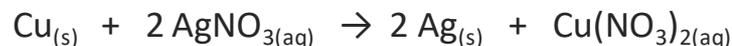


<http://cacm.acm.org/news/167583-penn-develops-computer-model-that-will-help-design-flexible-touchscreens/fulltext>

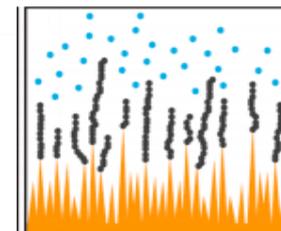
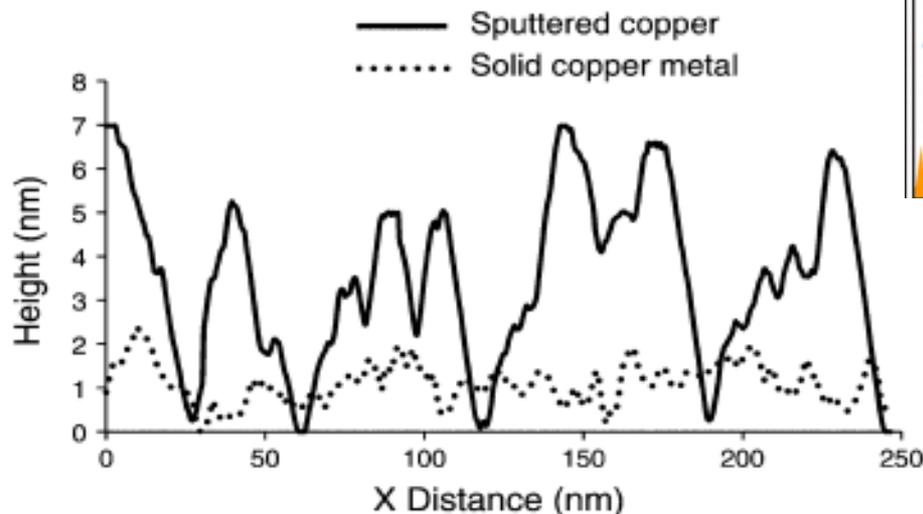
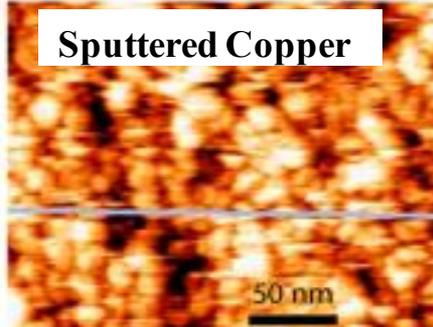
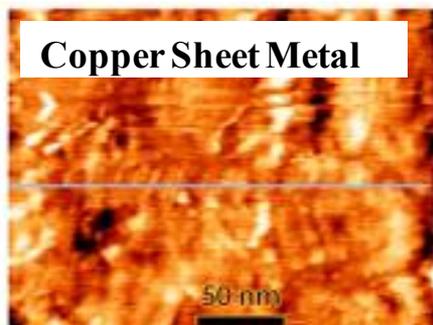


Background

You will prepare silver nanowires using a relatively straightforward chemical reaction between copper metal and a dilute solution of silver nitrate (AgNO_3)



The copper metal used in this experiment will be deposited on a glass substrate using a sputter coater. Sputtered copper produces nanoscale grains of copper that facilitate silver nanowire growth. With the assistance of a few microscopes, an Atomic Force Microscope (AFM) and a Field Emission Scanning Electron Microscope (FE-SEM), you will be able to peer into the nano realm and see your silver nanowires. A group of scientists who work in this field will help you determine the size of the nanowires via an internet connection.

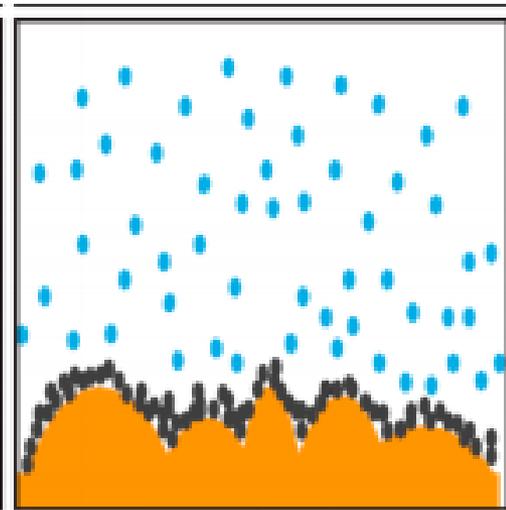


Scanning tunneling microscope (STM) data shows a rougher surface for sputtered copper.

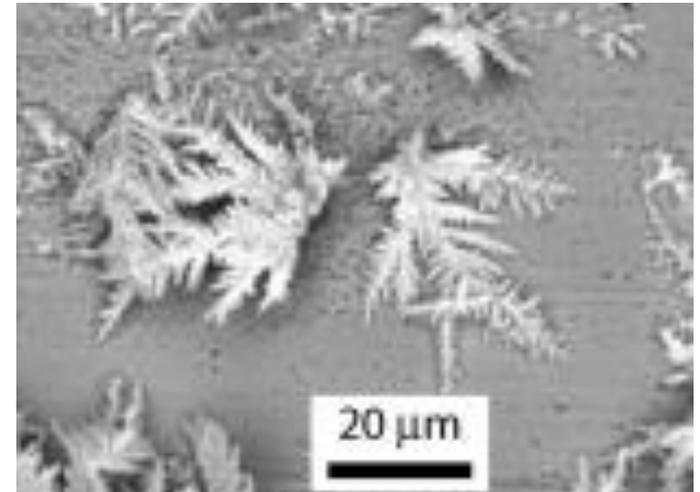


Background

It is interesting to note if a sheet of copper metal is used instead of copper sputtered on a glass substrate, silver dendrites will form instead of silver nanowires.



Ag⁺ ions exposed to copper sheet metal



Dendrites form with copper sheet metal



Background

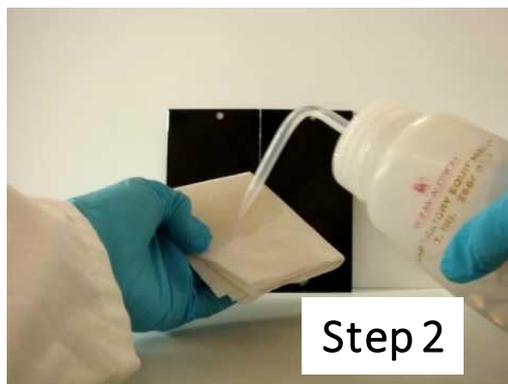
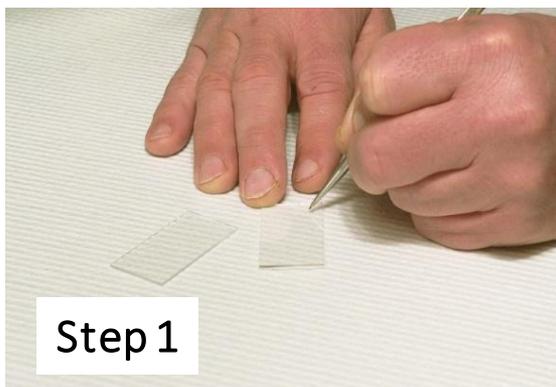
For this lab exercise, you will need the following :

- Silver nitrate (can be obtained from [here](#))
- Isopropyl alcohol
- Nitrogen source or canned air
- 100 mL beaker
- Diamond scribe
- Glass microscope slides
- Eppendorf tubes
- Disposable plastic pipettes
- Scotch tape
- Safety glasses
- Sonicator
- Sputter coater
- Compound light microscope with 10x objective lens
- AFM sample mounting supplies (optional)
- FESEM sample mounting supplies (optional)
- Shipping supplies



Procedure

- I. Cut 2 cm × 2 cm pieces from a microscope slide
- II. Clean substrates with alcohol
- III. Sonicate substrates in alcohol
- IV. Dry substrates with N₂ or canned air



Procedure

- V. In a 100 mL beaker, dissolve 0.85 g of silver nitrate in 50 mL of DI H₂O to create a 0.1 M silver nitrate solution.
- VI. Use a disposable plastic pipette to transfer four drops (approx. 75-100 μ L) of 0.1 M silver nitrate to an Eppendorf tube. Then fill the tube with DI H₂O to the 1 mL mark.
- VII. Add a mask to the glass substrate using Scotch tape to localize wires for viewing.

Step 5



Step 6



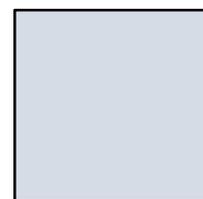
Step 7: Mask Creation



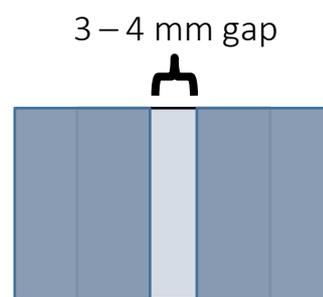
Use transparent
Scotch tape



Do not use frosted
tape



Glass Substrate



Scotch tape Scotch tape
Exposed glass



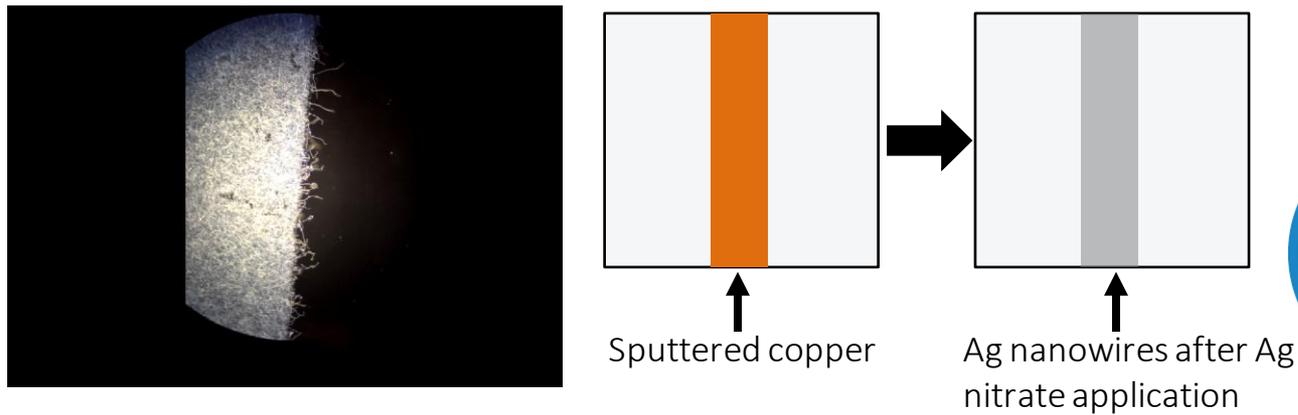
Procedure

- VIII. Sputter the glass substrate with a copper target for 10 minutes at 60 – 70 mA. Make sure the copper target is clean! Clean using sandpaper if necessary.
- IX. Remove the Scotch tape mask from the substrate and add 4-5 drops of the dilute silver nitrate solution to the substrate, allow to react for 10 min. During that time, the copper strip will begin to turn gray.

Step 8: Sputtering



Step 9: Silver Nitrate application



Procedure

- X. Perform Remote FE-SEM Analysis (Figures 1 and 2)
 - a) This will be performed remotely with the assistance of the Remote Access center staff.
 - b) Nanowire widths will be determined.
- XI. Perform Remote EDS Analysis (Figure 3)
 - a) This will be performed remotely with the assistance of the Remote Access center staff.
 - b) Chemical composition of the nanowires will be examined.

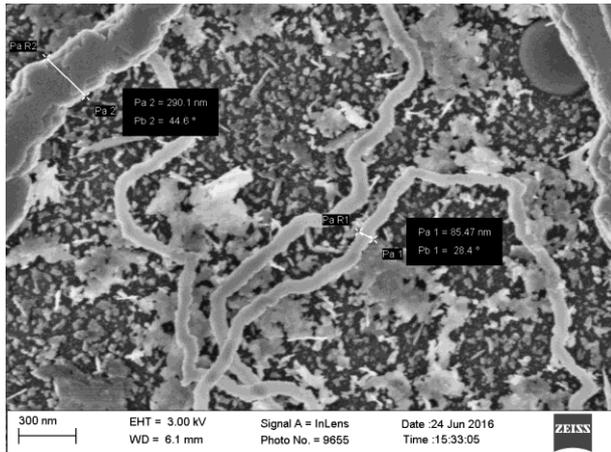


Fig. 1

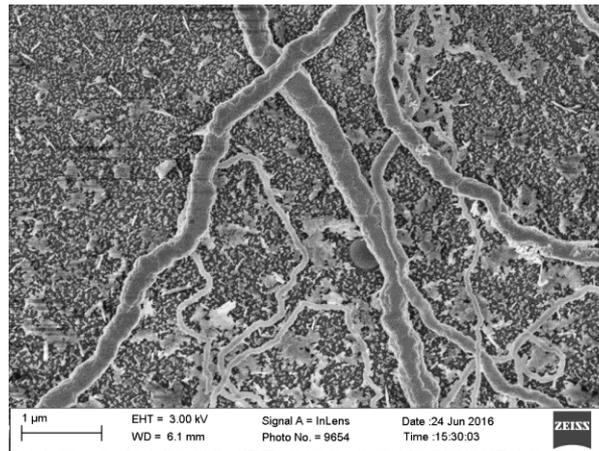


Fig. 2

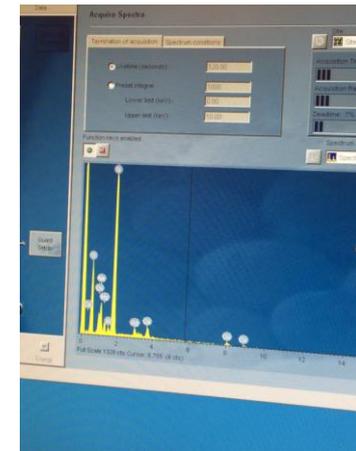


Fig. 3

Remote Access Connection Instructions

What makes these labs different and unique from other classroom experiments is that we have incorporated a section in each activity to remotely characterize your nanoscale samples from your classroom. Remote access to a variety of characterization tools can enhance the visualization of nano-related concepts by allowing students to see the effects of their work first hand. You can choose to mail your samples to our facility to be analyzed at a later date or you can use our samples that have been processed using the same procedure. Please use the following steps to successfully complete a remote session.

- I. Request a remote lab session specifying pertinent information such as: the day, the time, and the instrument you are interested in using by visiting our web site <http://nano4me.org/> Go to the *Educator's* tab and select the *Remote Access* tab in that section. You will see the list of partners with the instruments provided to chose from.
- II. You will be contacted by a Remote Access staff member to set up a test run to ensure you are set up properly and have the required infrastructure.
- III. Send samples or verify the in-house sample you would like us to prepare and load for characterization. Send your samples to the Remote Access center that you chose on your request.
- IV. There are two communications soft-ware packages, that will allow us to communicate instructions and answer questions during the session.
 - I. Zoom: You can obtain a free download at: <https://www.zoom.us/>
 - II. TeamViewer: You can obtain a free download at: <https://www.teamviewer.com/en/index.aspx>



Remote Access Connection Instructions

V. You will need:

- a) Computer with administrator access to install plug-ins and software
- b) An internet connection
- c) Speakers
- d) Microphone
- e) Projector connected to the same computer
- f) Web browser (Firefox preferred)

VI. During the test run you can refer to this guide to perform the following steps, but it's very important that you only proceed with these steps during your scheduled times. You may interfere with other remote sessions and potentially damage equipment if you log in at other times.

- a) Open and logon to your Zoom/Team-viewer account. You will be given the access code to enter at the time of your test and then again during the remote session.
 - If you are using the Zoom software, Remote Access staff will give you the access code.
 - If you are using the Team-viewer software, Remote Access staff will give you the ID & password.
- b) You should soon see the Remote Access desktop and at this point you can interact with the icons on the screen as if it were your desktop.
- c) Switch to full screen mode by selecting the maximize screen option in the top right corner of the screen.
- d) Upon completion of the session, move your mouse to the top right corner of the screen, and click on the X to disconnect the remote session. It will ask if you want to end the remote session. Click Yes.



References and Supplemental Material

- W.C. Sanders, P.D. Ainsworth, D.M. Archer Jr, M.L. Armajo, C.E. Emerson, J.V. Calara, M.L. Dixon, S.T. Lindsey, H.J. Moore, J.D. Swenson, *J. Chem. Educ.* 91 (2014) 705.

The Nanotechnology Applications and Career Knowledge (NACK) Center was established at the Penn State College of Engineering in September 2008 through the National Science Foundation (NSF) Advanced Technological Education program.

Please contact a NACK representative today to assist you in increasing the awareness of nanotechnology and education related opportunities across the nation. Visit our website for an expanded contact list.

NACK Center News is based upon work supported by the NSF under Grant No. 0802498. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Nanotechnology Applications and
Career Knowledge (NACK)
National Center



Pennsylvania State University
118 Research West
University Park, PA 16802



Funded, in part, by a grant
from the National Science
Foundation.
DUE 1205105

Visit us online at:
www.nano4me.org

