It has been shown that uni-axial strain shows cross-section geometry dependent characteristics. The nanorods generated from (110) surface are relatively stronger against uniaxial strain with respect to the nanorods generated from (111) and (100) surfaces.

StrainGraphs içerisinde Delta L yerine % uzama konulmalı.

2012/6/12 Huseyin Yagli <[huseyinyagli@gmail.com](mailto:huseyinyagli@gmail.com)>

Abstract:

**Structural properties of copper nanorods under strain: Molecular dynamics simulations**

Hüseyin Yağlı1, Şakir Erkoç2  
1Micro and Nanotechnology Program, Middle East Technical University, Ankara, Turkey  
2Department of Physics, Micro and Nanotechnology Program, Middle East Technical University, Ankara, Turkey  
  
Structural properties of copper nanorods generated from low-index surfaces (100), (110), (111) under uniaxial strain have been investigated. Classical molecular dynamics simulations at various temperatures have been performed using an atomistic potential. It has been found that uniaxial strain shows cross section geometry dependent characteristics. The nanorods generated from (110) surface are relatively stronger against uniaxial strain than the nanorods generated from (111) and (100) surfaces.  
  
**Keywords:**Nanorods, molecular-dynamics, uniaxial-strain

Introduction:

A general information about copper nanorods (mainly applications); structural properties (geometries, cross sections etc.). Application conditions

Methods of calculations: Details of MD simulations (PEF, integration (velvet), time step lenght, temperature, # of steps, how did you apply strain (%5) ?

Results: Figures, graphs, tables  (resimlerin yanına kaç step yapıldıklarını ve % kaç uzadıklarını yaz)

Discussions and conclusions:

References: yukarıdaki bilgileri aldığım birkaç makalenin referansı da yazılsın.

Not: Structural informations of these nanorods may be useful for various applications.

MD simulations have been realised by relaxing the system until reaching equilibrium in energy.

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| **Copper Nanorods** |
| **Nano Scale (nm) Cu** |
| |  |  |  | | --- | --- | --- | | **Product** | **Product Code** | **Order or Specifications** | | (2N) 99% Copper Nanorods | CU-M-02-NR | [Contact American Elements](http://www.americanelements.com/quote.html) | | (3N) 99.9% Copper Nanorods | CU-M-03-NR | [Contact American Elements](http://www.americanelements.com/quote.html) | | (4N) 99.99% Copper Nanorods | CU-M-04-NR | [Contact American Elements](http://www.americanelements.com/quote.html) | | (5N) 99.999% Copper Nanorods | CU-M-05-NR | [Contact American Elements](http://www.americanelements.com/quote.html) | |
| **Copper Nanorods**are elongated particles ranging from 10 to 120 nanometers (nm) with specific surface area (SSA) in the 30 - 70 m 2 /g range. Nano Copper is also available passivated and in [Ultra high purity](http://www.americanelements.com/Ultra_high_purity_metals&powders.htm)and high purity and coated and dispersed forms. They are also available as a nanofluid through the AE Nanofluid production group. Nanofluids are generally defined as suspended nanorods in solution either using surfactant or surface charge technology. Nanofluid dispersion and coating selection technical guidance is also available. Other nanostructures include nanoparticles, nanowhiskers, nanohorns, nanopyramids and other nanocomposites. Surface functionalized [nanorods](http://www.americanelements.com/Submicron_nano_powders.htm)allow for the particles to be preferentially adsorbed at the surface interface using chemically bound polymers. Development research is underway in Nano Electronics and Photonics materials, such as MEMS and NEMS, Bio Nano Materials, such as Biomarkers, Bio Diagnostics & Bio Sensors, and Related Nano Materials, for use in Polymers, Textiles, [Fuel Cell Layers](http://www.americanelements.com/fuel-cell.html), Composites and [Solar Energy](http://www.americanelements.com/AEsolarenergy.html)materials. Nanopowders are [analyzed](http://www.americanelements.com/ana_service.html)for chemical composition by ICP, particle size distribution (PSD) by laser diffraction, and for Specific Surface Area (SSA) by BET multi-point correlation techniques. Novel [nanotechnology](http://www.americanelements.com/nanotech.htm)applications also include [Quantum Dots](http://www.americanelements.com/quantum-dots.html). High surface areas can also be achieved using [solutions](http://www.americanelements.com/AEsolutions.html)and using [thin film](http://www.americanelements.com/AEthinfilm.html)by [sputtering targets](http://www.americanelements.com/Sputtering_targets_foils_castrods_plates.htm)and evaporation technology using [pellets, rod and foil](http://www.americanelements.com/Sputtering_targets_foils_castrods_plates.htm). Applications for Copper nanorods generally involve their magnetic properties and include in catalysts and magnetic recording and in medical sensors and bio medicine as a contrast enhancement agent for magnetic resonance imaging (MRI). Copper particles are being tested for site specific drug delivery agents for cancer therapies and in coatings, plastics, nanowire, nanofiber and textiles and in certain alloy and catalyst applications . Further research is being done for their potential electrical, dielectric, magnetic, optical, imaging, catalytic, biomedical and bioscience properties. Copper Nano Particles are generally immediately available in most volumes. Additional technical, [research](http://www.americanelements.com/conp.html#research)and safety (MSDS) information is available.  [[Copper(Cu) atomic and molecular weight, atomic number and elemental symbol](http://www.americanelements.com/cu.html)Copper](http://www.americanelements.com/cu.html) is a Block D, Group 11, Period 4 element. The number of electrons in each of Copper's shells is 2, 8, 18, 1 and its electronic configuration is [Ar] 3d10 4s1. In its elemental form copper's CAS number is 7440-50-8. The copper atom has a radius of 127.8 .pm and it's Van der Waals radius is 140.pm. Copper is an essential trace element in animals and plants, but in excess copper is toxic. Due to its high electrical conductivity, large amounts of copper are used by the electrical industry for [wire](http://www.americanelements.com/Sputtering_targets_foils_castrods_plates.htm). Of all pure [metals](http://www.americanelements.com/AEmetals.html), only [silver](http://www.americanelements.com/ag.html) has a higher electrical conductivity. Copper is also resistant to corrosion caused by moisture, making it a widely used material in pipes, coins, and jewelry. Copper is often too soft for its applications, so it is incorporated in numerous alloys. For example, brass is a [copper-zinc alloy](http://www.americanelements.com/cuzixnp.html), and bronze is a [copper-tin](http://www.americanelements.com/cusnnp.html) alloy. [Copper sulfate](http://www.americanelements.com/cus.htm) (CuSO 4·H2O), also known as blue vitrol, is the most well-known [[Elemental Copper](http://www.americanelements.com/cu.html)](http://www.americanelements.com/cu.html)copper compound. It is used as [[Copper Bohr Model](http://www.americanelements.com/cu.html)](http://www.americanelements.com/cu.html)an agricultural poison, an algicide, and as a pigment for inks. Cuprous chloride (CuCl) is a powder used to absorb carbon dioxide (CO2). Copper cyanide (CuCN) is often used in electroplating applications. Copper is available as [metal](http://www.americanelements.com/AEmetals.html) and compounds with purities from 99% to 99.9999% (ACS grade to [ultra-high purity](http://www.americanelements.com/Ultra_high_purity_metals&powders.htm)); metals in the form of [foil, sputtering target, and rod](http://www.americanelements.com/Sputtering_targets_foils_castrods_plates.htm), and compounds as [submicron and nanopowder](http://www.americanelements.com/Submicron_nano_powders.htm). Copper was first discovered by Early Man. The origin of the word copper comes from the Latin word 'cuprium' which translates as "metal of Cyprus". Cyprus, a Mediterranean island, was known as an ancient source of mined copper. See Copper [research](http://www.americanelements.com/cumnr.html#research) below. |

New Copper-based Nanowire Technology

NanoForge has revolutionized the production of copper nanowires by developing a low cost, large scale synthesis process. Copper nanowires are ideal for making low-cost transparent-conductive films, which are used to make flat panel displays, touchscreens, solar cells, organic LED lighting, E-ink panels and low-E architectural glass. With copper nanowires, it is finally possible to economically make displays and solar cells built on plastic films rather than glass or silicon substrates since copper nanowires are:   
  
    • **Highly flexible**, unlike older generation technologies such as Indium-Tin-Oxide   
    • **Lower cost** than other proposed solutions such as silver nanowires  
    • **Easily etched** to create custom surfaces using off-the-shelf copper printed   
      circuit technology

NanoForge Nanowire Technology

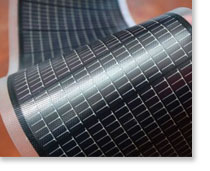
NanoForge copper nanowires are less than 80nm in diameter -- 5 times thinner than the wavelength of blue light, but are 300 times that in length: over 20 microns. They have nearly the same shape as pine needles. Spread out on a surface, the nanowires overlap and chemically bind to each other, creating a highly conductive path for electrons to flow. Very few wires are needed to overlap in order to make a conductive path, so a thin coating of nanowires can make a very significant impact on conductivity without significantly impacting the transparency of the film.

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| --- | --- |
| [http://nanoforge.com/images/wiley-chart-250.jpg](http://nanoforge.com/technology.html) | [http://nanoforge.com/images/Trans-WaveChart-250.jpg](http://nanoforge.com/technology.html) |
| Transmittance vs. Conductivity for  Copper Nanowires and Other Technologies.  Click image to enlarge. | Transmittance vs Wavelength for  Copper Nanowires and ITO.  Click on chart to enlarge. |

Thin films created from NanoForge copper nanowires have transparency and conductivity comparable to the industry standard material Indium-Tin-Oxide (ITO). Unlike ITO, NanoForge's nanowire based thin films:   
  • are compatible with plastic substrates,   
  • eliminate the need for high temperature sputtering and annealing processes,   
  • do not degrade or crack when flexed,   
  • are compatible with high speed roll-to-roll manufacturing techniques with   
    minimal waste, and  
  • are compatible with industry-standard copper etching technologies.  
  
In comparison to emerging technologies such as Silver Nanowires, NanoForge copper nanowires have equivalent transparency and conductivity performance, do not have issues with electromigration and are significantly less expensive.

Markets for Nanowire Solutions

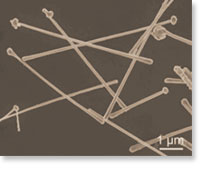
Unlike the legacy Indium-Tin-Oxide based materials, Copper nanowire-based Transparent-Conductive films can be applied to plastic substrates using a high volume, roll-to-roll manufacturing process. The cost savings over traditional glass-based substrate manufacturing is substantial both in terms of raw material cost, capital equipment requirements and production rate.  
  
Uses for nanowires include:   
    • Thin film solar cells  
    • Flat panel displays  
    • OLED panel lighting   
    • Touch screens  
    • E-Ink systems  
    • Electro active glass   
    • EMI shielding systems  
  
Copper nanowires are poised to revolutionize these industries since products based upon flexible substrates cost less, are much lighter, and are able to withstand much higher mechanical stresses without cracking or breaking.

**Thin Film Solar Panels**By taking the advantage of the ability to "print" nanowire solutions on flexible media, NanoForge products can be used on plastic substrates to create flexible solar panels, displays, and more.

[](http://www.youtube.com/watch?v=DPF9Kp7W_s0&feature=related)  
  
Visit YouTube for an interesting video that shows the durability of flexible displays.

NanoForge Products

**Copper Nanowires in Aqueous Solution**Copper nanowires are sold in a water-based carrier and are easily integrated into either aqueous or solvent-based ink formulations.   
  
• Standard product average nanowire dimensions are:   
    Maximum 80 nm in diameter  
    Minimum 20 microns in length  
  
• Custom dimensions can be produced under special order.   
  
• Prototype ink formulations and film drawdown techniques are provided.  
  
• Typical nanowire coverage needed for a 85% transparency / 50 Ohm conductivity film is 75mg copper nanowire per square meter of film area.  
  
• Copper nanowires are sold by the gram of copper content in solution.  
  
**Please**[contact NanoForge](http://nanoforge.com/sales.html)**for current pricing and lead times.**  
  
**Future Products**  
Next generation products for specialized applications include custom ink formulations/coating techniques, and alloyed/coated copper nanowires. 

**Detail Closeup of Nanowires**   
NanoForge nanowires' low-profile highly-conductive properties allow ease of application and consistent substrate   
electrical properties.