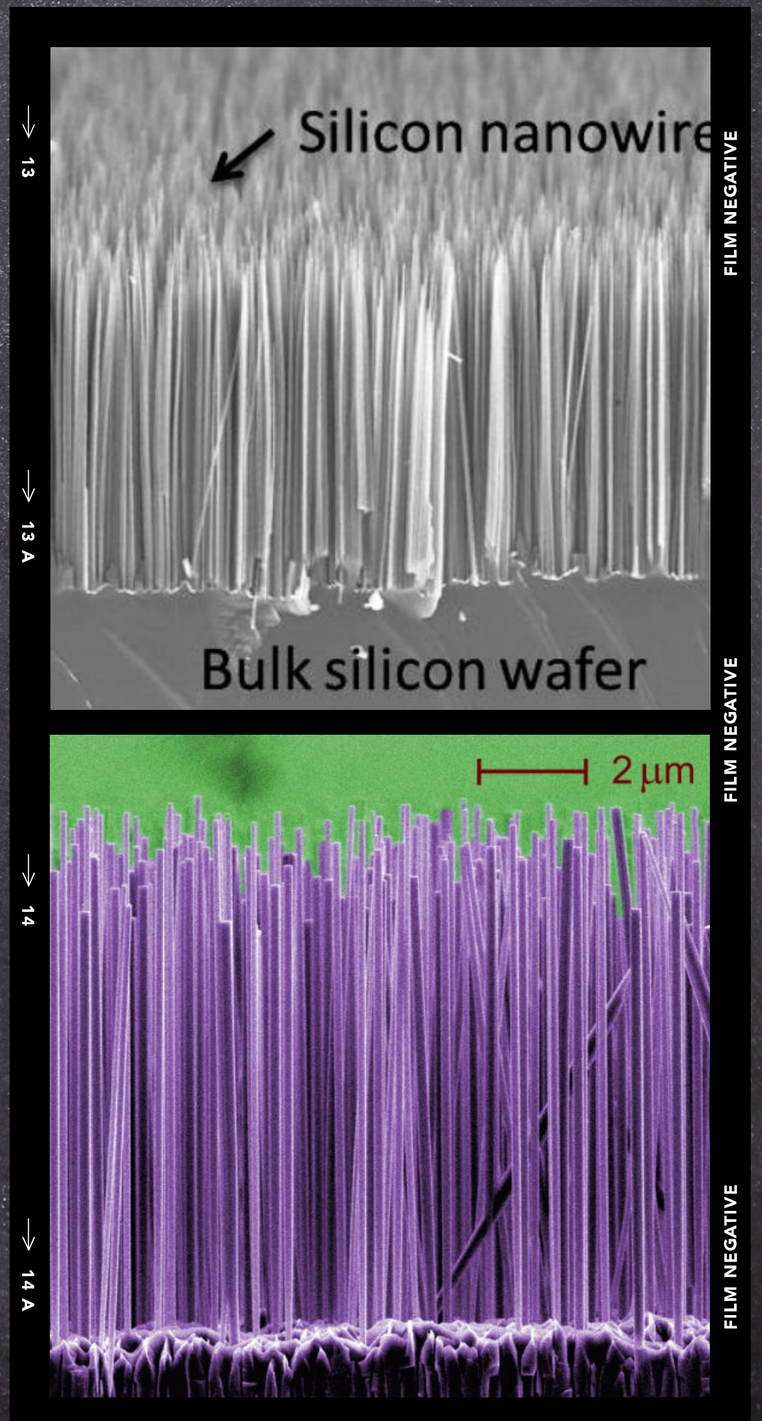
SILICON NANOWIRES

ARYAN SAGAR - 2022MMB1372
RISHAV KUMAR - 2022MMB1389

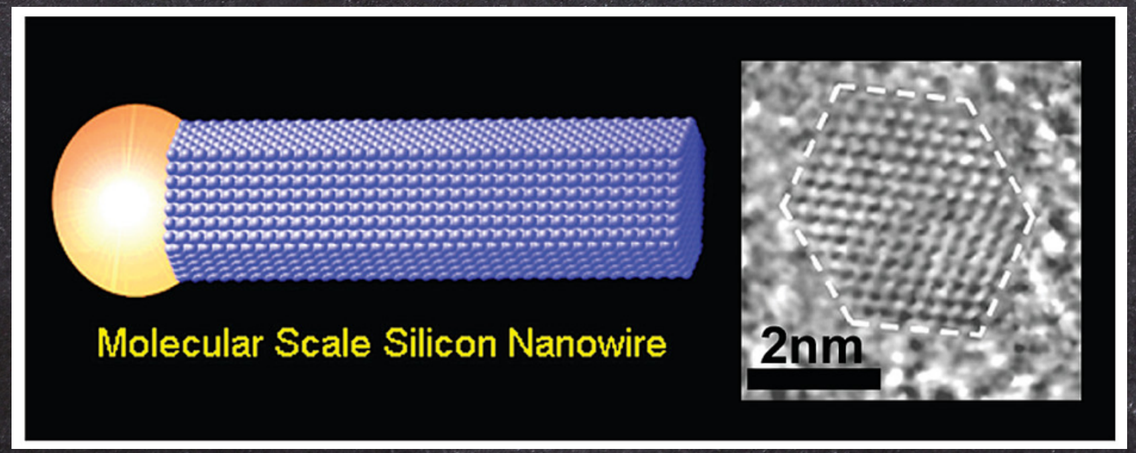
INTRODUCTION

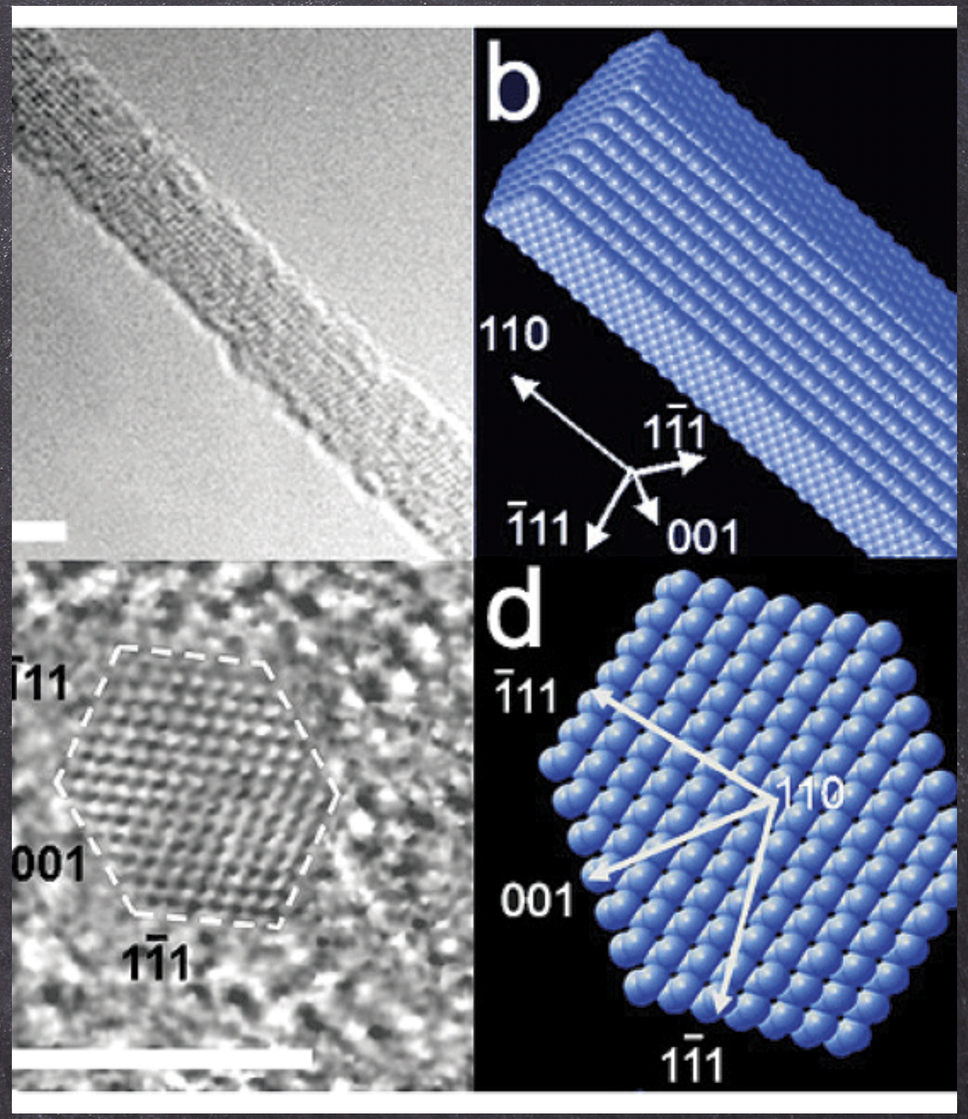
- also known as SiNWs
- Is a type of semiconductor nanowire
- Discovered in early 2000s



PROPERTIES

- Atomic structure : hexagonal shape
- Diameter : few nm - 100nm
- Length : micrometer to several millimeter
- Doping : for vary electrical conductivity
- High mechanical strength
- Melting point : 1410* C

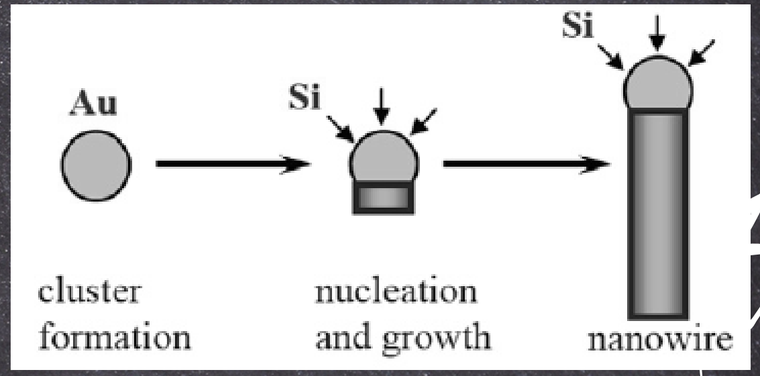




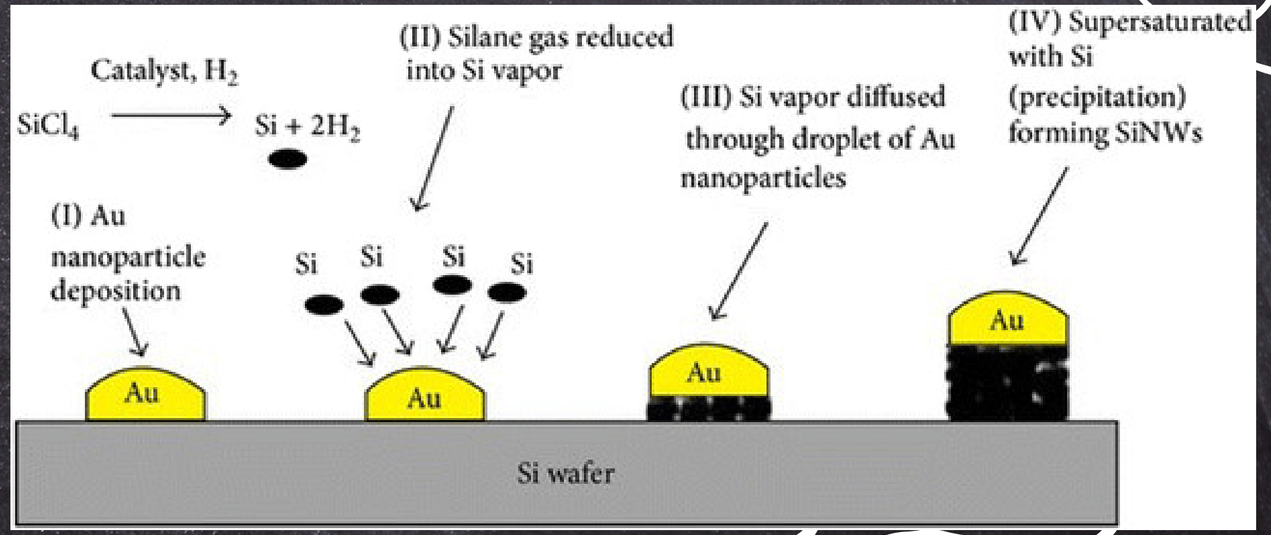
SYNTHESIS

Silicon nanowires are synthesize by Fabrication techniques such as

- Vapor-Liquid-Solid (VLS) Growth: In this method, a vapor containing silicon is introduced into a high-temperature furnace with a metal catalyst (typically gold or silver) on a substrate. The vapor condenses on the catalyst particles, and silicon nanowires grow from these catalyst seeds.

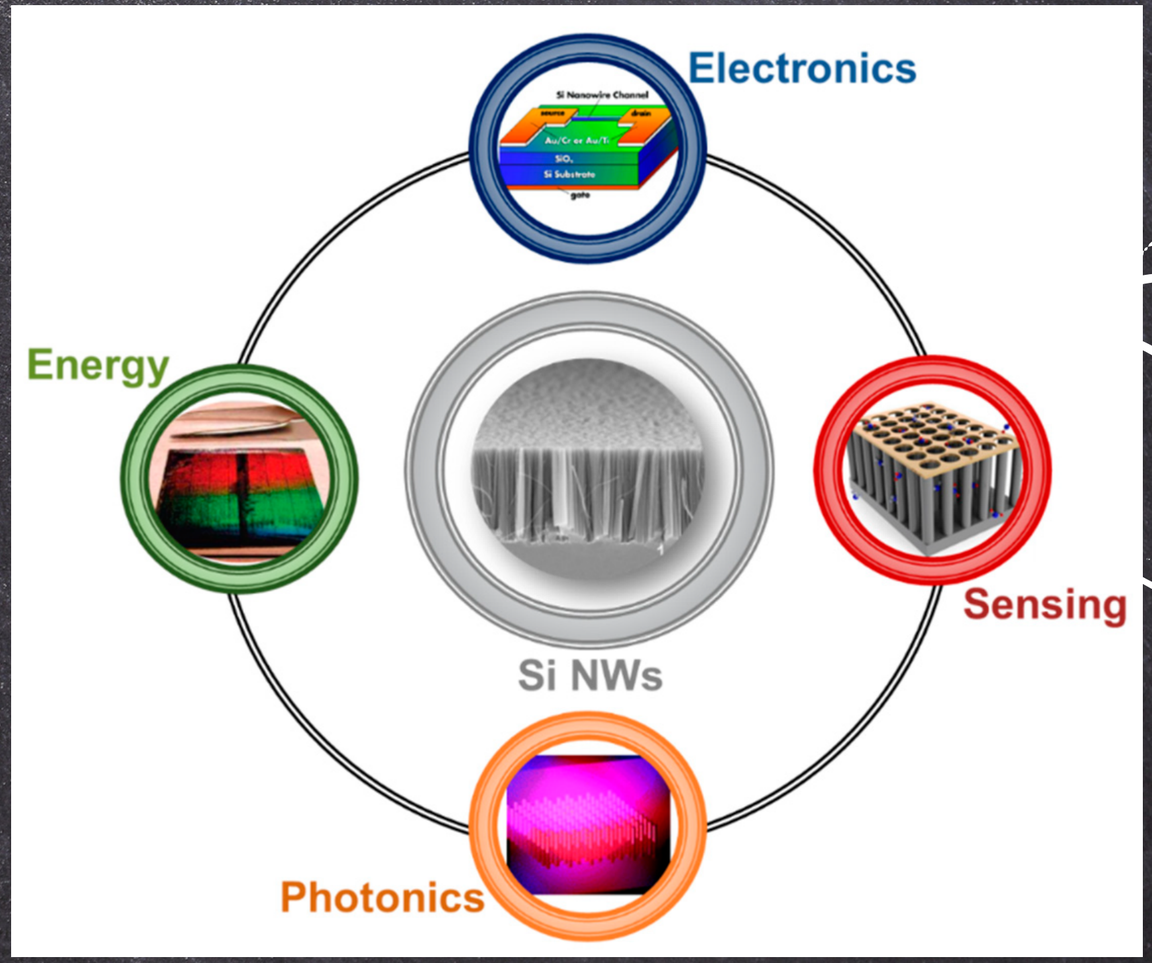


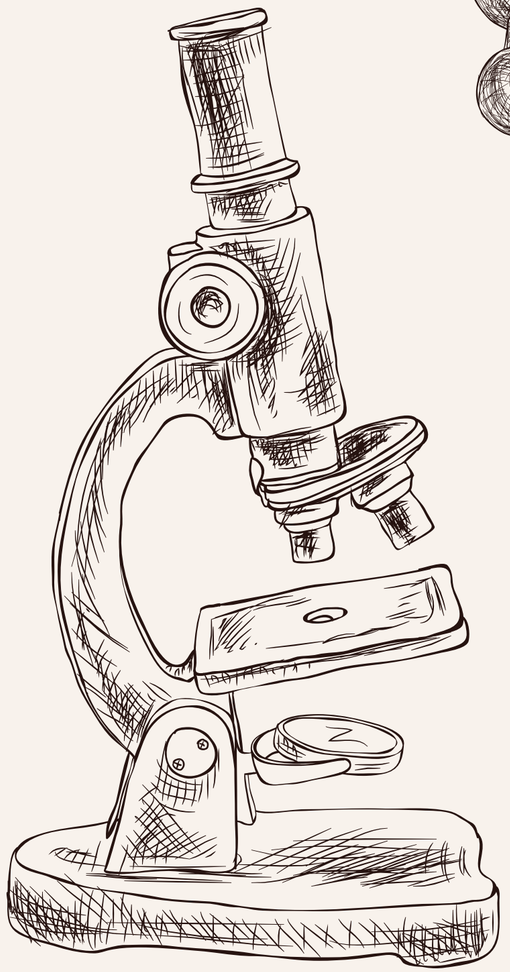
- Chemical Vapor Deposition (CVD): SiNws can be synthesized by chemical vapor deposition, where silicon-containing gases are decomposed on a substrate to form nanowires. This method allows for better control over the growth parameters and the properties of the nanowires.

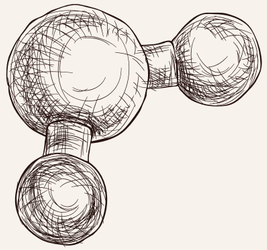


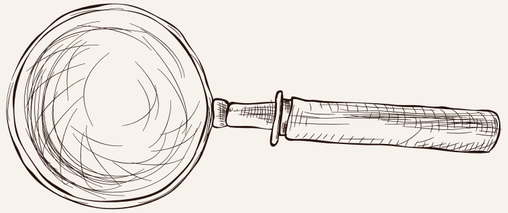
APPLICATIONS

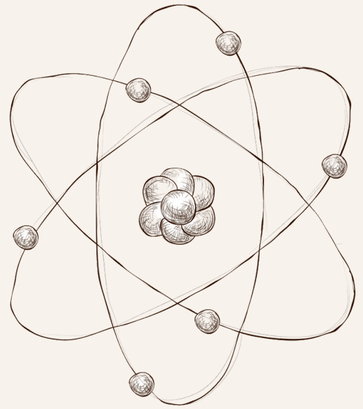
- ELECTRONICS : Transistors (FETs)
- SENSORS : Gas Sensors , Biosensors
- Energy Conversion : Photovoltaics (Solar cells)
- Nanomedicine : Drug Delivery , Biosensing
- Energy Storage: Supercapacitors , Lithium-ion Batteries:
- Quantum Computing : SiNWs used as qubits due to their ability to trap and manipulate individual electrons or spins.
- NEMS : SiNWs can be used in sensors, actuators, and resonators, for highly sensitive measurements and mechanical manipulation at the nanoscale.







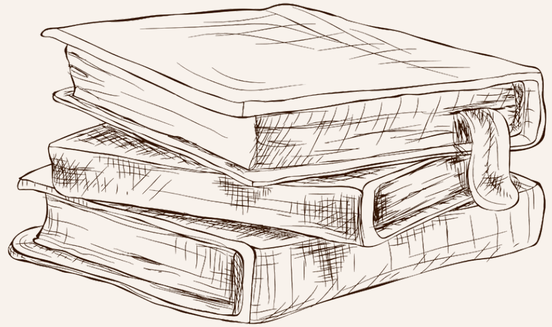




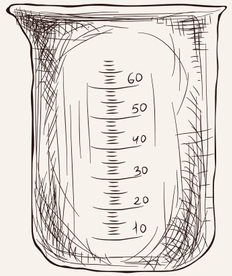
Characterization
of

SILICON NANOWIRE

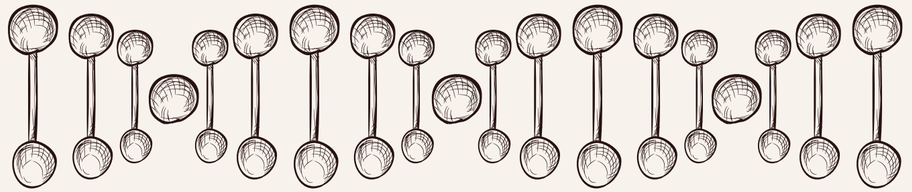
Presented by Rishav Kumar & Aryan Sagar
2022mmb1389 & 2022mmb1372



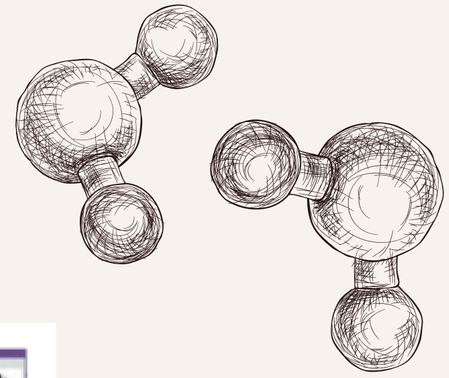
Techniques

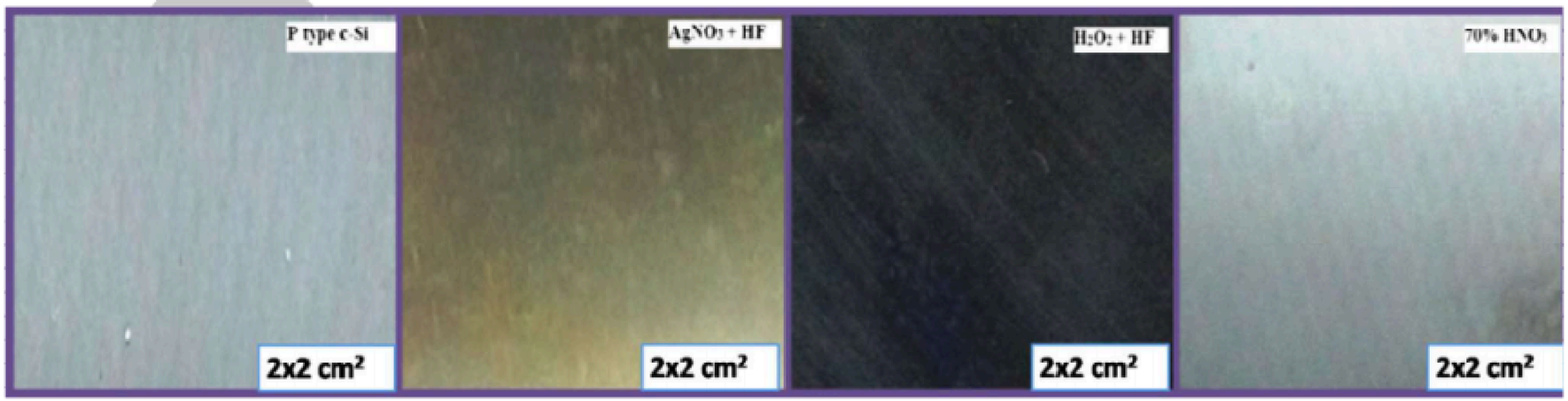


- X-Ray Diffraction (XRD)
- Light Optical Microscopy
- Electron Microscopic Techniques
  - Scanning Electron Microscopy (SEM)
  - Transmission Electron Microscopy (TEM)
- Scanning Probe Microscopy
  - Scanning Tunneling Microscopy (STM)
  - Atomic Force Microscopy (AFM)
- Spectroscopic Characterization
  - UV-Visible-NIR Spectroscopy
  - Fourier-Transform Infrared Spectroscopy (FTIR)
  - Photoluminescence Spectroscopy
  - Raman Spectroscopy
- Thermal Analysis
  - Thermal Mechanical Analysis (TMA)
  - Differential Scanning Calorimetry (DSC)
  - Thermal Gravimetric Analysis (TGA)
  - Differential Thermal Analysis (DTA)
- Porosimetry
  - Mercury Porosimetry
  - Nitrogen Adsorption
  - BET (Brunauer-Emmett-Teller)



1. Optical Microscopy





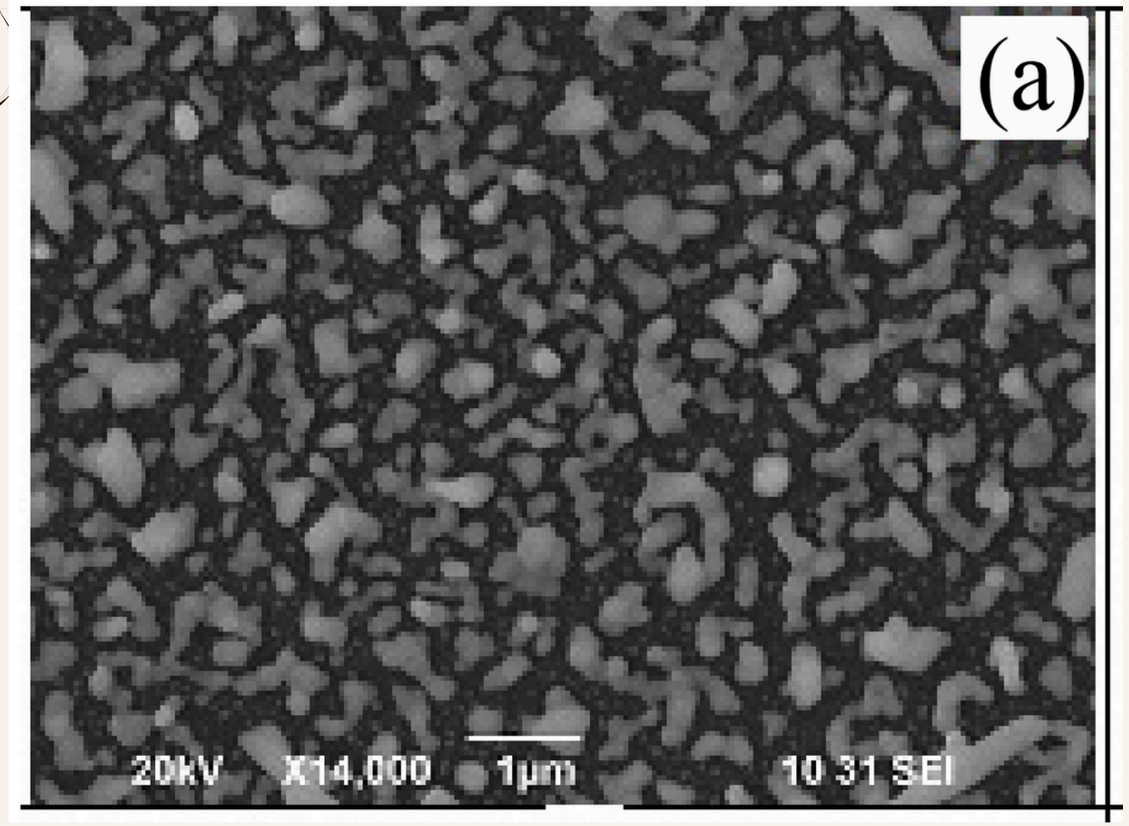
01 Optical image of RCA-cleaned SiNWs

02 Optical image of Ag electroplated SiNWs yellowish becaluse of deposition of silver nanoparticle on silicon substrate

03 H2O2 + HF etched SiNWs optical image

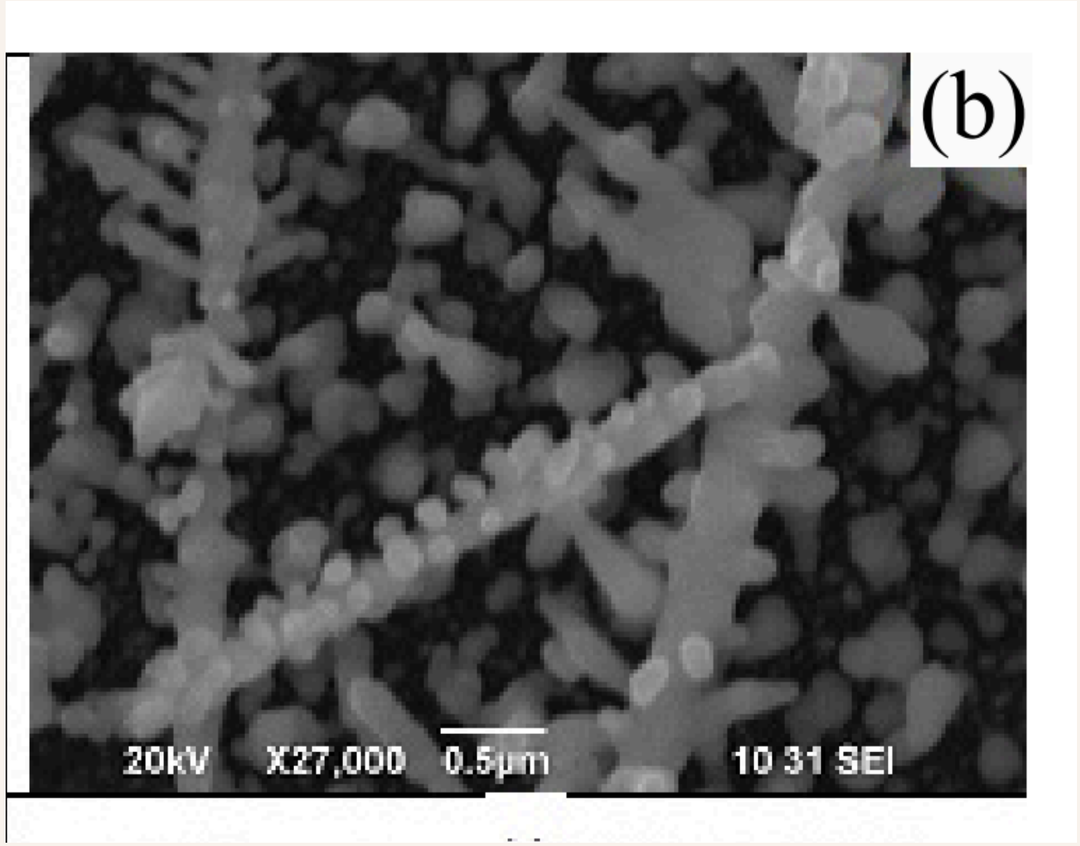
04 HNO3 etched SiNWs optical image

SEM



SEM images morphology of electroless Ag-nanoparticle deposited on a p-type Silicon Substrate with axial orientation of (111) from a HF/AgNO3 solution after a treatment (Ag deposition) times of : 60 seconds

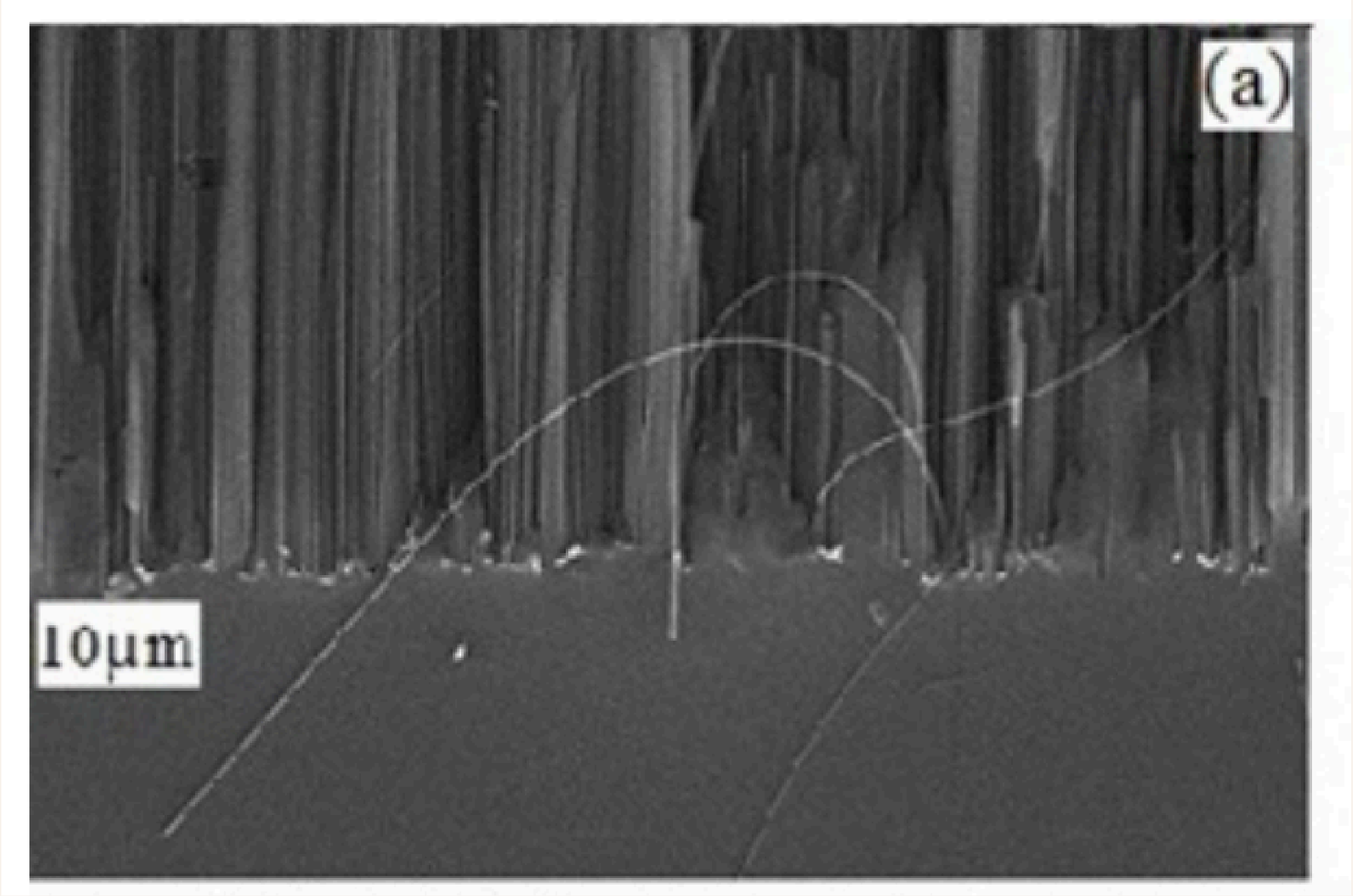
SEM



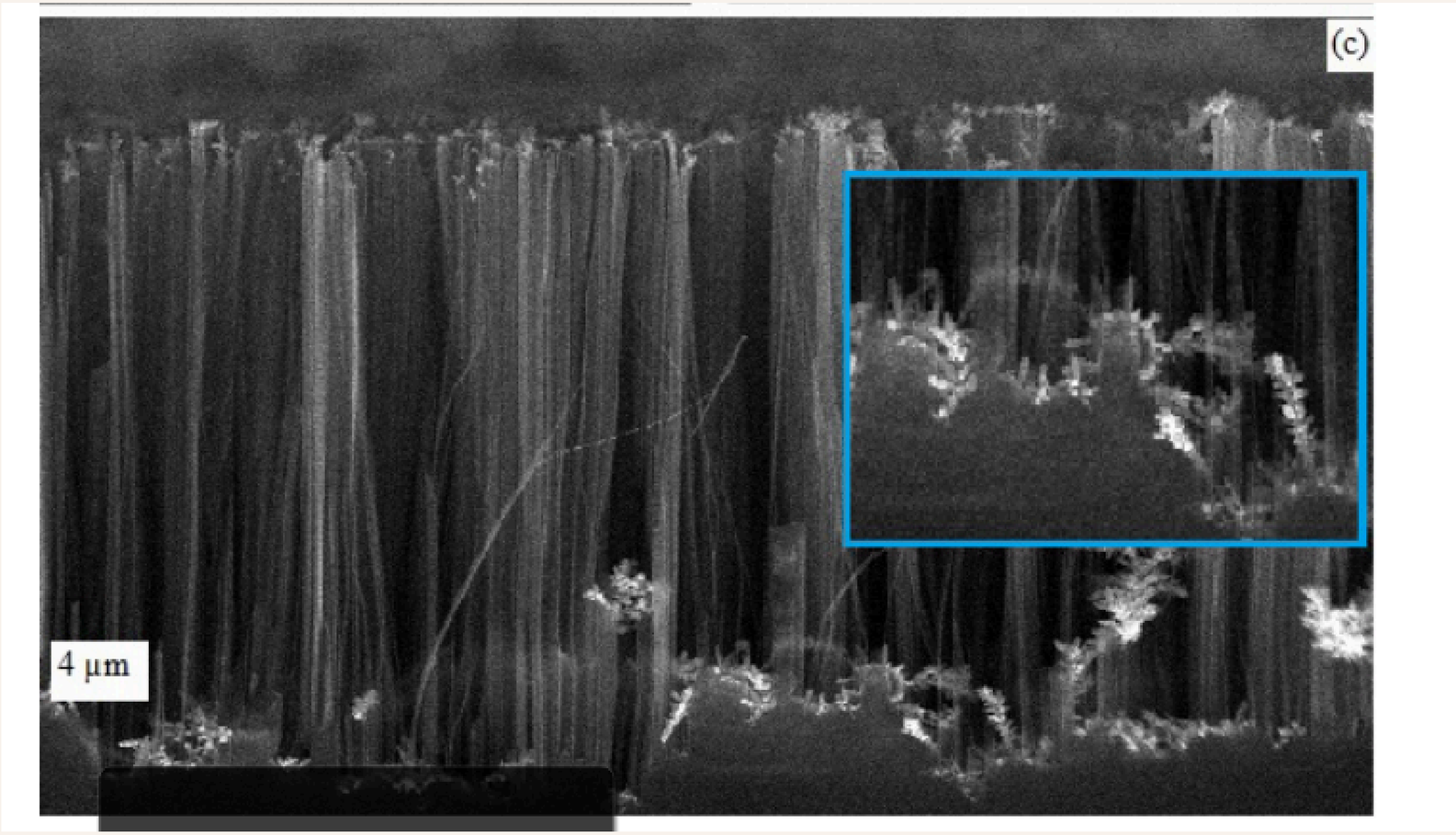
SEM images morphology of electroless Ag-nanoparticle deposited on a p-type Silicon Substrate with axial orientation of (111) from a HF/AgNO3 solution after a treatment (Ag deposition) times of : 75 seconds

SEM

Cross-sectional SEM image of the synthesized Silicon nanowires array for Ag treated samples. Etched for 45 minutes with deposition time of 60 seconds.



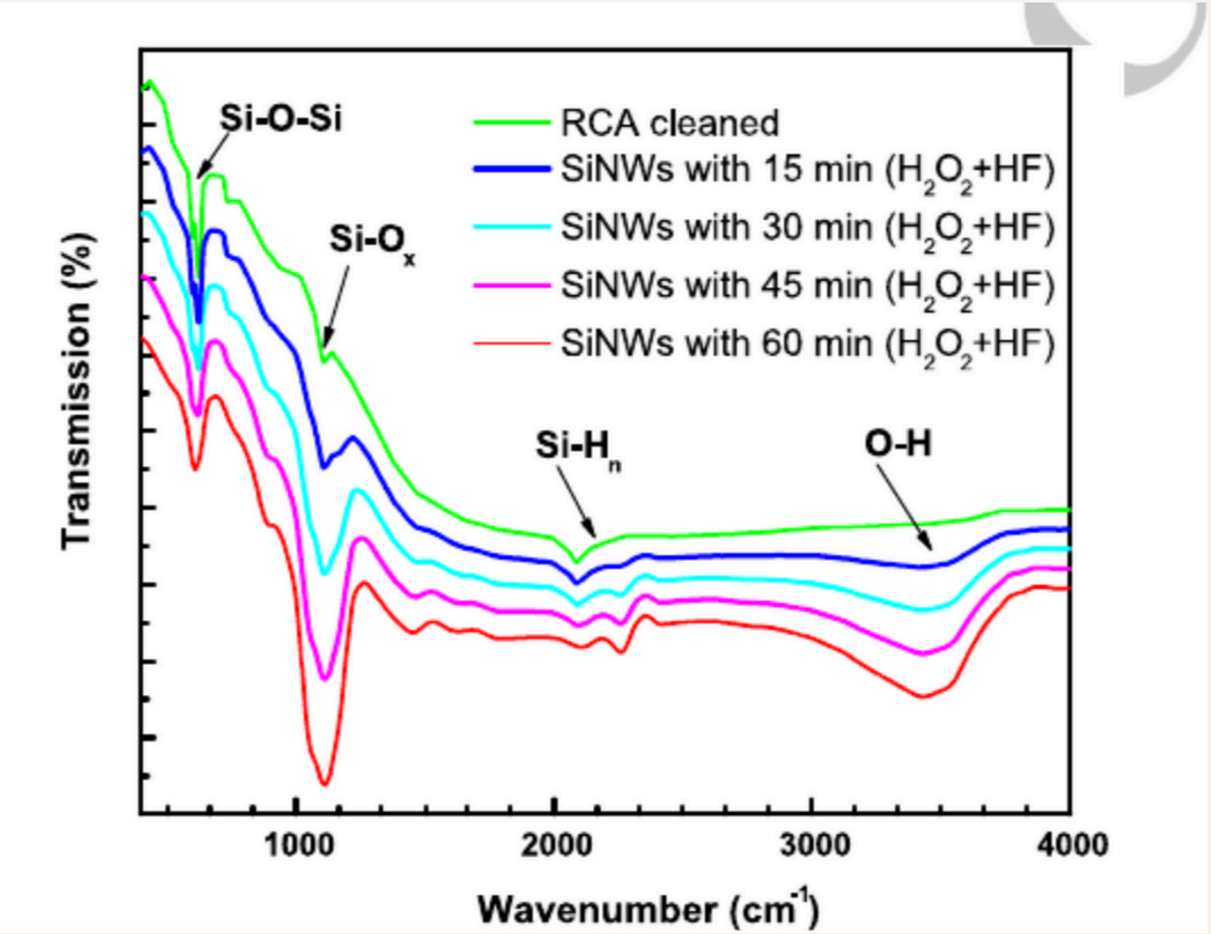
Cross-sectional SEM image of the synthesized Silicon nanowires array for Ag treated samples.
Etched for 75 min with nanoparticle deposition time 60 seconds. In some location of the substrate, SiNWs are beginning to break apart (shown in the inset) as etching time is increased to 75 minutes



FTIR

FTIR spectra of RCA-cleaned Si wafer and SiNWs with different etching time. The RCA-cleaned Si wafer shows three major vibrational peaks at 623, 1108 and 2087 cm-l. The vibrational signature at 623 cm- corresponds to Si-O-Si stretching with full width at half maxima (fwhm) of 40 cm- . However, 1108 and 2087 cm- vibrational signatures correspond to Si-Ox and Si-H2 stretching.

FTIR signatures of SiNWs with variation of etching time

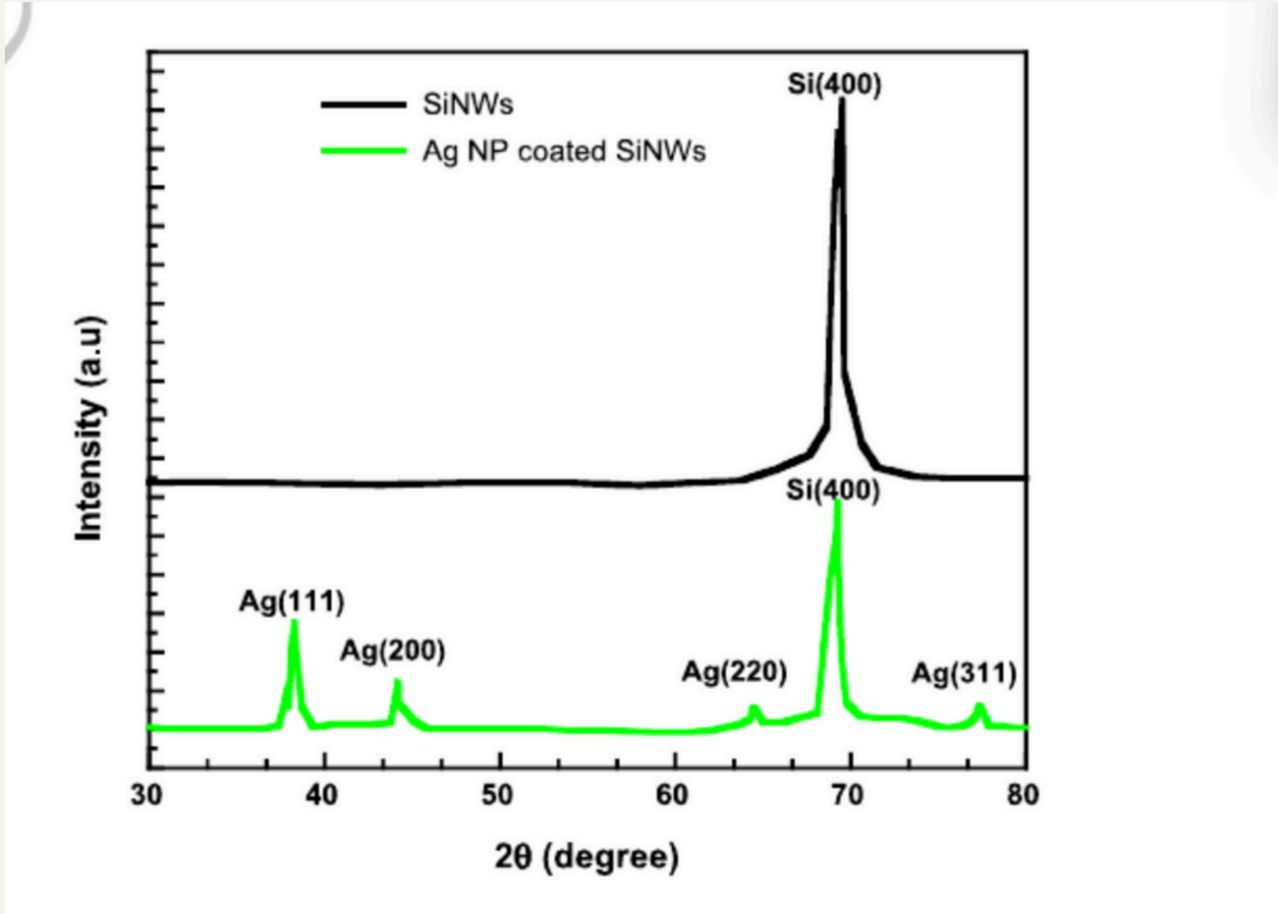


XRD

Figure shows XRD spectra of Ag nanoparticle-coated SiNWs and cleaned SiNWs. The Ag nanoparticles were found at 38.20, 44.10, 64.350 and 77.260 angles with corresponding plains of (I I I), (200), (220) and (3 11), respectively. However, only one XRD plane (400) is found at 69.370 for SiNWs.

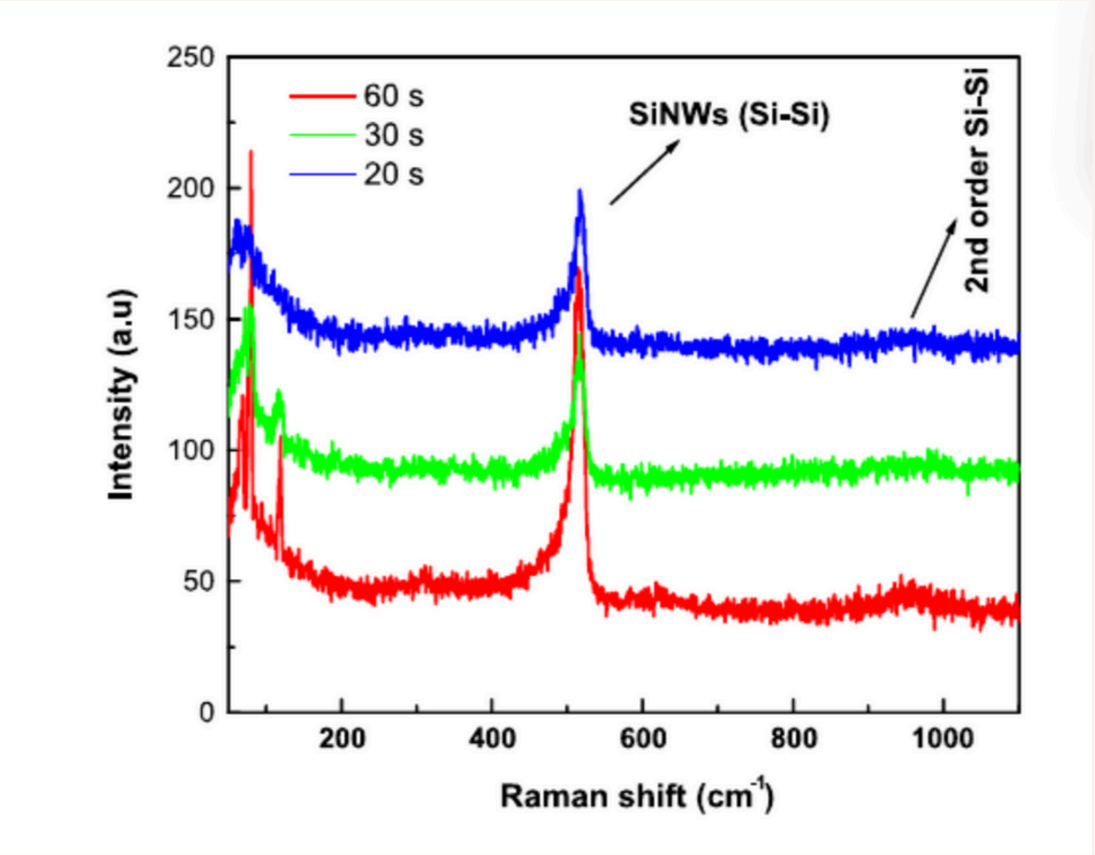
The estimated size of Ag particle is 23 nm, and of SiNWs is 14.77 nm.

XRD of Ag nanoparticle-coated SiNWs and cleaned SiNWs

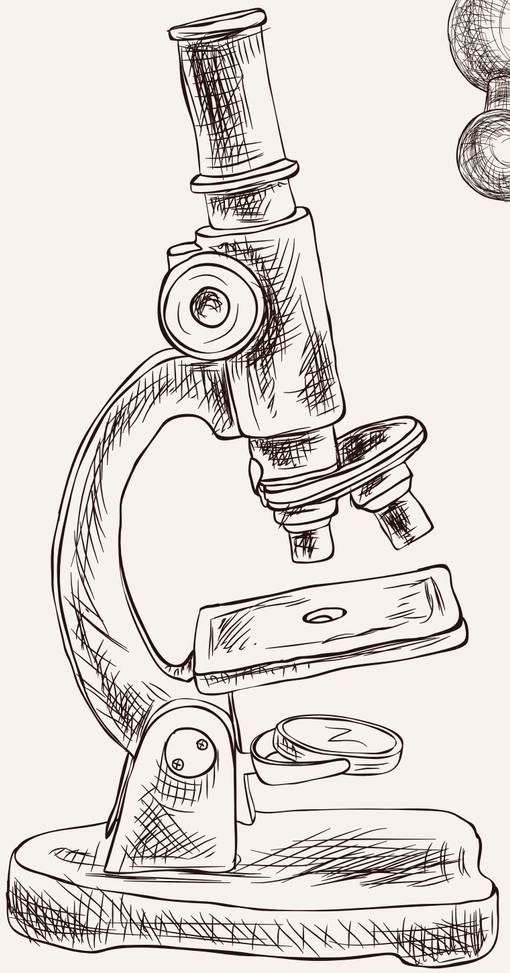


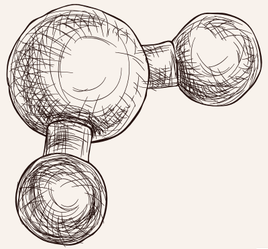
RAMAN SPECTROSCOPY

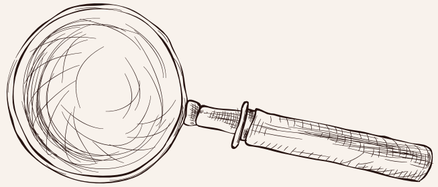
The first-order transverse optic (TO) of Si Raman spectra of 20-s electroplated SiNW arrays is observed at 517.2 cm- and a very small second-order Si-TO peak at around 987.5 cm -1. Raman peak at 517 cm-l indicated crystalline SiNWs with tailing toward redshift due to Fano effect. Fano effect is the interference between the background and resonance scattering process observed by Raman spectra, due to which the asymmetric line shapes are observed at lower wave number side.

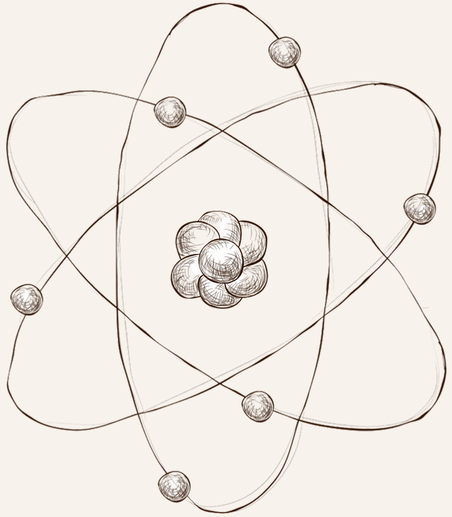


Raman spectra for 20-, 30- and 60-s Ag electroplated and etched SiNWs









Thank you!

Do you have any questions?

sorry for not giving any answers