

2019

High Impact
Technology
Exchange
Conference



MNT Education Special Interest Group (MNT^eSIG)

July 23, 2019

Online Visualization and Simulation Tools for Nanotechnology Education

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MNT^eSIG

MICRO NANO TECHNOLOGY
education
SPECIAL INTEREST GROUP



Exponential Convergence of Nanotechnology, Robotics and Artificial Intelligence (AI)



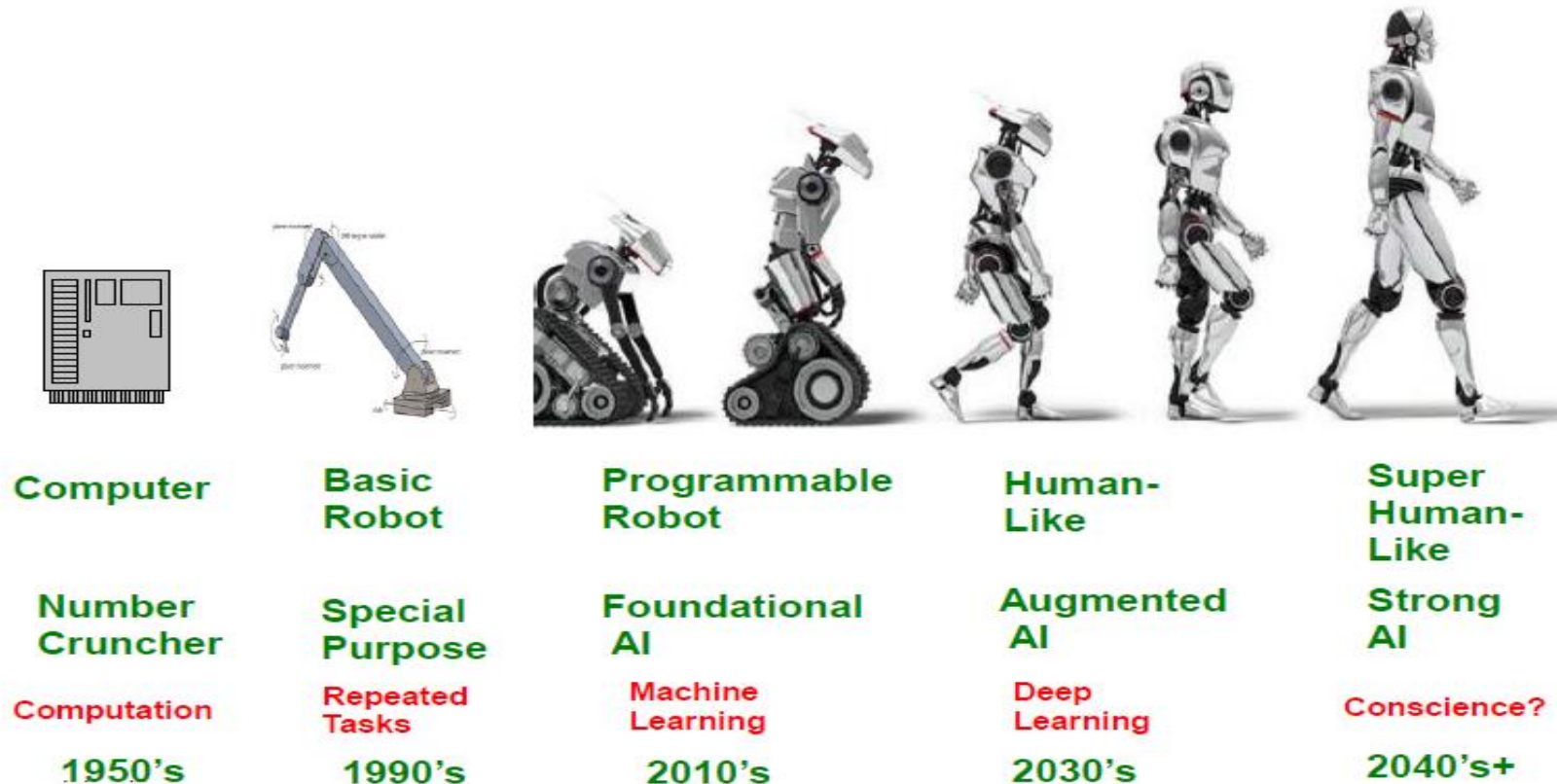
2019

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Exponential Convergence of Nanotechnology, Robotics and Artificial Intelligence (AI)

Modern AI Theory of Evolution

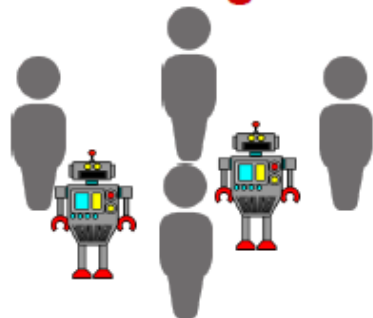


2019

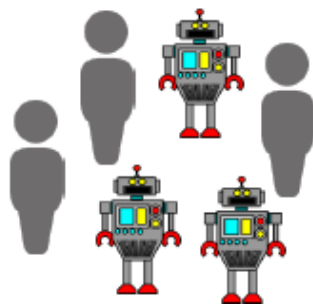
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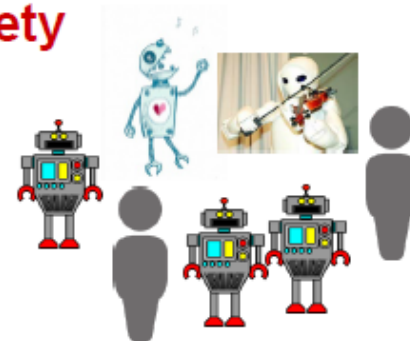
An Integrated Human and Robot Society



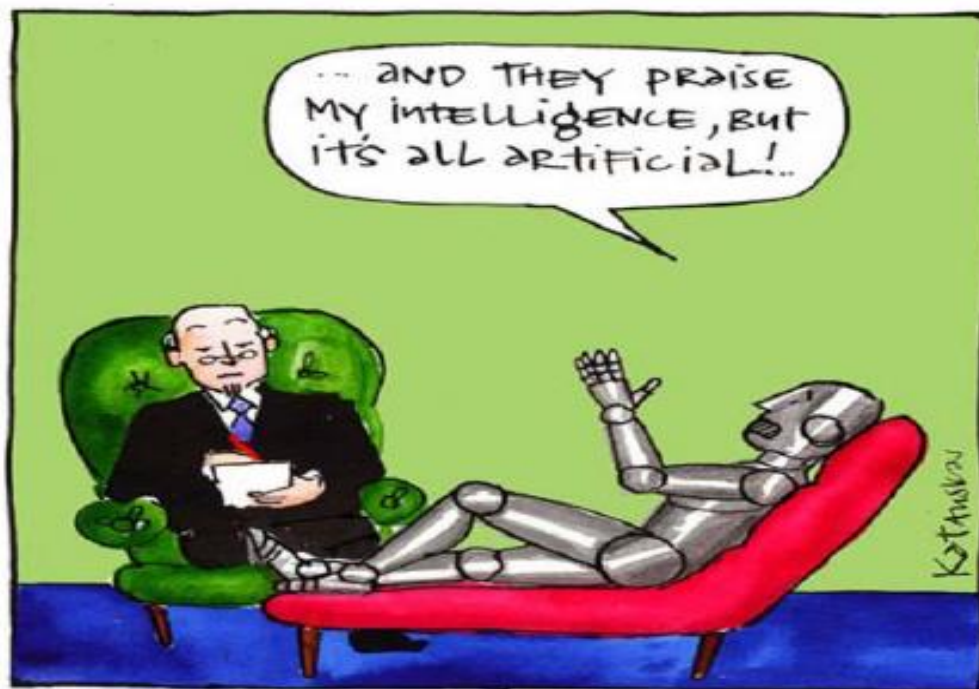
Manager



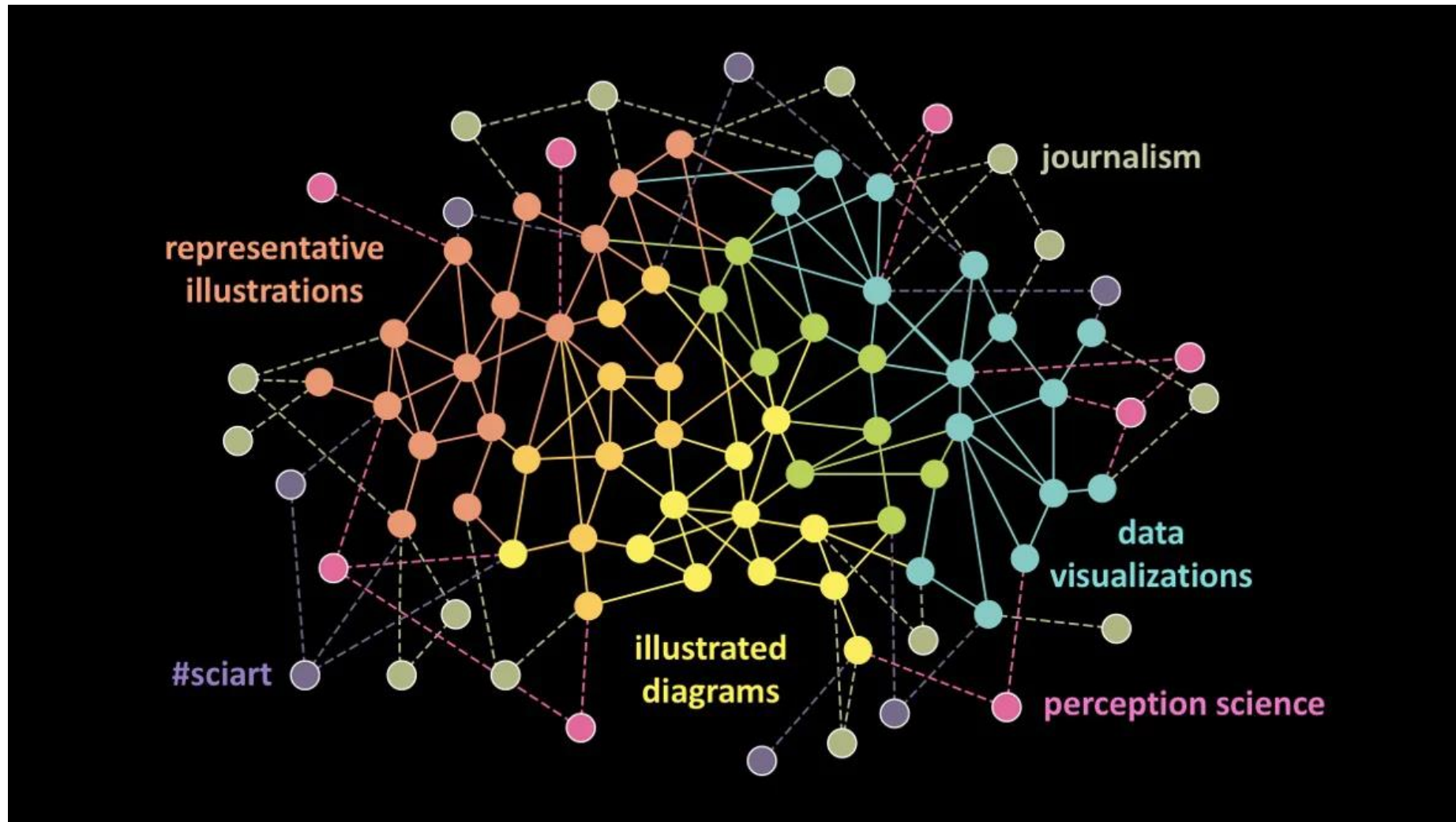
A Party



Entertainment



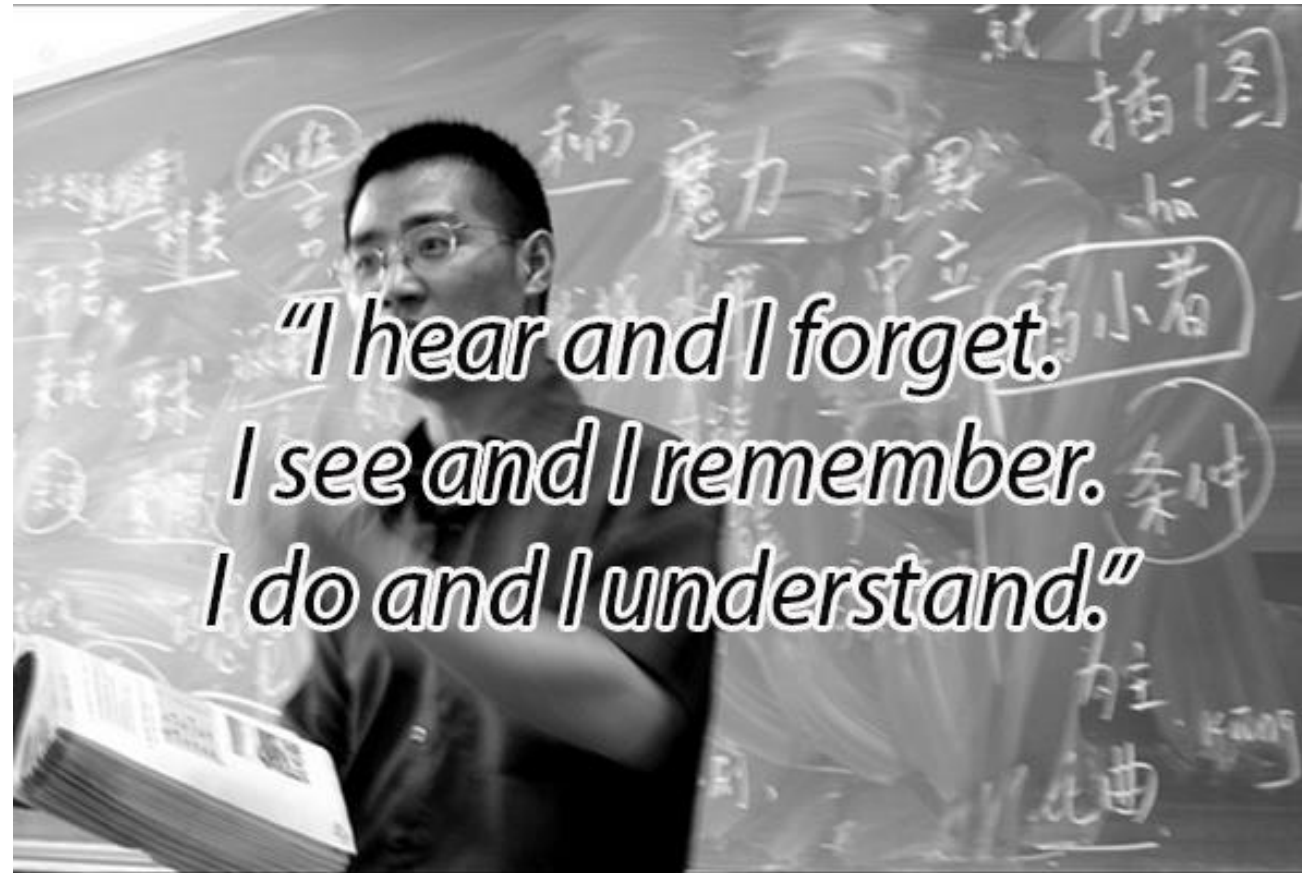
Visualization and Simulation



<https://blogs.scientificamerican.com/sa-visual/visualizing-science-illustration-and-beyond/>

2019

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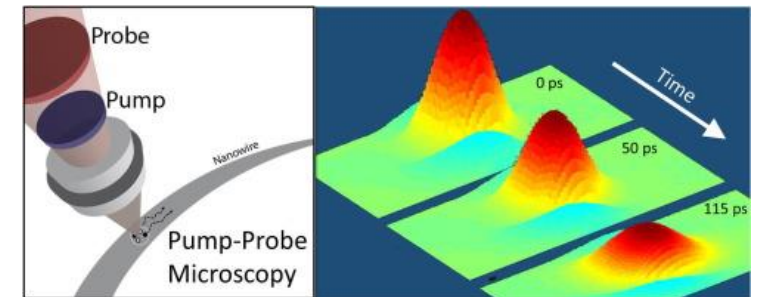
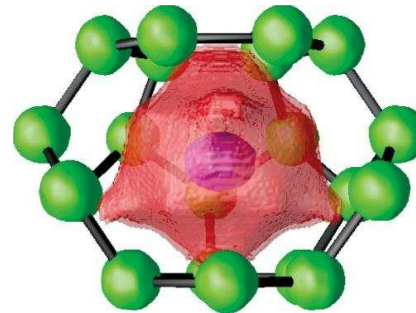
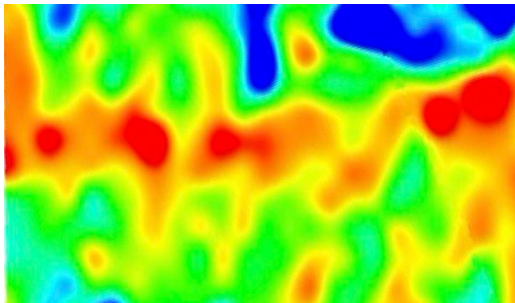


Visualization and Simulation

“The purpose of computing is insight, not numbers.”

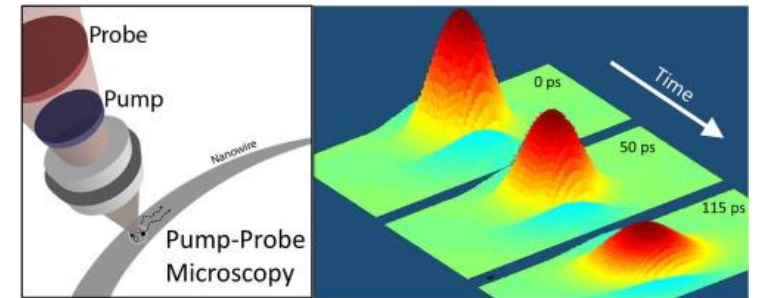
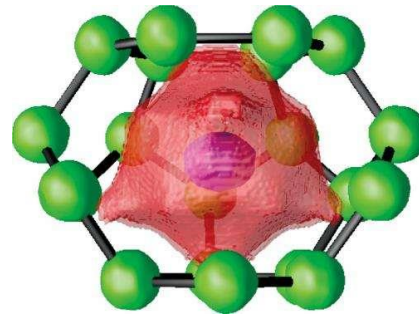
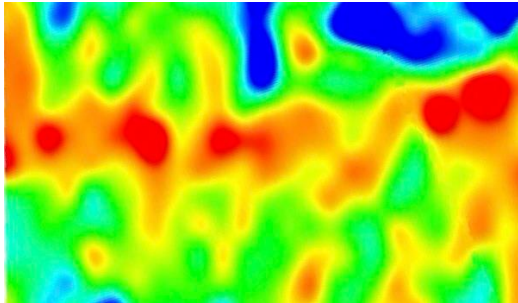
--- R. W. Hamming

- Simulations are recognized as an efficient and effective way of teaching complex and dynamic engineering systems.
- A simulation-based teaching environment enables students to acquire experience and consider their previous results.
- Simulation has been shown to be effective in improving teaching and learning of various subjects.
- By reducing practical learning time for students, and for schools and programs, simulation reduces costs for practice oriented educational methodology.



Visualization and Simulation

- The advantages of using engineering and technology simulation-based training also include reducing the gap between the learning environment and the "real" environment and making available training "real world" situations that are difficult to simulate in a hands-on lab.
- Traditionally for teaching technology-based courses, laboratory experiments were offered using a hands-on approach.

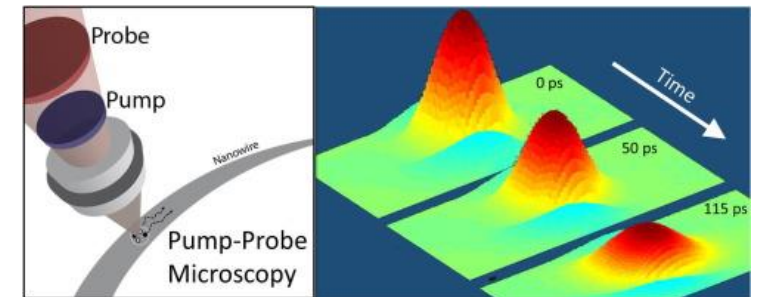
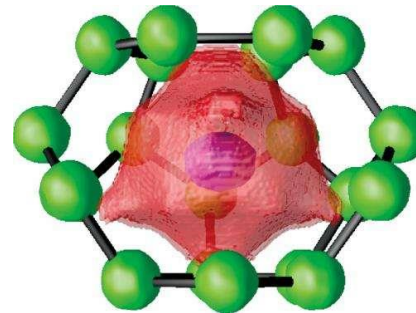
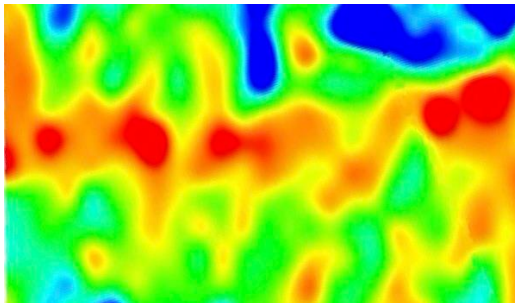


Visualization and Simulation at the Nanoscale

- Visualization plays an important role in the modern scientific process.
- Visualization of processes can be achieved by using laboratory instruments, online simulation and remote access instruments.

Online Methods of Visualizations and Simulation at the Nanoscale:

- Remote Accessible Instruments for Nanotechnology (RAIN)
- NoanoHUB: www.nanohub.org

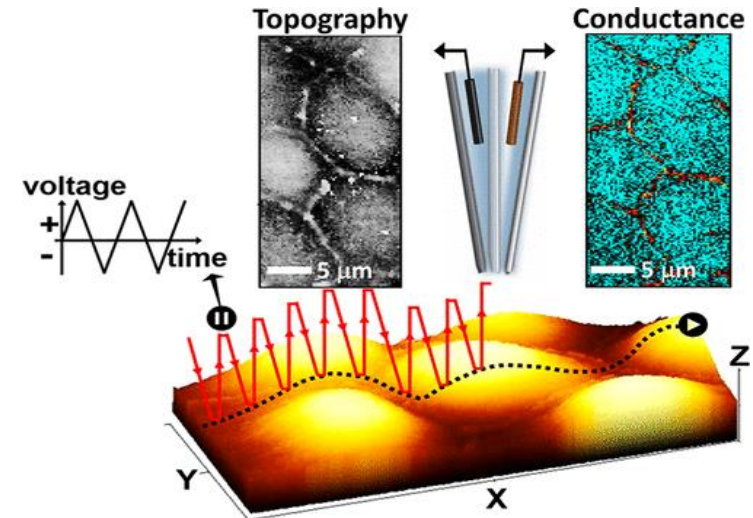
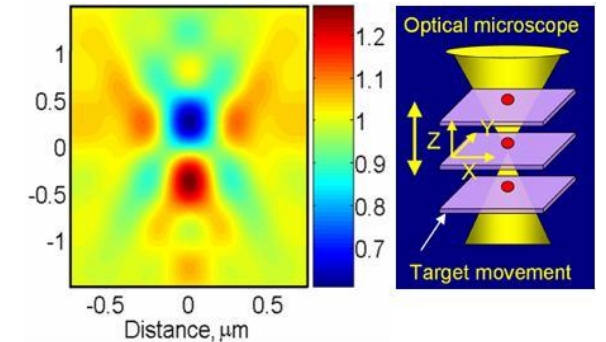
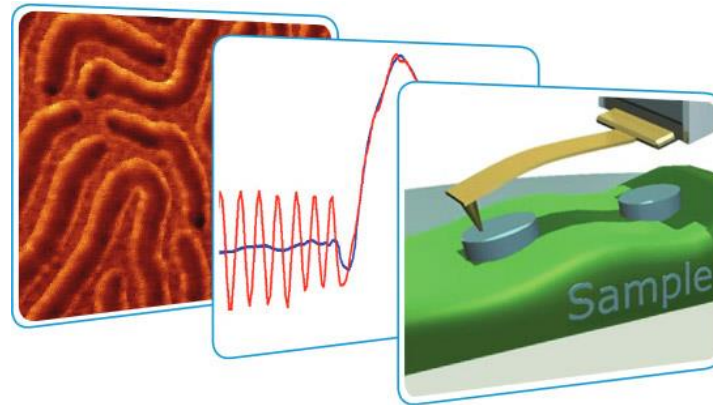
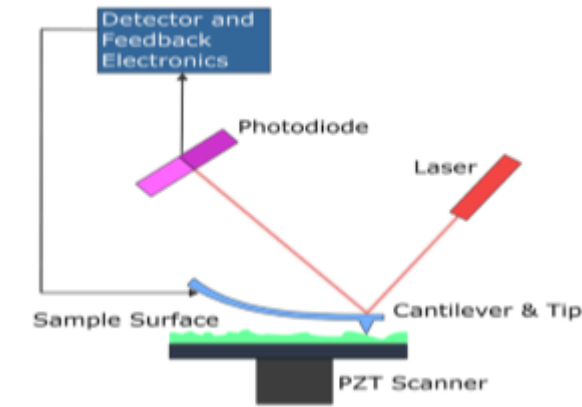


Learning through Visualization and Simulation at the Nanoscale

Remote Accessible Instruments for Nanotechnology (RAIN): Types of Tools

RAIN allows students to access and control microscopes and analytical tools, to look at nanosized materials from the ease of classrooms, or home computers, all across the country. Students control the tools over the Internet from 19 centers in real-time.

- Atomic Force Microscope (AFM)
- Optical Microscope
- Confocal Microscope
- Scanning Electron Microscope (SEM)
- Energy Dispersive Spectroscopy (EDS)
- Profilometer
- Ultraviolet–visible Spectrophotometer
- Molecular Analyzer
- Fourier Transform Infrared Spectroscopy (FTIR)
- X-ray fluorescence (XRF)
- Fabrication Tools



RAIN Network Partner Locations



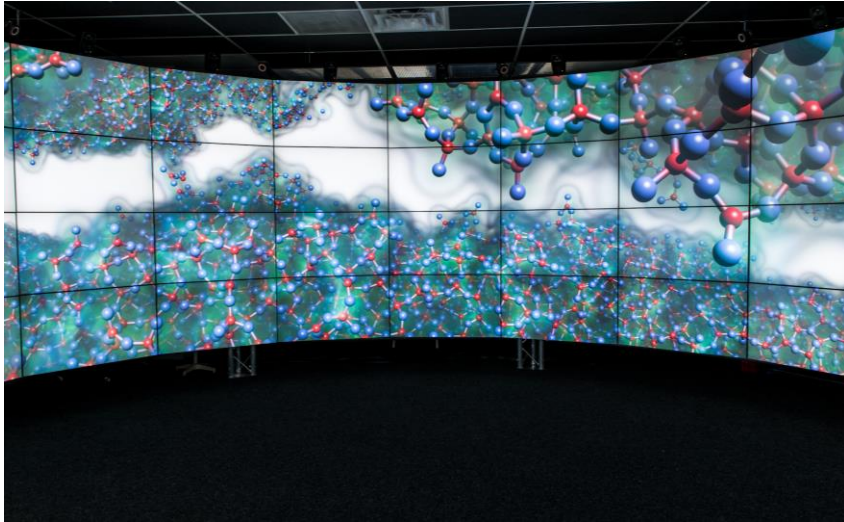
RAIN Network Instruments

nano4me.org/remoteaccess

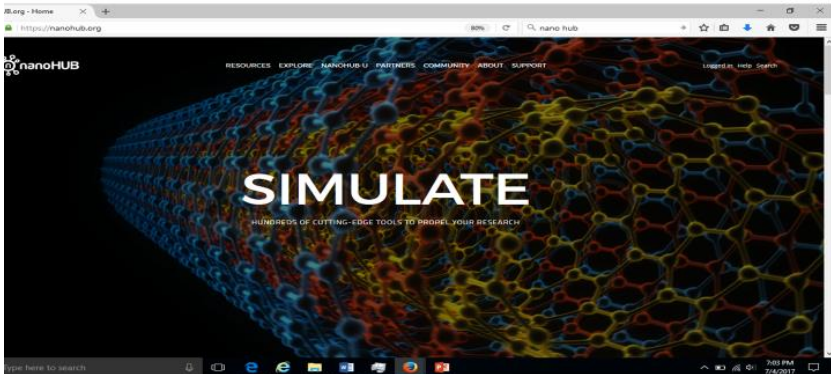
RAIN Site	Remote Access Instruments
Arizona State University	SEM
Erie Community College	SEM/EDS
Forsythe Tech Community College	AFM
Northcentral Technical College	SEM, AFM, Flex AFM
North Seattle College	Confocal Microscope, AFM, Profilometer, SEM/EDS
Oakton Community College	SEM/EDS, Flex AFM, Profilometer
Pasadena City College	SEM/EDS
Pennsylvania State University	FESEM/EDS, SPM/AFM, Profilometer, UV-vis
Salt Lake Community College	SEM, AFM/SPM
University of Texas at San Antonio	SEM/EDS

Source: Dr. Cakmak, Penn State





Crystal Viewer Tool
[Nanohub.org](https://nanohub.org)



Learning through Visualization and Simulation at the Nanoscale

Simulation

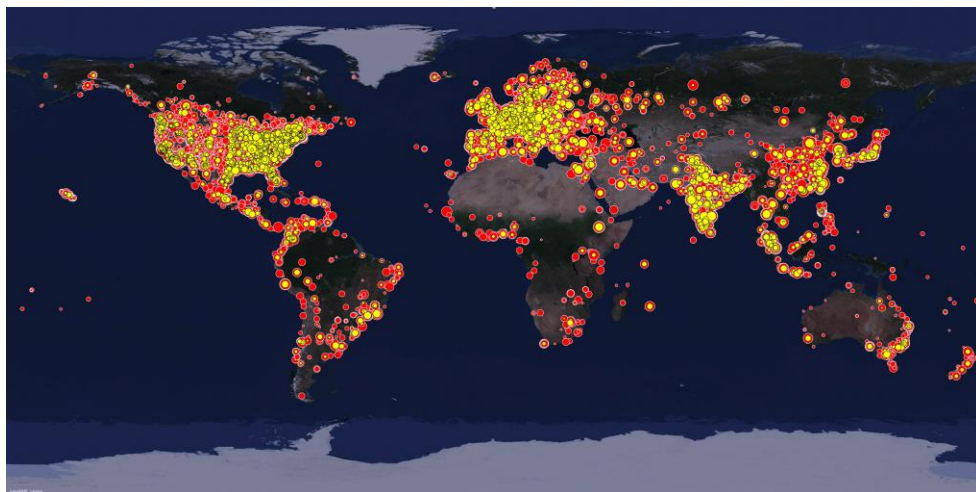
Simulation offers a number of other advantages

(a) allowing the user to modify system parameters and observe the outcomes without any harmful side effects

(b) eliminating component or equipment faults that affect outcomes

(c) supporting users progress at their own pace in discovery and understanding of concepts and issues,

and (d) enhancing the presentation of “dry” concepts by integrating theory and practice



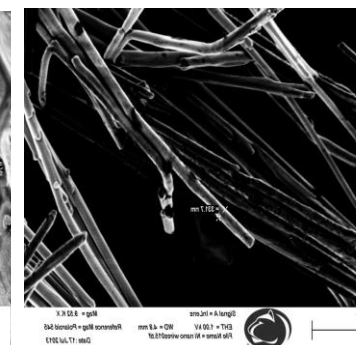
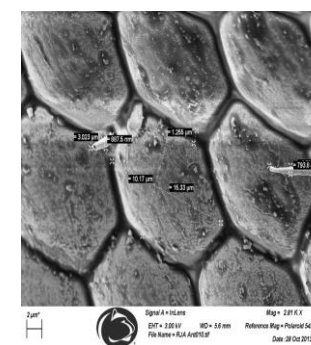
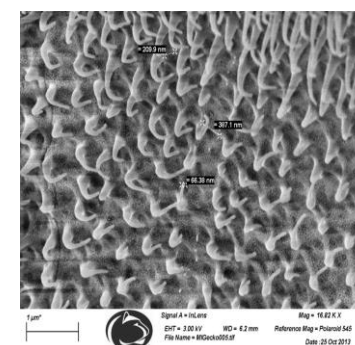
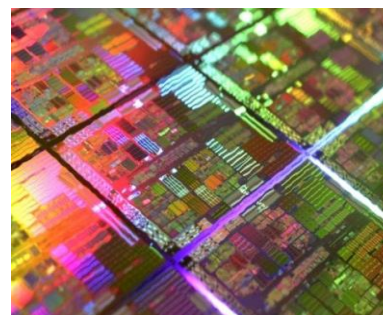
Crystal Viewer Tool
Nanohub.org



Learning through Visualization and Simulation at the Nanoscale Nanohub.org



- Computing Cloud located at Purdue University
- 500+ simulation tools
- 1.4 million users Worldwide
- 5500 resources





SIMULATE

explore the powerful tools at your fingertips

Workspace

Development workspace

nanoDDSCAT

Calculate scattering and absorption of light by targets with arbitrary geometries and complex refractive index.

Crystal Viewer Tool

Visualize different crystal lattices and planes

MOSFet

Simulates the current-voltage characteristics for bulk, SOI, and double-gate Field Effect Transistors (FETs)



Type here to search

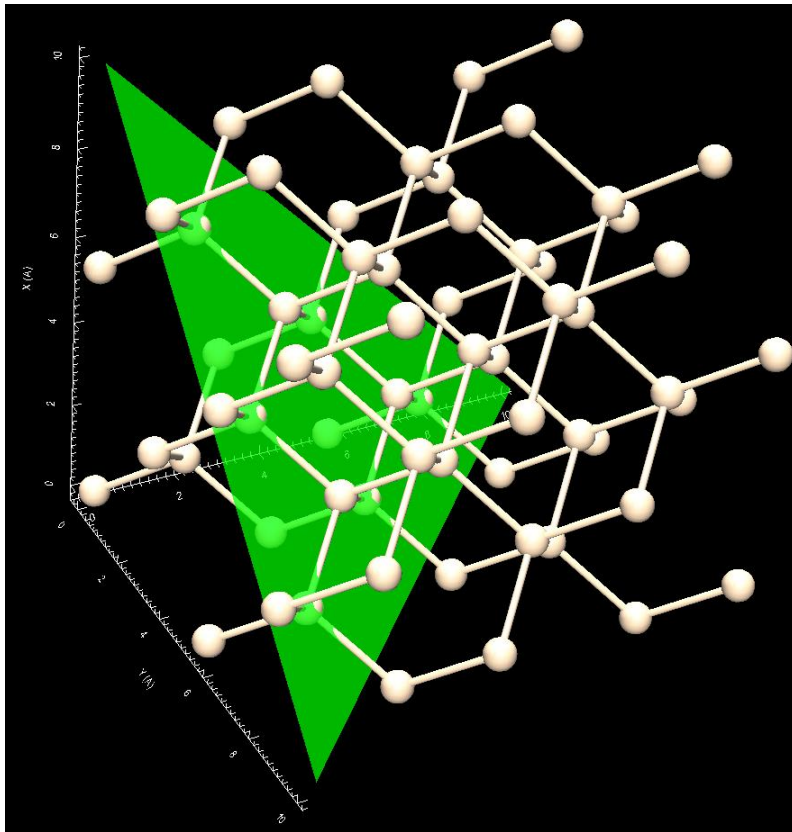


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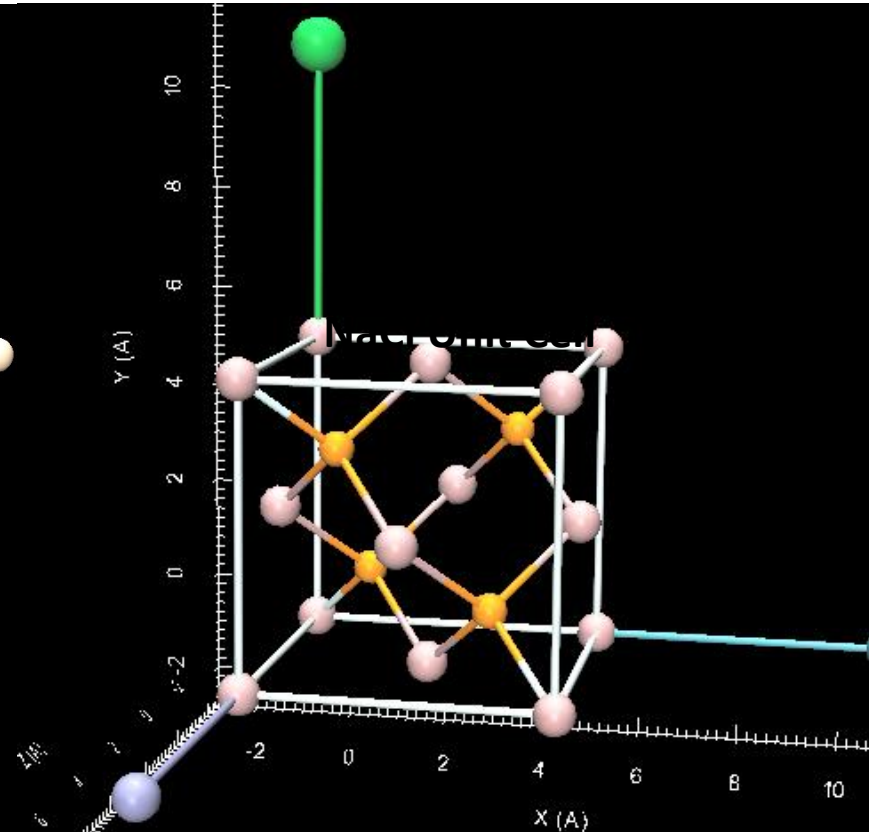


The Crystal Viewer simulation tool allows:

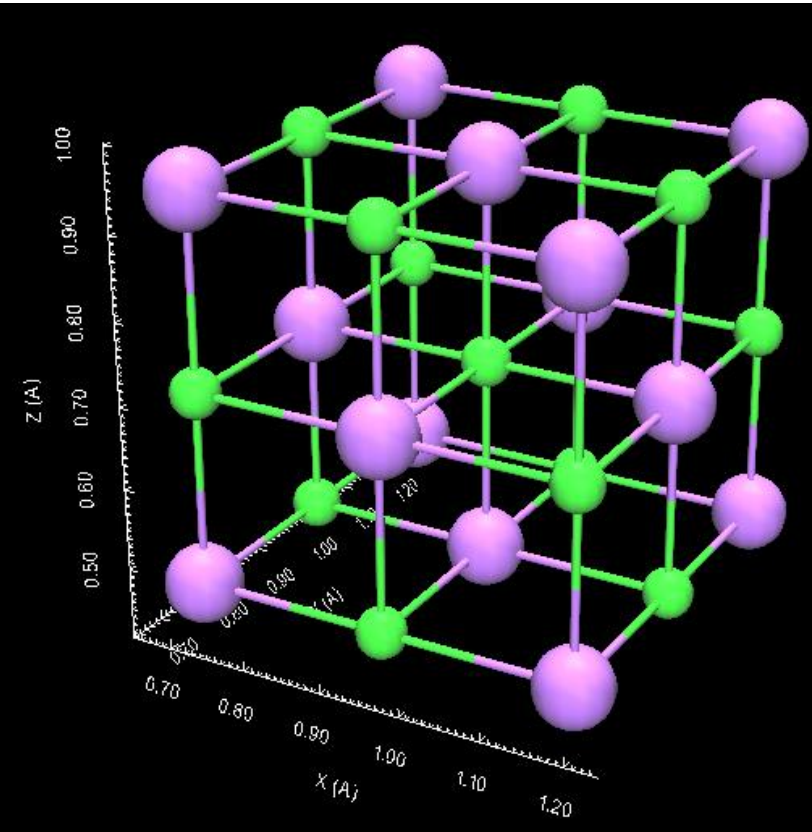
- (a) viewing all materials which have periodical structure
- (b) building crystal structure even not exists in nature



Silicon With Miller Plane

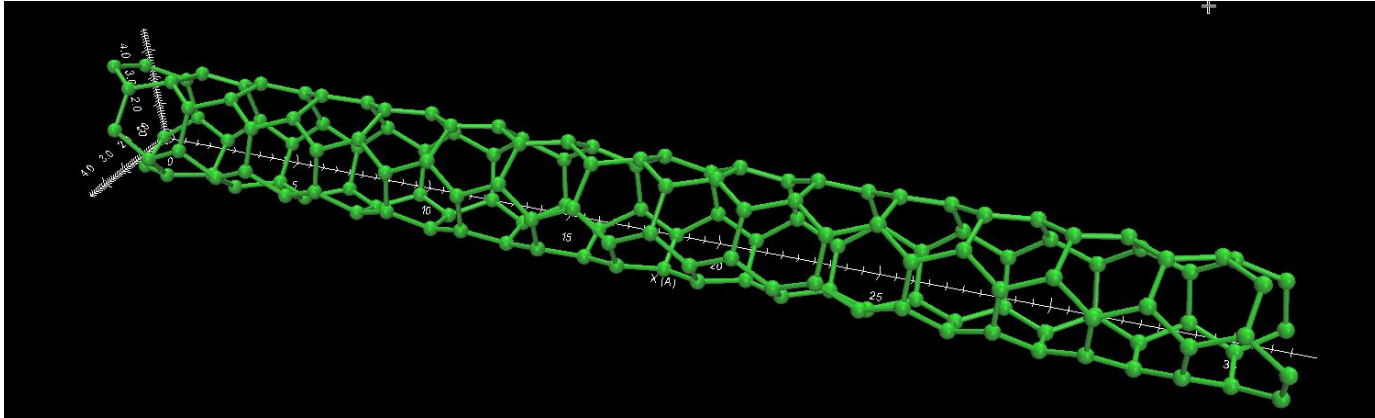


GaP Unit Cell

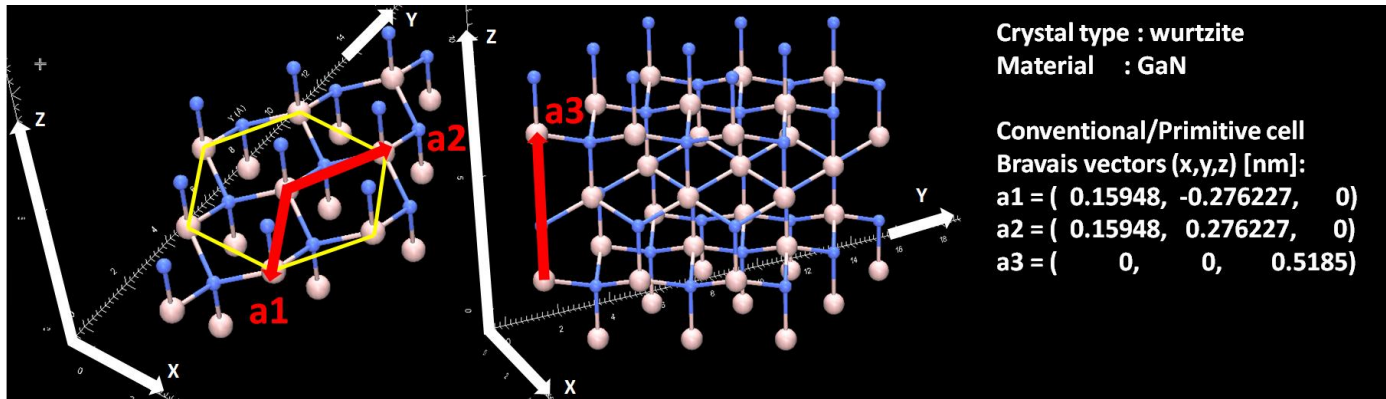


NaCl Unit Cell

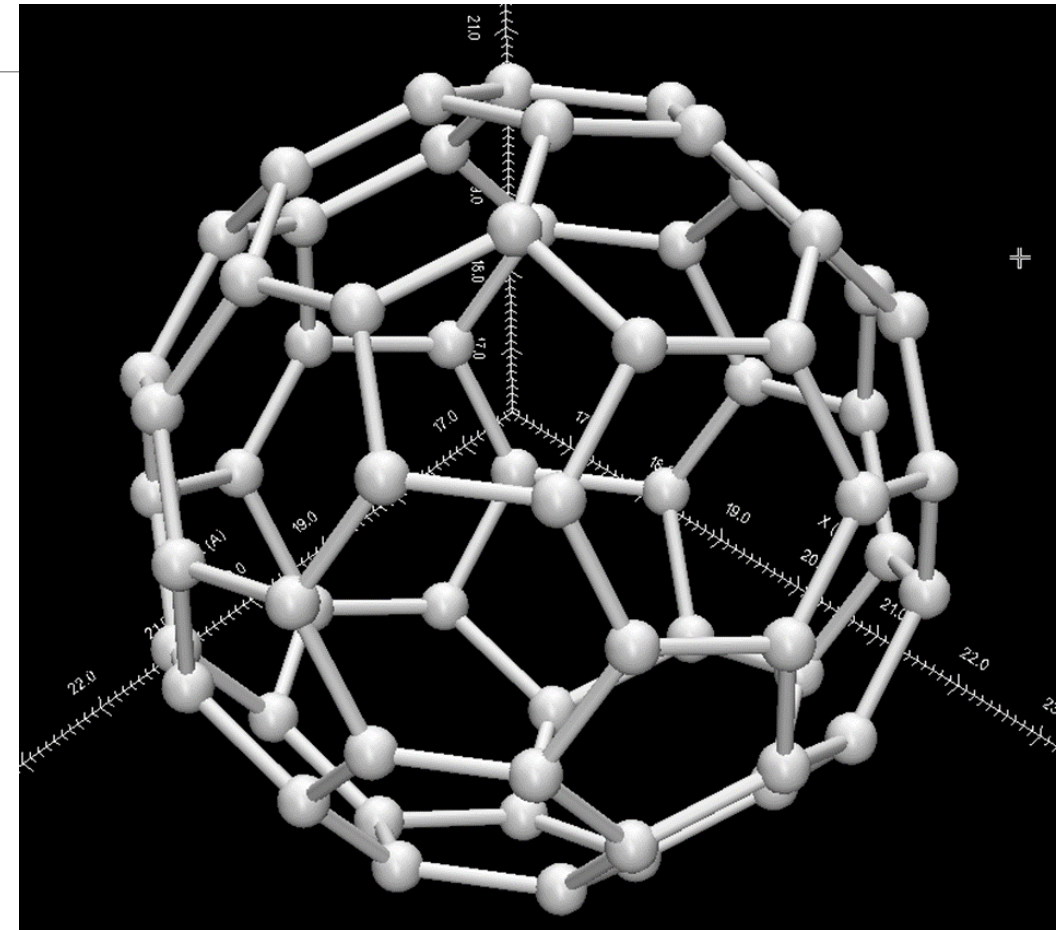
Examples of Nano Structure Visualization



Carbon nano tube



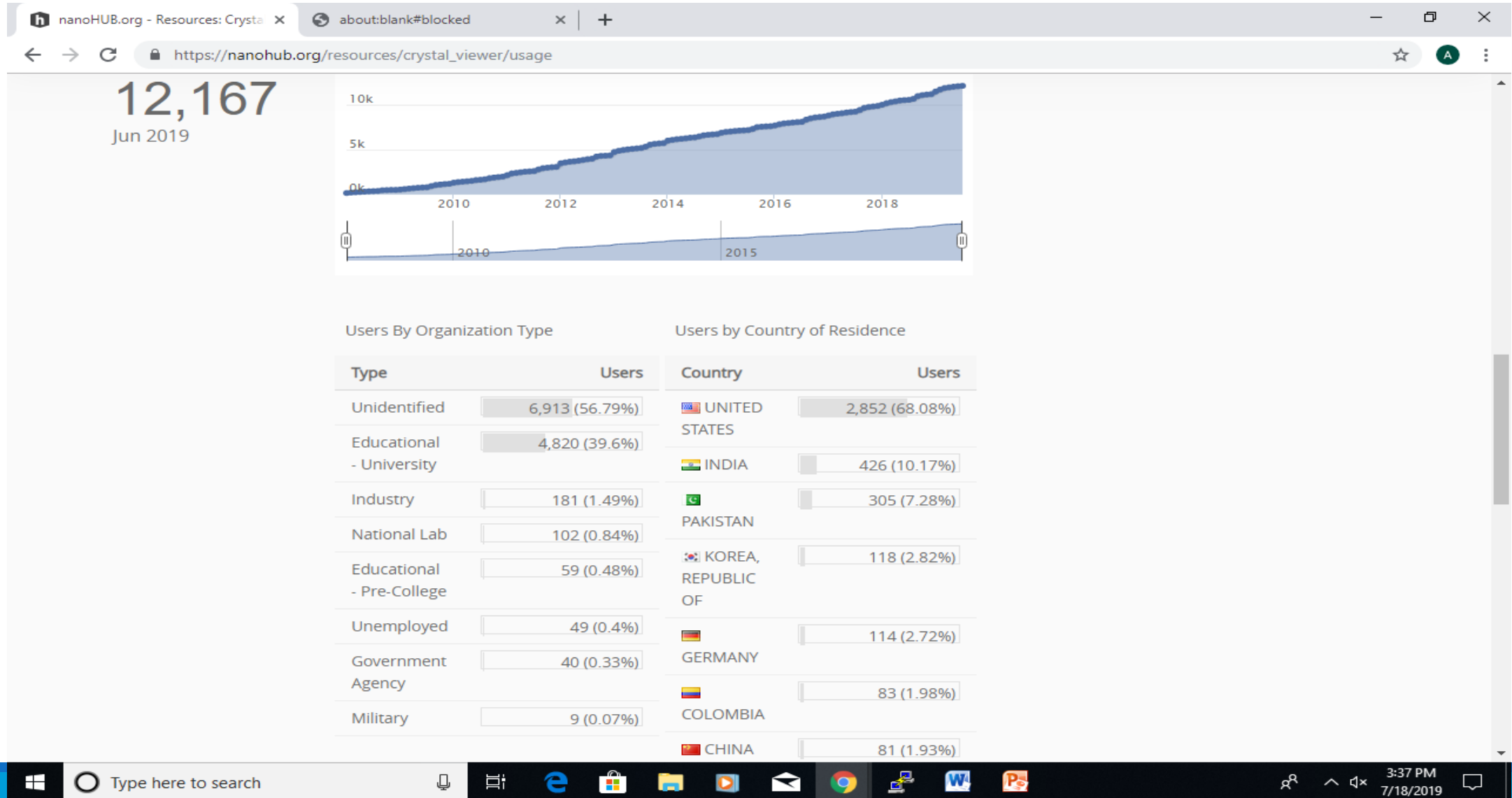
GaN Bravais Vectors



Buckey Ball

Crystal Viewer

Worldwide Usage



NanoDDSCAT

Calculate scattering and absorption of light with arbitrary geometry and complex Refractive Index

1. Target

nanoHUB.org - Resources: Tools: x Inbox (47) - ahmed.khan@tbiil.e x 401 Authorization Required x +

https://nanohub.org/tools/dda/session?sess=1503582

1 Target → 2 Spectrum Calculation → 3 Field → 4 Process → 5 Simulate

Cylinder Axis Orientation

$$SHPAR3 = \begin{cases} 1 & x - \text{axis} \\ 2 & y - \text{axis} \\ 3 & z - \text{axis} \end{cases}$$

Cylinder Axis Orientation Diagram: A 3D coordinate system with x (red), y (blue), and z (green) axes is shown. A yellow cylinder is oriented along the x-axis. The cylinder's length is labeled SHPAR1, its radius is labeled SHPAR2, and its axis is labeled "Cylinder Axis".

Shape of Nanosystem

Select Shape File: 6. Cylinder

Shape Parameters (nm)

SHPAR1:	16
SHPAR2:	16
SHPAR3:	1
SHPAR4:	0
SHPAR5:	0
SHPAR6:	0

Dipoles per (nm): 1

Target Rotations

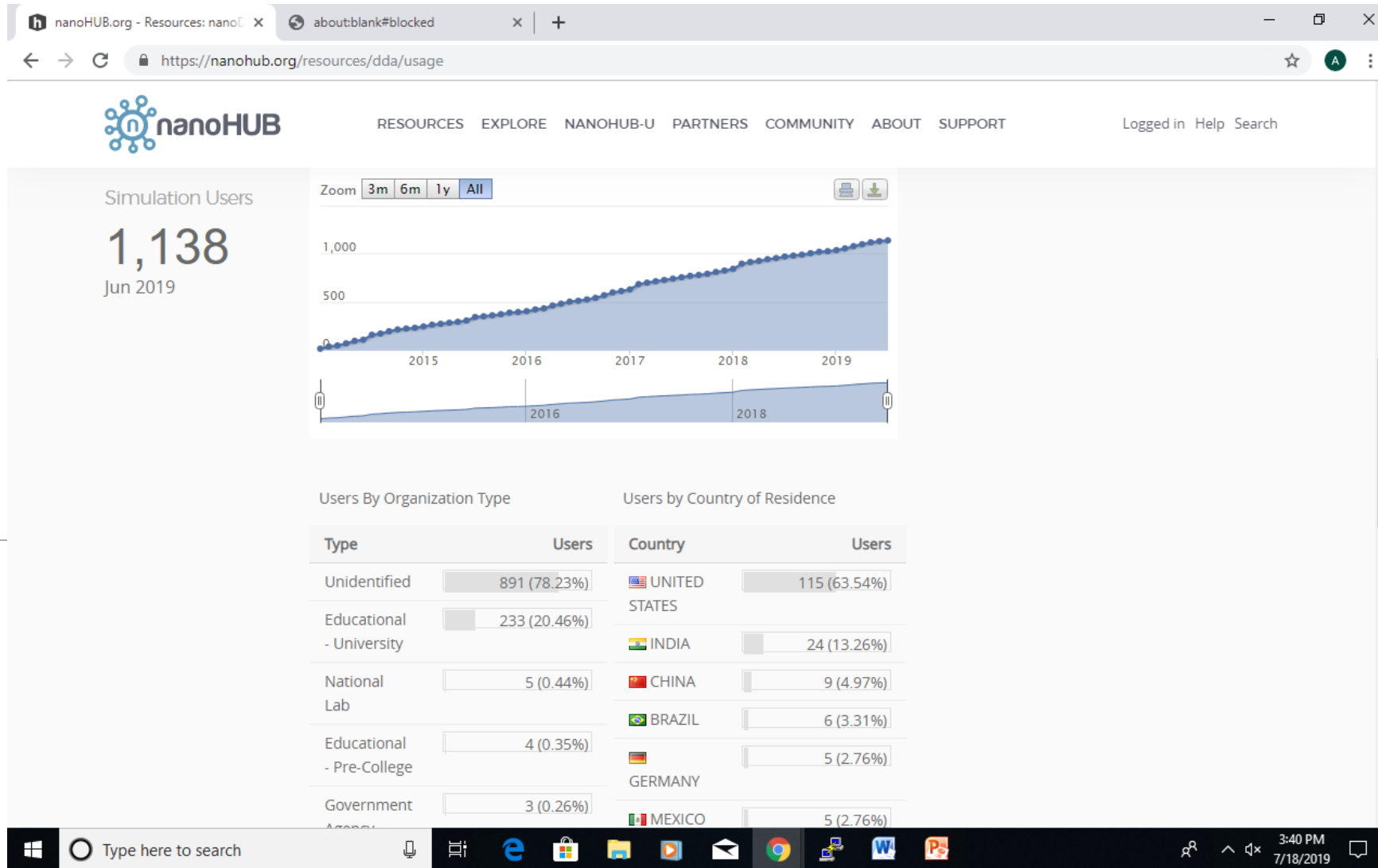
Rotation around X-axis | Rotation around Y-axis | Rotation around Z-axis

Type here to search

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NanoDDSCAT

Worldwide Usage

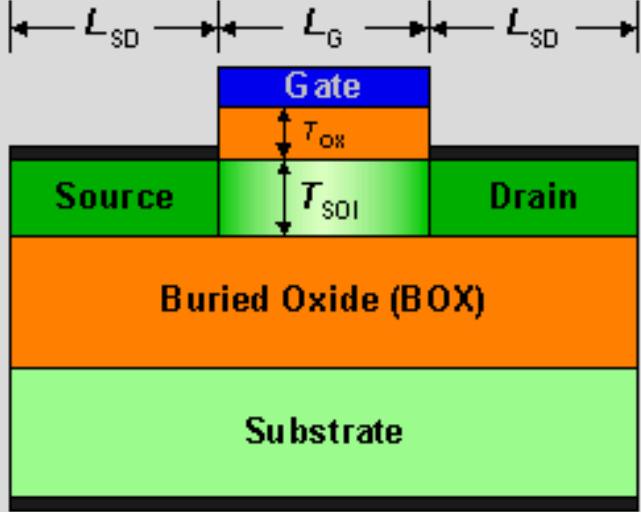


MOSFeT

Simulate the current-voltage characteristics for Bulk, SOI, and double-gate Field Effect Transistors (FETs)

Substrate Nodes:

Device Width:



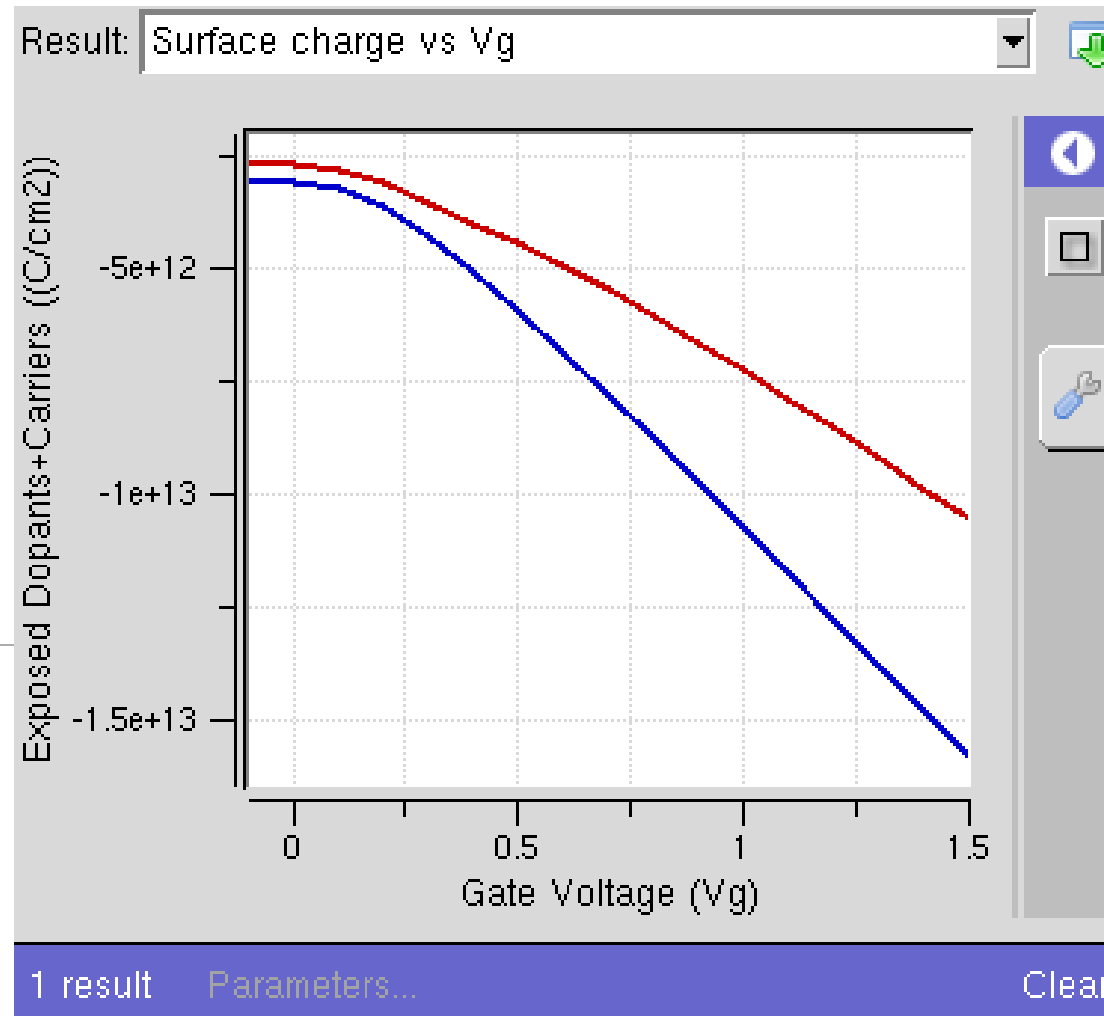
Source/Drain Doping Concentration:

Channel Doping Concentration:

Substrate Doping Concentration:

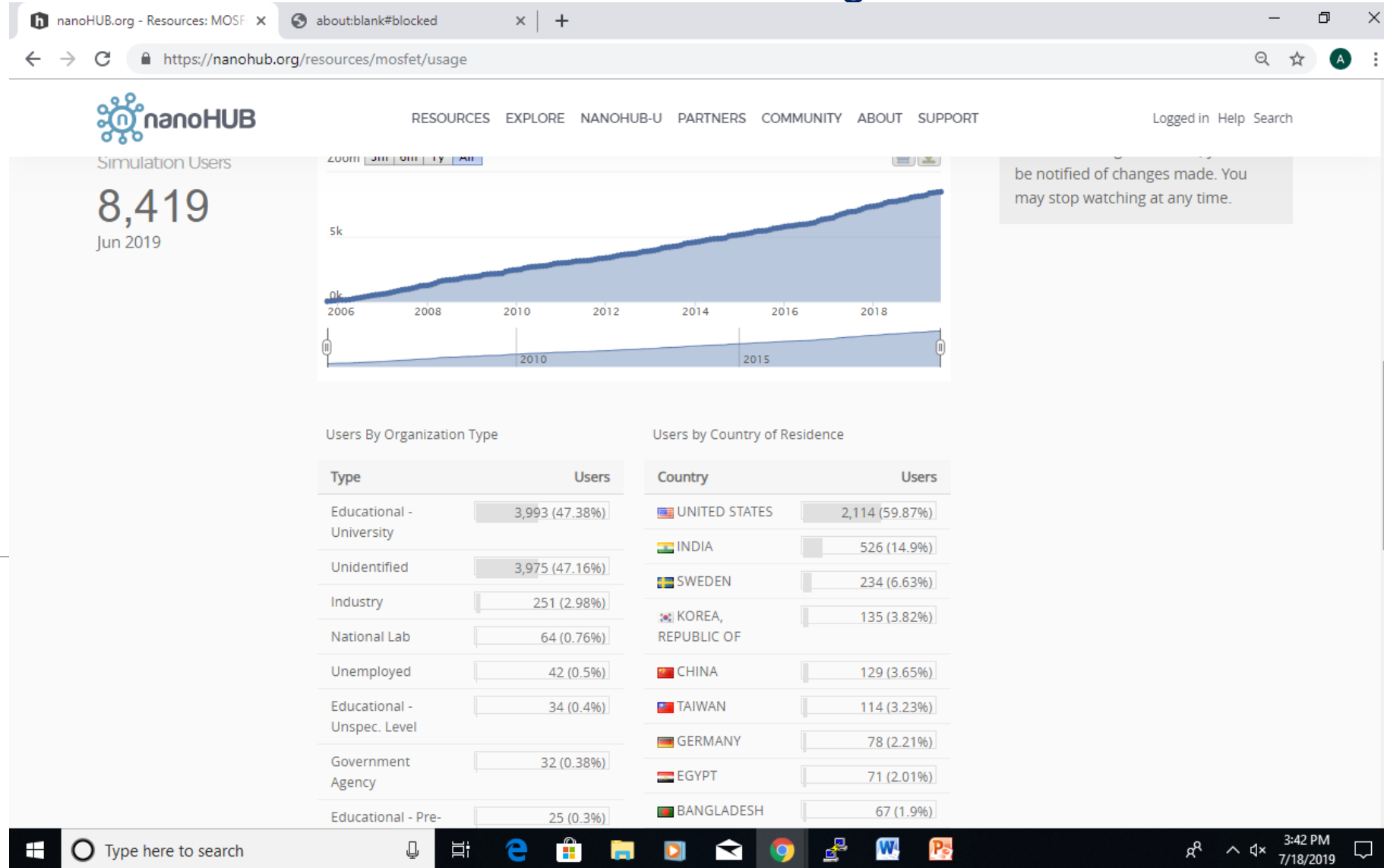
MOSFeT

Simulate the current-voltage characteristics for Bulk, SOI, and double-gate Field Effect Transistors (FETs)



MOSFeT

Worldwide Usage



Online Visualization and Simulation Tools for Nanotechnology Education

Target Audience & Curricula

Targeted Students

- 4 year degree program in engineering and engineering technology
- 2 year Associate degree in engineering and engineering technology
- K-12

Suggested Courses

- Introduction to Nanotechnology
- Introduction to Semiconductor Manufacturing
- Material Science
- STEM courses
- Undergraduate research and Independent study
- Micro electro mechanical systems (MEMS)



Online Visualization and Simulation Tools for Nanotechnology Education

Conclusion

- Enhanced teaching/learning of nanoscale phenomena
- Enrichment of STEM component
- Supporting the Nanotechnology Workforce development
- NanoHUB is an excellent simulation tool for introducing and analyzing nanotechnology phenomena at all educational levels at no cost.
- RAIN provides free online remote access to real world Nanotechnology tools.



References

1. Salahuddin Qazi, and Robert Decker, “ Visualization of Nanoscale Components Using Atomic Force Microscopy” Proceeding of the ASEE (American Society of Engineering Education) Annual Conference and Exposition, San Antonio, Texas. June 2012.
2. Salahuddin Qazi and Robert Decker, “Visualization and Manipulation of Nanoscale Components Instruction for Engineering Technology Students,” Proceeding of the 2011 ASEE Annual Conference and Exposition, Vancouver, B.C., Canada June 2011.
3. Salahuddin Qazi and Robert Decker, “Instructional Laboratory For Visualization and Manipulation of Nanoscale Components Using Low Cost Atomic Force Microscopes, Proceeding Of ASEE Annual Conference, Louisville, Kentucky, June 2010.
4. Tanya Faltens, “Simulation-Based Activities for Nanotechnology Education on nano HUB , <http://mnt-conference.net/downloadpresentaions.html>
5. Material modifications for nanotechnology application and characterization, testing of nanotechnology structures and materials Nanotechnology Applications & career knowledge, October 2010. WWW.Nano4me.org
6. Remote Accessible Instruments for Nanotechnology (RAIN) <http://www.nano4me.org/remote> access
7. nanoHUB nanoHUB.org https://nanohub.org/resourcescrystal_viewer
8. <https://www.facebook.com/nanotechnology.rain>
9. <https://nanohub.org/search/?terms=nano+visualization+tools>
10. Cherner, Y., & Khan, A. S., & Karim, A., & Mullett, G. J., (2011, June). Use of Adaptable Simulation-based Virtual Laboratories for Teaching Alternative Energy and Energy Conservation in Engineering & Technology Programs Paper presented at *2011 ASEE Annual Conference & Exposition, Vancouver, BC, Canada*.
11. Khan, Ahmed S. (2012). *Nanotechnology: Ethical and Social Implications*, CRC Press, Boca Raton, FL. pp.313-317.

Acknowledgement

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Thanks....Any Comments...Questions?

*To know what you know and what you do not know, that is true knowledge.
--- Confucius*

*The art of knowing is knowing what to ignore.
--- Rumi*

