



## Classroom Lesson Development

(to be posted on website)

Title of Lesson **Chemistry of Nanomaterials**

RET Project Connection Center for Microwave Magnetic Materials and Integrated Circuits

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School The Winsor School

Town/District Boston, MA

Subject(s) taught Chemistry

Subjects covered in lesson Nanomaterials: Chemistry, Fabrication and Applications

Grades appropriate Grades 10-12

Lesson duration Three weeks

Goals/Objectives of lesson To help students understand the chemical and physical properties of nanomaterials, the fabrication process and the applications the nanomaterials are designed for.

Background information Pre-reading references, in-class handouts and various scientific articles will be provided

Essential questions What are thin-film, nanowires and nanoparticles? How are they made? What are they used for?

### Links to Frameworks and Standards

National Content Standard A  
Ability necessary to do scientific inquiry  
Understandings about scientific inquiry  
Content Standard B  
Structure of atoms  
Structure and properties of matter  
Chemical Reactions  
Interactions of Energy and Matter

State Content Standards

#3 Periodicity 3.3-3.4

#4 Chemical Bonding 4.4-4.6

#5 Chemical Reactions and Stoichiometry 5.1-5.5

#8 Acids-Bases and Oxidation-Reduction Reactions 8.1-8.4

Scientific Inquiry Skills Standards

SIS1 Make observations, raise questions and formulate hypothesis

SIS2 Design and Conduct Scientific Investigation

SIS3 Analyze and interpret results of scientific investigation

SIS4 Communicate and apply the results of scientific investigations

Mathematical Skills

Construct and use tables and graphs to interpret data

Solve simple algebraic questions

Perform basic statistical procedures to analyze center and spread of data.

Measure with accuracy and precision.

Convert within a unit.

Use common prefixes.

Use scientific notation.

Use ratio and proportion to solve problems

Local AP Chemistry:

1. The chemical elements are fundamental building materials of matter, and all matter can be understood in terms of arrangements of atoms that always retain their identity.
2. Chemical and physical properties of materials can be explained by the structure and arrangement of atoms, ions or molecules and the forces between them.
3. Changes in matter involve the rearrangement and/or reorganization of atoms and/or transfer of electrons

Materials required Materials:

Microscope cover slips used as glass substrates ( Fischer Scientific, 18 mm x 18 mm)  
Whatman Anodisc 47  
Sodium nitrite (Fluka Chemicals)  
Sodium acetate (Sigma Chemicals)  
Nickel(II) chloride hexahydrate (Sigma-Aldrich Chemicals)  
Iron(II) chloride, anhydrous 99.99 % (Alfa Aesar)  
Zinc chloride (Aldrich Chemicals)  
Cobalt (II) chloride (Aldrich Chemicals)  
Gallium-Indium Eutectic Mixture(Sigma-Aldrich Chemicals)  
N<sub>2</sub>(g)  
Distilled water  
Acetone  
95% ethanol/5% methanol  
1.0 M NaOH  
37% HCl  
70% HNO<sub>3</sub>  
ferrofluid

Equipment:

Spin-sprayer (spin rate=145 rpm; 90°C)  
pH meter  
Sonicator  
Magnetic Stirrer  
Electronic balance  
Diamond cutter for cutting the substrates to the desired size

Lesson development 1. Pre-reading:

Nanotechnology by Mark Ratner and Daniel Ratner  
Video Homework 1: "What is nanotechnology?"  
Video Homework 2: "The Power of small."

2. Peer-Led Laboratory Experiment Discussion

Creating Models of Ferrite Crystal Lattice  
Preparing thin-films and nanowires  
Fingerprinting using Xray Diffraction Patterns  
Magnetic Properties of Thin-films

3. Scientific Paper Research Presentation

Design a nanomaterial for a specific application.

- References
- 1.Liu, M., Obi, O, Lou, J., Stoute, S., Huang, J.Y., Cai, Z., Ziemer, K. and Sun, N. (2008) Applied Phys Lett 92, 152504.
  - 2.Matsushita, N., Nakamura, T and Abe, M. (2002) IEEE Transactions on Magnetics, 38, 5, 3111-3113.
  - 3.Jing, Y., Zhang, H., Jia, I., Shi, Y. and Liu, Y. (2004) J Mater Sci Technol, 20, 1, 35-37.
  - 4.Liu, M., Lagdani, J., Imrane, H., Pettiford, C., Lou, J., Yoon, S., Harris, V.G., Vittoria, C. and Sun, N. (2007) Appl Phys Lett, 90, 103105.
  - 5.Abe, M. (2000) Electrochimica Acta, 45, 3337-3343.
  - 6.Hai, T.H., Van, H.T.B., Phong, T.C. and Abe, M. (2003) Physica B, 327, 194-197.
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