

# Green Chemistry : A Scalable Project From Math to MEMS

For High School to Frosh Students

# Rationale-Green Chemistry

- *Green Chemistry/Chemical Engineering* can be defined as the design of products and processes that minimize the use and generation of hazardous substances
- The MEMS device under study has a chemo-selective surface coating that detects and adsorbs NO<sub>x</sub> gases
- NO<sub>x</sub> gases are pollutants: Nitrogen Oxide gases contribute to the “greenhouse effect”
- At the title indicates, this project study uses modeling/mathematical analysis to predict/identify NO<sub>x</sub> releases within the MEMS device parameters

# From the Title to the Topics

- Scalable-this project can be taught at the high school through frosh level
- Project-This is a project-based learning endeavor using the “guided inquiry” approach
- Mathematics-modeling is used for analysis; based on its importance in atmospheric chemistry-applicable equations are studied for use in this project.
- MEMS-a micro-electromechanical systems sensor developed using micro-fabrication techniques (in this case to detect and remove NO<sub>x</sub> gases).

# Scalable

- Each primary component covers topics as they would be developed in high school courses or taught in the Frosh year
- Graphic art and design can be emphasized
- Calculators or Excel can be used for modeling
- Mathematics-Algebra to Calculus
- Chemistry-Introductory to General Chemistry concepts and related labs
- Climate Science-fundamentals of meteorology and physics
- Design-using CAD and MatLab

# Project Foci-Highlights

- Chemistry with a focus on *atmospheric chemistry*. Topics in Green Chemistry such as *pollution prevention*
- Math, using a scaffolding approach to teach the *modeling equation* for the release of a gas (*Gaussian Plume Model*)
- MEMS by providing a research opportunity to understand the concepts and *design* based development parameters
- Policy/History/Government are reviewed so students understand both regulatory *history* and current *standards*

# Project Outline

- Background information is studied. Writing and critical thinking are emphasized as the students read and analyze U.S. EPA and international case studies
- Concepts such as plume, diffusion, stack height, atmospheric stability and 3-D spaces are explained in preparation for the upcoming mathematical applications
- Half of the course develops mathematical concepts needed for the final model. Predictions from this model are used to design the MEMS device

# Project Based Topics/Concepts

## Mathematics

- Plume Equations
- Variables
- Perpendicularity
- 1-3 Dimensionality
- Physical Geometry
- Exponential Function
- Excel
- Graph
- Statistical Analysis

## Chemistry

- VOC's, CFC's, PAH's
- Concentration
- CO , CO<sub>2</sub>, NO<sub>x</sub>, Ozone
- Radioactivity
- Acid Rain
- Greenhouse Gases
- Diffusion
- Molecule
- Combustion

# Project Outcomes Per Student

- A summary narrative characterizing the release being modeled
- The mathematical model (algebra based for pre-Frosh level students-calculus based for Frosh level students)
- Development of a design/model for a MEMs device based upon literature review and guided design principles embedded in a design program
- Revision as needed for extra credit in school or entry into an academic contest in the fields of chemistry, environmental science, mathematics or physics

# Next Steps

- Funding for development of the modular curriculum into a full course text for each of the three levels
- Isolating and augmenting the chemo-selection process into a separate lab sequence
- Offering the course at the Frosh level as a seminar
- Incorporating the project into a Green Chemistry course series
- Expanding the project to include more of the mechanical, electrical and computer engineering aspects

## Thank you to Green UP-MI Chemistry & Engineering Conference 2014

This and similar projects at the high school to Frosh level are done to promote interest and achievement in STEM fields. The goal is to motivate and inspire students to an extent that they exude the attitude reflected in the following statement: “Stand back, I’m going to try (and succeed in) science!”

