Tuesday Morning, November 5, 2002

Advancing Toward Sustainability Topical Conference
Room: C-210 - Session AT-TuM

Aerosols and Climate Change, Growing Energy Demands, and Benign Semiconductor Manufacturing

Moderator: R.L. Bersin, Emergent Technologies Corporation

8:40am **AT-TuM2 Individual Particle TOF-SIMS Imaging Analysis of Aerosol Collected During the April 2001 Asian Dust Event**, ***R.E. Peterson***, *B.J. Tyler*, University of Utah

Time of Flight Secondary Ion Mass Spectroscopy can provide information regarding the surface chemistry, including both organic and inorganic compounds, of individual atmospheric aerosol in the micrometer size range. X-ray analysis has commonly been used to analyze the composition of single particles but has several important limitations. Principally, X-ray analysis cannot be used to study organic compounds in the aerosol, it offers low sensitivity for light elements common in crustal material and it cannot distinguish isotopes. TOF-SIMS has the potential to provide superior performance in these areas. We have developed statistical image processing methods to allow extraction of individual particle spectra from TOF-SIMS images. In mid April 2001 a strong Asian dust event was tracked by satellite across the Pacific Ocean and into the continental United States. While Asian dust deposition is common in Hawaii, strong events characterized by significant visibility degradation have been much less frequently reported in the Rocky Mountain west. Samples were taken during and after the event at the University of Utah in Salt Lake City, Utah. Size segregated samples were collected on aluminum substrates using an 8 stage Graseby-Anderson cascade impactor and total aerosol samples were collected with 47 mm Fluoropore filters. Surface and depth profile analysis of the particles was performed using a Phi Trift I TOF-SIMS instrument. Statistical methods, including PCA, mixture models and neural networks, were used to extract spectra of individual particles from the TOF-SIMS images and to classify particles based on their surface chemistry and depth profiles. Differences in both the chemistry and size distribution of the particles could be seen between the aerosol collected during the Asian dust event and aerosol collected post-event at the University of Utah site.

9:00am **AT-TuM3 Atmospheric Aerosol Detection, Analysis and Transformation**, ***P.H. McMurry***, University of Minnesota **INVITED**

Atmospheric aerosol particles scatter light, deposit on surfaces and in lungs, and participate in chemical transformations. This lecture will focus on the formation of new particles in the atmosphere by homogeneous nucleation, and on the chemical and physical properties of such freshly nucleated particles. It is important to understand nucleation since it affects the number concentrations of particles in the atmosphere. Number concentrations, in turn, determine the extent to which clouds form, and clouds play a central role in the earth's radiation balance. Our understanding of nucleation has progressed rapidly in the past few years due to recent advances in measurement. Routine measurements of aerosol size distributions down to 3 nm are now possible. Such measurements have shown that nucleation is ubiquitous in the atmosphere. We now are carrying out measurements that will help us understand what species are responsible for the formation and growth of new atmospheric particles. We have developed techniques to measure properties of freshly nucleated (3-10 nm) particles, including their tendency to absorb water, their volatility as a function of temperature, and their chemical composition. In this lecture these new measurement methodologies will be described, and our recent measurements will be discussed.

9:40am **AT-TuM5 Future Environmental Issues Associated with the Generation of Electricity**, ***J. Stringer***, EPRI **INVITED**

Over the next twenty to forty years the world-wide demand for electricity will increase substantially. In part, this is because of the increasing energy demand, particularly in the developing countries, and the increasing fraction of this energy that will be provided as electricity. In part, it is because of the increase in the global population, with most of this increase taking place also in the developing countries. Certainly for the immediate future, this demand will be met largely by the burning of fossil fuels. This will result in significant environmental challenges, and the major challenge is probably the emission of CO_2. It is not the object of this paper to discuss the issue of global warming: it is enough that there will almost certainly be a continuing global political pressure to limit these emissions. The current situation will be reviewed, with special emphasis to the United States, and the probable global developments will be discussed. The current options will be described, including methods that are being proposed for the capture and sequestration of the emitted CO_2. The major issues relate to the separation of the CO_2 from the relatively dilute concentration of the gas in the very large volume of the combustion off-gas, and the transport of the concentrated gas to a repository. The security and permanence of the various proposed repositories clearly must also be clearly defined and monitored. Alternative paths, including the decarbonization of the generation of electricity, will also be discussed. This decarbonization has been in progress for many years, and clearly the end-point in terms of combustion-based generation is represented by the use of hydrogen as the fuel. Production of hydrogen, either by separation of hydrogen from a hydrocarbon such as methane, or by reforming, presents significant issues, and the transportation and storage of the hydrogen are also issues which have still to be solved. Non-combustion based methods - nuclear fission, hydroelectric generation, biomass combustion, wind-power, and photovoltaic generation - will be briefly reviewed in terms of their possible contributions within the time scale defined above. Other aspects of the overall problem include improved efficiencies in the generation of electricity, reduced losses in transmission, and continued improvements in the efficiency of end use. Most importantly, all of this must be achieved with a minimum economic impact

10:20am **AT-TuM7 The Challenge of Relating Basic Research to the Solution of Environmental Problems**, ***D.R. Baer***, Pacific Northwest National Laboratory

Many members of the research community have enthusiastically redirected their research efforts to address important national problems. This paper examines the difficulties researchers face in actually having an impact on solving these problems. Several examples demonstrate the willingness of researchers to undertake environmentally related research projects and to participate in efforts that help define a critical scientific agenda. However, evidence indicates that the transfer of new scientific information to environmental technology and application is a more difficult challenge. There are several barriers to the rapid transfer of new scientific information to technological practice. Barriers include the nature research funding, an accepted (mis)understanding of the relationship between pure and applied research, the challenges of basic scientists and engineers working on multidisciplinary teams and working with non-technical people and organizations who have a vested interest in the problem and solution. To have a significant impact on environmental problems, technologists need to become involved in many activities, well beyond those associated with laboratory research.

10:40am **AT-TuM8 ESH Performance Plays a Vital Role in Sustaining the Growth of the Semiconductor Industry**, ***C. Miller***, *W. Worth*, International Sematech **INVITED**

Rapid technology advances and rapid growth have historically been the basis for the success of the semiconductor industry. Over the last twenty five years the industry has enjoyed a growth rate (~15%) which far exceeds the growth rate of the U.S. economy overall (3-4%). To ensure that this rapid growth rate can be sustained into the future, it is important that the industry makes efficient use of natural resources, minimizes any impact on the environment, and ensures the protection of its workers and the communities in which it operates. It has been repeatedly shown that resource efficiency is linked to lower operating costs and better environmental performance. International SEMATECH's Environment, Safety and Health (ESH) division is engaged in several projects that are aimed at enabling continued, sustainable growth for the industry. These include energy and water conservation, perfluorocompound (PFC) emissions reduction as well as early ESH assessment of the multitude of new chemicals and materials being considered for 157nm photolithography, ultra-low dielectrics, and advanced gate stacks. The timely assessment of any potential ESH impacts associated with these novel materials is essential to ensure that they are used in a safe and environmentally sound manner through cost-efficient ESH solutions and controls. This paper will describe the approach and results of SEMATECH's efforts in the areas of resource conservation, PFC emissions reduction and early identification of potential ESH impacts associated with the next generation semiconductor chemicals and materials.

Tuesday Afternoon, November 5, 2002

Advancing Toward Sustainability Topical Conference
Room: C-210 - Session AT-TuA

Benign Manufacturing, Climate Change, International Trade and World Economy, and Theological Considerations of Sustainable Development

Moderator: P. Maroulis, Air Products & Chemicals Inc.

2:00pm **AT-TuA1 A Framework and Practices for Advancing Toward Sustainability**, ***L.G. Heine***, Zero Waste Alliance/International Sustainable Development Foundation **INVITED**

There is currently a movement, gaining momentum worldwide, toward what is commonly called sustainability or sustainable development. A generally accepted definition of sustainability is that which meets the needs of the present without destroying the ability of future generations to meet their own needs. While few would disagree that this is an imperative, there is confusion as to how to achieve this goal. Green Chemistry is often held up as a tool for chemists, chemical engineers and others who design materials to help move society towards the goal of sustainability. Green chemistry is the design of products or processes that reduce or eliminate the use and/or generation of hazardous substances. The focus of green chemistry is on design because it is at the level of molecular design that decisions are made that impact how the material will be processed, used and managed at the end of its life. A framework for sustainability called The Natural Step (TNS) has emerged from Sweden as a mental model of what sustainability might look like at the global level. In The Natural Step, four System Conditions are defined that characterize how humans can engage with the natural world in a way that will not lead to progressive deterioration. This model is helpful in defining what sustainability is NOT, but it is not prescriptive for how sustainability can be achieved. This presentation looks at the System Conditions as defined in The Natural Step along with the principles and practices of Green Chemistry, and ideas taken from frameworks for ecologically sound manufacturing and product design such as "zero waste" to illustrate how some businesses are positioning their companies to become more economically competitive through sustainable business practices.

2:40pm **AT-TuA3 Chemical Plant Safety After 9/11: Reducing Risks Associated with the Use of Organo/chlorinated Solvents in Degreasing Operations**, ***C.A. LeBlanc***, Toxics Use Reduction Institute **INVITED**

The mission of the Surface Solutions Laboratory (SSL) is "to identify, develop and promote safer alternatives to hazardous materials such as chlorinated and other organic solvents." These materials are often used in industrial processes such as surface preparation, coating, cleaning, rinsing, drying and analysis in the production of manufactured goods. Located at the University of Massachusetts Lowell, SSL is a division of the Toxics Use Reduction Institute (TURI), established by the Commonwealth in 1989. Chemical advances are typically accompanied with advances in equipment, in this case, degreasing operations. This talk will focus on the lessons learned and the progress made in working with well over 100 companies in solvent-substitution projects during a five-year period. These firms range from high-tech (for example, semiconductor) to low-tech (for example, machine shop) enterprises. The events of September 11 may serve as a catalyst to improve plant safety, as local, state and federal agencies, as well as businesses contend with the prospect of deliberate chemical misuse. Attendees to this session will better understand how successful technical diffusion and technical transfer occurs. The role that 'disruptive technologies' play in these endeavors will be discussed as time allows.

3:20pm **AT-TuA5 Global Warming: How Much is Too Much?**, ***J.B. Smith***, Stratus Consulting Inc. **INVITED**

The Earth's climate warmed about one degree Fahrenheit during the 20th century. Most of the warming in the last half of the century was the result of greenhouse gas emissions from societal activities. Should emissions continue increasing without a concerted effort to control them, projections are that temperatures could increase about 3 to 10°F by 2100. Policy makers are struggling to control the growth of greenhouse gas emissions. While initial efforts such as the Kyoto Protocol will at best slow the rate of emissions growth, ultimately concentrations of greenhouse gases need to be stabilized. What is an appropriate target for stabilizing atmospheric concentrations of greenhouse gases? The United Nations Framework Convention on Climate Change, which the United States ratified, states that concentrations of greenhouse gases will eventually be stabilized at a level that is not dangerous. This talk, which is based on a recent report by the Intergovernmental Panel on Climate Change, addresses different ways in which policy makers may be able to determine what is a safe (i.e., not dangerous) level of climate change. Five "reasons for concern" about climate are addressed: 1) impacts on unique and threatened systems; 2) effects of change in extreme weather; 3) inequitable distributional effects of climate change; 4) total (aggregate) impacts of climate change; 5) risk of major changes in the climate system. The literature on climate change impacts was surveyed to determine what a dangerous level of climate change may be for each reason for concern.

4:00pm **AT-TuA7 The Garden, the Wilderness, and Covenant: Formulating a Theological Mandate for Sustainable Development**, ***S. Meyers***, Harvard Divinity School

The 20th Century witnessed a debate between paradigms of economic development, namely the State-led and Neo-liberal models. Each have gained ascendancy and "orthodoxy" at different points in time but neither have brought forth their promised fruits to many of the peoples who continue to dwell in abject poverty and both have contributed to worldwide environmental degradation. Yet these economic debates contain theological notions of humanity's relationship to creation which predate them be several millennia. The Hebrew Bible provides three symbols through which humans understand the earth. The first two symbols are found in the beginning of the book of Genesis and are those of the Garden of Eden and the chaos of the wilderness. The third is found later in Genesis as the covenant made between God and all of creation following Noah's flood and in the covenant that formed the People of Israel in the book of Exodus. The Garden of Eden symbol underpins neo-liberal theory which sees the earth as a gift from God to be exploited and, through human ingenuity and God's divine will, never to prove human consumption unsustainable. The wilderness imagery corresponds to state-led development which advocates authoritarian rule, central planning, and an underlying Malthusian belief that the earth can not sustain humanity unless nature can be carefully controlled and subjugated. Both symbols are anthropocentric and can never produce environmental ethics that are not fundamentally related to an understanding of the earth as the object of human dominion. Covenant, however, is a theocentric perspective that recognizes God as the Creator of both humans and all of nature, and denies a natural order that puts humans as the "lords of the earth." Building on Moltmann's Trinitarian process, basic moral axioms can be created that form the basis for reinterpreting humanity's relationship to nature and God and to create a theological underpinning for new paradigms of sustainable development.

4:20pm **AT-TuA8 Climate Change Science Economics and Politics**, ***W. Moomaw***, The Fletcher School **INVITED**

The science of climate change has been studied for over 100 years, but only in the past 15 years has it been a subject of policy and diplomacy. There is now a substantial body of scientific knowledge that demonstrates that certain atmospheric trace gases such as water vapor, carbon dioxide, methane, ozone and nitrous oxide trap heat that keeps the earth's average temperature around 60 deg. F. Human activities have increased each of these gases substantially: carbon dioxide by 30% and methane by over 100%. Temperature measurements on land and in the oceans demonstrate a clear rise in temperature of about 1 deg F during the past century. Measurements several miles above the earth's surface show a smaller increase. Since fossil fuels are associated with both carbon dioxide, methane and some nitrous oxide releases, attention has focused on the energy sector as the major target of mitigation efforts. Modeling of the climate system and the economy with and without climate change show a range of energy intensity have generated an intense debate over what to do. The U.S. has withdrawn from the Kyoto Protocol that would require emissions reductions 7% below 1990 levels by 2012, but remains committed to the Climate Convention that identifies climate change as a problem requiring action. The Kyoto Protocol could be ratified by enough countries to enter into force for a majority of industrial countries even if the U.S. that is responsible for about one-quarter of emissions does not participate. This has major implications for international trade and for industrial design. This presentation will attempt to untangle claims and counterclaims to reveal what is at stake and what are some possible outcomes for planetary systems and for the world and U.S. economy.

5:00pm **AT-TuA10 Invited Speakers Panel Discussion with Audience Participation. Title of the Panel Discussion and background information on the panelists will be posted openly at the Symposium.**

Authors Index

Bold page numbers indicate the presenter