Technology for Sustainability
Room 320 - Session AT-ThM

Development and Implementation of Sustainable Processes

Moderator: R.L. Bersin, Emergent Technologies Corporation

9:00am **AT-ThM3 Development and Implementation of Green Processes for Manufacturing**, *D.A. Dornfeld,* ***N. Krishnan,*** University of California, Berkeley **INVITED**

Environmental and health issues associated with manufacturing (specially semiconductor manufacturing) are growing in importance and offer strong incentives to reduce resource use and minimize waste. The large flows of materials and energy throughout the economy lead to a wide range of upstream environmental impacts. A strategy for a comprehensive design for environment (DFE) tool to assess the environmental and health impacts of semiconductor manufacturing and to feed this information back into semiconductor equipment and process development cycles is presented. This work builds upon previous research at Berkeley such as environmental value analysis system (EnV-S). A comprehensive approach including (i) scope considering upstream life cycle impacts and facilitating integration into downstream environmental assessments and (ii) metrics supporting a wide range of local and global environmental and health metrics, is proposed. Ideally, feedback loops from DFE tools can inform designers of equipment and processes and aid environmental decision making by regulators, industry suppliers, utilities, etc. A further goal is to promote the broader use of this tool to support industrial ecology. The tool can also have a strong educational component if used in a classroom environment to support the teaching of environmentally conscious manufacturing and industrial ecology. There are several significant intellectual hurdles: what level of detail is required, how can we link upstream life cycle impacts and facilitate downstream environmental assessments of electronics, what local and global environmental metrics are needed (e.g. for health hazard issues), and can the tool be an effective policy planning instrument? The paper will address these issues based on our experience so far with a much reduced scope of effort in EnV-S. The results of this work should establish the feasibility of real, effective design and manufacturing for reduced environmental impact.

9:40am **AT-ThM5 Environmental Accounting of Air Biofiltration using an Energy-based Life-cycle Assessment Approach**, ***D.R. Tilley,*** *P. Ganeshan,* University of Maryland, College Park

Biofilters are shown to remove gaseous pollutants such as volatile organic compounds, hydrogen sulfide, nitric oxide and carbon monoxide from industrial waste emissions. Biofiltration integrates one of nature's most free services into a sustainable technology that has environmental advantages not shared with competitive technologies. To account for the free services of nature used in biofiltration, life-cycle assessment (LCA) was integrated with the solar emergy methodology (emergy is the total amount of energy of one form required directly and indirectly to make a product or provide a service). Our evaluation demonstrates the ability of emergy-based LCA to quantify, and place into perspective, the importance of natural processes in ameliorating industrial wastes. It also quantifies the life-cycle advantages that biofiltration possesses over other treatment technologies.

10:00am **AT-ThM6 Living Machines Out of Control: Experiments in Autonomous Ecological Engineering**, ***P. Kangas,*** *D. Blersch, D. Callahan, M. Walsh,* University of Maryland

Ecological engineering is a new field that utilizes ecosystems for environmental problem-solving. One application of ecological engineering has been termed living machines because of the close coupling of ecosystem with its technological interface. Most living machine designs have been multipurpose, aquatic systems with an emphasis on wastewater treatment. In this presentation experiments for making living machines autonomous, or self controlling, are described. Three working prototypes are presented to illustrate the path towards living machine autonomy. First, a solar-powered, floating system that improves water quality of a pond or lagoon is described. Second, a wetland soil microcosm that alternatively feeds itself carbon or nitrogen based on a redox sensor is described. Third, a home-scale wastewater treatment and recycling system that is interfaced through the internet is described. These kinds of systems with increasing degrees of autonomy represent a new approach to bioremediation where by living machines work on environmental improvement tasks independently of direct human control. These systems can be thought of as being "out of control" (in the same way as Rodney Brooks' new generation of robots), because they are designed to have their own independent agendas and power sources. Future directions in autonomous living machines are discussed for wastewater treatment and for other biologically-based processes.

10:20am **AT-ThM7 Enhanced Safety, Reliability and Cost Control with Integrated Gas Control Packages**, *N.A. Downie,* Air Products and Chemicals, UK*; J.J. Hart,* Air Products and Chemicals, Inc.*; J. Irven,* Air Products and Chemicals, UK*; R.E. Parise,* ***R.M. Pearlstein,*** *J. VanOmmeren,* Air Products and Chemicals, Inc.

The high-pressure gas cylinder is a reliable package for containing and transporting a wide variety of specialty gases used in semiconductor processing operations. These packages are typically used in gas cabinets that feed the delivery lines leading to the point of use. We found it to be advantageous to move some of the functions that control the pressure, flow and purity of the gas away from the gas cabinet panels, where they are conventionally found, by integrating them directly onto the gas cylinder package itself. In this paper, we will outline a number of these integrated functions, and demonstrate how they can lead to improved safety and product quality while also lowering the users' cost of ownership (COO). For example, by integrating a fixed, sub-atmospheric pressure regulator into the cylinder valve, gas will only be dispensed when the suction of the process equipment is applied. As a result, the risk of a hazardous gas release to the atmosphere can be substantially controlled. Further, these integrated delivery systems can permit a greater filling density of the process gas compared to dilute mixtures or low-pressure adsorbent systems. The increased gas inventory significantly reduces the cost of ownership of the system by reducing down-time for cylinder replacements while still effectively mitigating the high pressure risks.

10:40am **AT-ThM8 Responsible Care(r): Protecting our Industry**, ***J. Henninger,*** Air Products and Chemicals, Inc. **INVITED**

When Responsible Care was launched in the late 1980's, it was a groundbreaking initiative and unique in industry. Its goals were: improve environmental, health and safety performance and allay community concerns about the industry. As a result, the performance of the industry improved significantly as did the relationships with our neighbours but not the general public. The program is being expanded and improved significantly to address the issues of today, e.g., terrorism. The presentation will describe the Responsible Care and how Air Products uses it to protect our people, our customers, our communities, the environment, and our license to operate.

Technology for Sustainability
Room 320 - Session AT-ThA

Science and Technology Related to Global Effects: Emissions, Climate, and Transport

Moderator: S. Raoux, Applied Materials

2:20pm **AT-ThA2 SeaWiFS Land and Ocean Vegetation Measurements - A Six-year Set of Climate Change Records***, R.A. Barnes,* Science Applications International Corporation and SeaWiFS Project

SeaWiFS (the Sea-Viewing Wide Field-of-View Sensor) was launched in August 1997. It commenced on-orbit operations in September 1997 and continues to make images of the Earth surface at a 1 km areal resolution to this day. The SeaWiFS data set currently contains two transitions of the El Nino-Southern Oscillation (ENSO). With an electronic design that includes bi-linear gains, SeaWiFS makes measurements of both the dark ocean and the much brighter surface of the land. As a result, SeaWiFS provides the first truly global measurement set of vegetation changes from a single instrument. SeaWiFS also provides a baseline for one of the multi-decadal climate change data sets proposed by NASA. This data set includes Earth surface measurements from the MODIS (Moderate Resolution Imaging Spectroradiometer) sensors currently flying onboard the Terra and Aqua spacecraft and from the VIIRS (Visible and Infrared Imaging Radiometer Suite) instrument to be flown onboard the NPP (NPOESS Preparatory Program) spacecraft, which is currently scheduled for launch in 2007. Subsequent VIIRS instruments are planned to be flown for several decades into the future, as part of NPOESS (the National Polar-orbiting Operational Environmental Satellite System). For ocean vegetation measurements in particular, the requirements for the Climate Data Records (CDRs) include extensive calibration/validation and atmospheric correction programs, since approximately 90% of the top-of-the-atmosphere radiance measured by the satellite instruments comes from the atmosphere.

2:40pm **AT-ThA3 Environmental Transformation of Uranium-Organic Complexes: Implications for Transport and Remediation***, C.W. Eng, G.P. Halada,* State University of New York at Stony Brook*; A.J. Francis, C.J. Dodge,* Brookhaven National Laboratory

Transportation and fate of uranium are fundamentally affected by the nature of their association with pervasive organic environmental molecular constituents resulting from natural or man-made sources. Understanding the role of organic ligands and the transformation of these complexes is essential to the development and optimization of remediation technologies. For example, u-organic complexation adversely affect the ability of certain bacteria to reduce soluble uranium (U(VI)) to a more insoluble form (U(IV)).@footnote 1@ Organic ligands can coordinate with uranium in aqueous solution and perhaps decrease the effectiveness of the ZVI. In literature, the fate of the uranium and organic ligands are not fully elucidated in these systems. Our research provides fundamental information about the structure and transformation of uranium-organic complexes through electrochemical and spectroscopic analyses. The organic ligands chosen in this study will be relatively simple molecules (e.g. salicylic acid, catechol), which are used as analogs for more complex molecules found in the environment. The objectives of this work include a) characterization of the uranium and organic ligands; b) the electrochemical behavior of u-organic complexes; c) the relative stability and mobility of the uranium-organic complexes; and d) the ultimate fate of the uranium and ligands. X-ray Photoelectron Spectroscopy , laboratory and synchrotron-based Fourier Transform Infrared analysis, and in-situ electrochemical experiments will be combined with synchrotron-based X-ray Absorption and Raman spectroscopies. The resulting structural and molecular spectroscopic data is then used to generate computational molecular models, so that molecular orbital structures of complexes can be related to both stability and reactivity of uranium-organic ligands. @FootnoteText@@footnote 1@ Biotransformation of uranium and other actinides in radioactive wastes, A.J. Francis, Journal of Alloys and Compounds (1998), 271-273, 78-84.

3:00pm **AT-ThA4 Managing Greenhouse Gas Emissions using ISO 14064 as a Quantification, Reporting and Verification Guide***, J.C. Shideler, J.H. Schaarsmith,* Futurepast: Inc. **INVITED**

Organizations increasingly are identifying greenhouse gas emissions as significant environmental aspects of their operations and activities. Emissions may be direct, such as with the use of SF6 in manufacturing operations, or indirect, such as with the use of energy resources derived from fossil fuel sources. The increasing focus on control and reduction of greenhouse gas emissions from anthropogenic sources has stimulated the development of a management system standard -- ISO 14064 -- that provides a common template for quantification, reporting, and verification of greenhouse gas emissions data. The authors survey the US and international legal and regulatory environment pertaining to greenhouse gas emissions, and describe how ISO 14064 can help organizations develop and report data for internal management purposes or for US or international emissions reporting or trading.

3:40pm **AT-ThA6 Climate, Technology and the Energy Dimension of Sustainable Development***, J. Edmonds, G. Stokes, J. Clark,* Pacific Northwest National Laboratory **INVITED**

The global energy system will need to evolve to provide both abundant resources at reasonable prices while simultaneously addressing environmental quality issues ranging from acid rain to mercury emissions to regional air pollution and climate change. Focusing on the goal of the UN Framework Convention on Climate Change, stabilization of greenhouse gas concentrations, we have looked into the inevitable transformation of the global energy system over the next century and beyond. These results suggest that a range of technologies, some likely permanent parts of the future energy and some transitional technologies, will be required to meet the challenge. What emerges are a variety of possible global energy technology strategies where the ability of a particular technology system to meet the cost and environmental goals of society determine the ability of the technology to compete and succeed in meeting the demand for primary energy which may well triple over the course of this century.

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