

THE CHEME NEWS

Fall / 2009

Internal Newsletter of the Department of Chemical Engineering
Carnegie Mellon University

Message from the Department Head

We are six weeks into the Fall semester but welcome, nonetheless to all of the new faces in the department; sophomores, Masters and PhD students alike. In addition, we have two staff members who were hired last spring; Dr. Dave DeLo and Ms. Shannon Young. And last but not least, Dr. Eranda Nikolla who was hired onto the faculty last summer but will not be joining us until Fall 2011 as she is currently a postdoc in the Chemical Engineering Department at Caltech.

In some respects, it seems to me that the pace of change in the department has slowed over the past year, but that is probably because the changes associated with the renovation of Doherty Hall over the prior years were so dramatic and intrusive. I have to say that, now that it has been one year since completion, I still think that we did a great job. The level of disruption was much lower than in many other departments that have gone through the same exercise, and at the end of the day, there seem to have been no major mistakes in the way in which the new space was designed. This is a testament to the effort that the faculty, staff and architects put into the design phase of the project.

As you will see by reading through the following pages, there is much going on in the department. Many of our students and the faculty have been very active over the summer, winning awards and doing other great things to bring recognition to the department. Over the past few months the faculty has also been discussing making modifications to the processes that we use to provide advising to both undergraduates and new graduate students. This is being done in response to some of the comments that we have heard from students over the past couple of years and will improve the quality of curricular advising and career mentoring that we are able to provide. The new processes will be announced shortly and will involve Cindy Vicker and Shannon Young to a greater extent than in the past.

On the research front, there are a number of noteworthy events. Our projections for research funding indicate that the department's research budget will exceed \$10M for this fiscal year; the first time that it has ever exceeded the \$10M mark. The faculty is also discussing and will implement some changes to the structure of the research areas that we use to define our program. What has traditionally been known as the Solid State Materials group will become the Catalysis and Surface Science group. In addition, we will be creating a new area in energy research (exact name to be decided) in order to reflect the significant level of effort within the department on energy related problems. More details to follow in future issues.

Andy

Department News

Renovation Update: Rose Frollini

Jendoco Construction, the construction manager for the renovation of our facilities, has announced that the Phase II Doherty Hall Project has won a 2009 Preservation Award from the Pittsburgh Historic Review Commission for the “Sympathetic Renovation” of Doherty Hall.

The Historic Review Commission is a seven-member board, appointed by the Mayor. Its function is to protect historically and architecturally important buildings and neighborhoods in the City of Pittsburgh. Built in 1908 as one of the original buildings of Andrew Carnegie’s Carnegie Technical School, Doherty Hall is designated a Historic Landmark by the Pittsburgh History and Landmarks Foundation.

During the renovation, special care was taken to try to preserve as many of the original features as possible. For example, in removing the ceiling in the first floor hallway, the arched ceiling of the original wing of the building was uncovered and the Construction Core Team, which included the architects, Jendoco, Campus Design, and representatives of the Chem. E., Physics and Art Departments, decided to incorporate it into the design instead of going ahead with its planned demolition. (This wing was built around 1908. The current front of the building and lobby area was not added until 1950.)

Additionally, while the Project included Life-Safety and ADA upgrades in all areas, wherever possible, original details were kept in tact. These included interior and exterior windows, and woodwork and the Hornbostle stairs at the back of the wing. The original roof trusses were left in place and are partially exposed in the ceiling of the third floor CFE lab and grad office.

The Phase II Project is currently awaiting results of the evaluation of the Green Building Practices followed during the renovation and is anticipating that the Project will be LEED certified, a rarity for projects involving laboratory renovations.

CPS Program: Recent Outreach Events

The CPS Program and the Department sponsored or will sponsor the following programs to educate students and the public about careers in engineering:

Engineering Experience(SEE) for Girls, July, 2009

This program is sponsored by ICES at Carnegie Mellon. **Neil Donahue, Annette Jacobson and Rose Frollini** presented a workshop and experiments about Energy and Climate Change for middle school girls from the Pittsburgh. Special thanks to **Katlyn Henry, Gabriella Farnham and Lea Hildebrandt** for volunteering their time for this event.

Nisha Shukla presented a workshop for SEE about Nanotechnology that included synthesis and characterization of nanoparticles. Sincere thanks to **Seif Yusef, Johanna Chung Lee, Abigail Devin Odeck and Nathaniel Odeck** for volunteering their time for this session.

National Chemistry Week at the Carnegie Science Center--this celebration will be held on Friday, October 23. We currently need volunteers for the morning and afternoon shifts (9am-12noon and 12 noon-3pm).

Contact **Annette Jacobson(jacobson@andrew)** for more information.

SWE sponsored High School Day for Girls in the Pittsburgh Area at Carnegie Mellon is scheduled for Wednesday, October 21. We will present a session on Macromolecules and their applications that include many consumer products.

Connections to chemical engineering will be highlighted.

Shop News: Larry Hayhurst

Collaborative Machining Center has new capabilities

The Collaborative Machining Center, with the support of PITA has increased its capabilities with the purchased of a CNC Milling Machine with a Renishaw Tool Setting and Inspection Probe system. Using an inductive system, the probe unit has no external wiring and may be freely transferred between the tool changer and machine spindle. Besides increasing the accuracy of set-ups, post manufacturing inspection and verification is a unique new capability that keeps step with the trend in industry. Student teams working with regional industry will have access to the state of the art technology.

With the conclusion of a U.S. Department of Labor training program at the MAGLEV Inc. facility in McKeesport PA, the Collaborative Machining Center has relocated its 6-axis robots on campus and to NREC. One robot is set up to weld in the CMC shop; one is being used by Dr. Chris Atkeson, of the Robotics Institute, to explore humanoid robotics and human aware environments. One is being used by Dr. Jeremy Ficca in the Digital Fabrication Lab. Three are being used by Jean-Sebastien Valois, Commercialization Specialist in projects at the NREC facility in Lawrenceville. While not as glamorous as autonomous robotics, industrial robotics accounts for 99.9% of robotics applications globally and integrating industrial robotics in the education and research activity of the university is a positive step towards practical education.

See: <http://cmc.cheme.cmu.edu/cmchomepage.html>

Mark your Calendar

Graduate recruiting weekend will take place, Friday, March 5 through Sunday, March 7, 2010.

Faculty News

Good Luck to Larry Biegler who has been appointed the 2009 "Olaf A. Hougen Visting Professor of Chemical Engineering" at the Department of Chemical and Biological Engineering of the University of Wisconsin for the fall of 2009. Distinguished chemical engineering academics have been recipients of this award.

Congratulations to Larry Biegler who won the 2009 ICS Prize of the INFORMS Computing Society. The INFORMS Computing Society has announced that **Larry Biegler** and **Andreas Wachter** are the winners of the 2009 ICS Prize for the best English language paper or group of related papers dealing with the Operations Research/Computer Science interface. They received the award for their paper On the Implementation of an Interior-Point Filter Line-Search Algorithm for Large-Scale Nonlinear Programming, which was published in Mathematical Programming, Series A in 2006. The ICS Prize will be presented at the 2009 INFORMS Annual Meeting in the ICS Business Meeting. The ICS Prize winners and the ICS Student Paper Award winner will make presentations in a special ICS Prize session.

Congratulations to Andy Gellman who has received a \$2 million research grant from the Department of Energy. The grant supports the development of atomically and molecularly structured surfaces that will improve the efficiency of catalysts used to create products for the specialty chemical and petroleum industries. Gellman also leads a research team developing new solid enantioselective surfaces, materials that can be used to select between the "left-handed" and "right-handed" versions of complex molecules. In all typical respects the molecules are identical but the handedness confers on them the potential for having very different chemical effects in living organisms.

Congratulations to Larry Biegler, Ignacio Grossmann and Arthur Westerberg who have been recognized as the 2009 recipients of AIChE's Warren K. Lewis Award for Chemical Engineering Education. The Warren K. Lewis Award is a major honor; its list of awardees is a Who's Who of chemical engineering research and education. Among other criteria, the award recognizes distinguished and continuing contributions to chemical engineering education based on contributions of lasting educational influence such as superior textbooks, lectures, and laboratory techniques or models. By bestowing this award, the chemical engineering community honors the perspective and contributions of the awardees with regard to Process Systems Engineering and their 1997 textbook on that subject, Systematic Methods for Chemical Process Design. The award citation is:

"For changing the way chemical engineers worldwide think about process systems through an authoritative textbook, popular short courses, educational software, and highly successful academic descendants

Welcome to Dr. Eranda Nikolla who recently received her PhD from the University of Michigan, will join the Department of Chemical Engineering as an Assistant Professor after she completes a postdoctoral appointment. Her doctoral research was in catalysis and solid oxide fuel

cells. She will join the Energy Science and Engineering group. The department is elated to add a promising young scientist to this important area of research.

Staff News

Welcome new staff members **Shannon Young** and **Dave DeLo**. Shannon joined the Department in November of 2008 as the Graduate Admissions Coordinator. Dave joined the Department in March of 2009 as the Institute of Advanced Energy Solutions Program Administrator.

Visiting Scholars

Professor Zhen Gao is working with Professor Nick Sahinidis' group in the area of optimization models and algorithms for planning, scheduling, and process operations problems.

Professor Kexin Wang is working with Professor Larry Biegler's group in a collaboration on projects related to algorithm improvement and implementation of nonlinear programs and on dynamic optimization for polymer processes.

Alumni News

Congratulations to Dr. Soni Oyekan who has received the 2009 Percy L. Julian Award from the National Organization for the Professional Advancement of Black Chemists and Chemical Engineers. The Percy L. Julian Award is the most prestigious award presented by NOBCChE. The award recognizes and honors a recipient's scientific contributions and achievements, dedication to research, commitment to the educational development of others and passion for the chemistry profession. Dr. Oyekan was specifically recognized for his contributions in oil refining and chemical engineering. He has 10 patents and numerous publications on a variety of topics in petroleum refining and catalysis.

Dr. Soni Oyekan has over 30 years experience in the field of petroleum refining and associated technologies. Soni came to the United States in 1966 from Nigeria and earned his B.S. degree from Yale University in 1970. He subsequently went on to garner M.S. (1972) and Ph.D. degrees (1977) from Carnegie Mellon University in chemical engineering. Soni is the Reforming and Isomerization Technologist of Marathon Oil Company. Soni's contributions in the chemical engineering profession are notable due to his contributions with respect to the efficient use of reactor engineering and catalysis in the processing of crude oil to meet consumer demands for transportation fuel, heating oil, propane and butane gases and for his extensive volunteer and leadership roles in the American Institute of Chemical Engineers (AIChE). Soni has held a variety of positions in AIChE. The positions include chair of Fuels and Petrochemicals Division (F&PD), chair of the Minority Affairs Committee (MAC) and he served as a director of the AIChE Executive Board. He is a member of the AIChE Foundation Board of Trustees and a Fellow of the AIChE. Soni has contributed over the years in technical discussions on petroleum refining at the annual National Petroleum Refiners Association (NPRA) Q&A conferences. He has been honored for his academic achievements and research in petroleum refining. Soni is a member of Sigma Xi and Phi Kappa Phi honor societies. He is a member of the Yale Manuscript Society. He was honored by AIChE's Minority Affairs Committee (MAC) with MAC's Distinguished Service award in 2000. The Fuels and Petrochemicals Division honored him with its Distinguished Service award in 2002. He is listed in the 2000 13th edition of Who's Who Amongst African Americans.

Dr Soni Oyekan was named an Eminent Black Chemical Engineer by MAC at the AIChE Centennial Meeting in 2008. He is the recipient of the AIChE MAC 2008 William W. Grimes award for excellent contributions in chemical engineering and mentoring of under represented minority groups.

Undergraduate News

Congratulations to Elizabeth Cole, who received the GEWN scholarship from the Society of Women Engineers for the 2009-2010 academic year.

GEWN (General Electric Women's Network) Scholarship: This award is given to a female undergraduate engineering student who has shown outstanding academic achievement as well as strong engineering potential. The award recognizes leadership abilities, acknowledges a high level of mastery of the engineering curriculum, and gives the recipient an opportunity to pursue professional development as a female in the field of engineering.

Congratulations to Carmeline Dsilva, a senior student in Chemical Engineering, who has been selected as recipient of the prestigious Barry M. Goldwater Scholarship. The Barry M. Goldwater Scholarship and Excellence in Education Program was established by Congress in 1986 to honor Senator Barry M. Goldwater. This scholarship is designed to attract outstanding students into careers in mathematics, the natural sciences, and engineering.

Congratulations to Ryan Chehanske, a senior Biomedical and Chemical Engineering major, who was inducted as an Andrew Carnegie Society Scholar. The award is given to students who show academic excellence and multi-dimensional characteristics.

Members of 2009-2010 SAC – Student Advisory Council

Sophomores: Nicolle Nacey	Seniors: Abdulwahab Abdulwahab
Jessica Santana	Alexa Beaver
Bryan Spencer	Carmeline Dsilva
	Robert Weigmann
Juniors: Modolu Fatukasi	
Pallavi Nair	

2009 – 2010 Officers of AIChE Student Chapter

President: Alexa Beaver	University Liaison: Joyce Xu
Vice President: Kushal Doshi	Lecture Chair: Young-Hye Song
Secretary: Sarah Link	Social Chair: Jaelyn Lock
Treasurer: Carmeline Dsilva	Industrial Liaison: Joshua Bordin
Webmaster: David Ryoo and Kelly Phouyaphone	Faculty Advisor: Jim Miller
Financial Board: Georgiy Baramidze, Ryan Chehanske	

Placement statistics for the 2009 Senior Class were as follows:

The average starting salary was \$66,523. The high was \$87,000 and the low was \$50,000. Seniors were hired by the following companies:

Capital IQ
Citigroup
Colgate Palmolive
ExxonMobil*
Honeywell
Johnson & Johnson*
Key Environmental Inc.

Merck & Co.*
Mitsui Chemicals
Nucor Steel*
Procter & Gamble
Proton Energy Systems
Schlumberger*
Westinghouse*

**Companies with more than 1 hire*

Members of the Class of 2009 went to the following graduate schools:

Carnegie Mellon
Case Western Reserve
Georgia Institute of Technology
Illinois Institute of Technology
Johns Hopkins
Lehigh
MIT
Northeastern School of Law

Stanford
Toledo University
University of Colorado, Boulder
University of Delaware
University of Pennsylvania
University of Toronto
Yale

Congratulations to the following students on the Spring 2009 CIT Dean's List:

SENIORS

Chrystal Chan
Elyse Coletta
Amanda Di Ienno
Lisa Plimpton
Nicholas Wren
Adam Zewe

Christopher Rizzo
Young-Hye Song
Anthony Yu
Seif Yusuf

JUNIORS

Alexa Beaver
Brian Bober
Joshua Bordin
Kyle Buchholz
Scott Chapman
Carmeline Dsilva
Bryan Friedman
Austin Good
Catherine Hartzell
Boo Kim
Amy Maples
Alicia Marrie
Christine Ndege

SOPHOMORES

Rachel Bradley
Nathan Bussiere
Gurmukh Chhabra
Si Won Choi
Sneha Joshi
Nikunja Kolluri
Jonathan Leung
Jacob Loiterstein
Aislinn McCloskey
Jungup Park
Richard Pattison
Kristen Severson
Chandrasekar Sivakumar
Joshua Taylor
Jincao Xu

Returning 2008-2009 Exchange Program Participants

Imperial College, London

Nakul Agarwal
Dana Evert-Parise
Kelly Phouyaphone
Robert Wiegmann

Aachen University, Germany

Mallory Foster

Welcome to our Exchange Students!

Imperial College, London

Ke Lun Chua
Ruien Hu
Tadeusz Kurpaski

Aachen University, Germany

Dennis Kloss
Theresa Lohaus
Qi Zhang

Universität Dortmund

Sebastian von Elm

If you are interested in participating in any of the Departmental Exchange Programs, the application deadline is January 22, 2010. See Cindy Vicker in DH1101 for application information.

Graduation 2009 Awards

The **Mark Dennis Karl Outstanding Teaching Assistant Award** recipient was **Benjamin Murphy**.

AICHe Professional Promise Award was presented to **Lisa Plimpton**.

The **Ken Westerberg Award** was presented to **Amanda Di Ienno**. The memorial fund "**The Ken Westerberg Memorial Prize for Excellence in Chemical Engineering Research**" has been established by the department with a generous contribution from Aspen Technology and other friends of the Westerberg's and of the department. This prize is presented every year during the departmental graduation ceremony to a senior who has shown exceptional promise for research in chemical engineering. This prize has been established in the memory of **Ken Westerberg** who died of leukemia at the very young age of 35. Ken was the son of **Art & Barbara Westerberg**.

The **Ken Meyer Award** was presented to **Drew Cunningham**.

The **Geoffrey D. Parfitt Award for Excellence in Research** was presented to **Elyse Coletta**.

The **American Institute of Chemists Foundation Award** "For Ability, Character, Scholastic Achievement and Potential" was presented to **Nicholas Wren**.

The **Carnegie Mellon McCabe Society** honors the memory of Warren McCabe, one of the great leaders in this department's history, by recognizing students who show an unparalleled dedication to their community. The inductees from the Class of 2005 are: **Brian Freeman, Ruchi Desai, Christine Ho, Chisom Amaechi, Peter Rodgers-Fischl, and Raphael Bertrand.**

The **Kun Li Award for Excellence in Education** was presented to **Professor Kris Noel Dahl.**

Graduate News

Congratulations to Teresa Kirschling, who has received an Award of Excellence from the American Chemical Society Division of Environmental Chemistry for her presentation "Impact of nanoscale zero-valent iron treatment on the geochemistry and microbial diversity of trichloroethylene contaminated aquifers" at the 238th ACS National Meeting in August 2009. Teresa is conducting her Ph.D. research with Chemical Engineering faculty member Bob Tilton and courtesy faculty member Greg Lowry of the Department Civil and Environmental Engineering.

Welcome to our new graduate students!

PhD Students

Alison Cozad	University of Minnesota-Twin Cities
Melissa Day	University of Delaware
Max Fahrenkopf	University of Wyoming
Ajit Gopalakrishnan	India Institute of Technology, Madras
Anthony Kotula	Drexel University
Timothy McFarland	University of Dayton
Sumit Mitra	RWTH Aachen University
Yisu Nie	Zhejiang University
German Oliveros Patino	Universidad Industrial de Santander
Andrea Paciga	Manhattan College
Ellis Robinson	Ohio State University
Wilson Sung	California Institute of Technology
Sharon Vuong	Rensselaer Polytechnic Institute
Linlin Yang	Cornell University
Yongju Yun	Seoul National University

MS Students

Chih-Wei Chu	National Taiwan University
Joohyung Lee	Yonsei University
Ranjit Ramanathan	NIT – Warangal
Mahmud Siamizade	Polytechnic University
Yizhi Zheng	Zhejiang University

MS-CPS Students

Hui-Lian Leo	Carnegie Mellon University
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Sairam Shekhar

University of Mumbai

MChE Students

Tejasvi Ashok

BMS College of Engineering

Karl Debiec

University of Pittsburgh

Eric Johnson

University of Massachusetts-Amherst

Ruo Chen Liu

Beijing Normal University

Congratulations to our second year Ph.D. students who passed their qualifier exams:

Adam Canady

Jonathan Meade

Juan Du

Rocco Panella

Frank DeCarlo

Stacy Pustulka

Ethan Demeter

Matthew Reichert

Vijay Gupta

Reza Rock

Angela Holmen

Robert Smith

Anita Lee

Yan Zhang

Congratulations to those that presented their thesis proposal:

Abdulrahman Alattas

Advisor: Ignacio Grossmann. Title: "Optimal Model-Based Production Planning for Refinery Operations"

Nicole Green

Advisor: Mohammad Islam. Title: "Phase Transitions in Colloidal Crystals"

Sylvain Mouret

Advisor: Ignacio Grossmann. Title: "Optimal Scheduling of Refinery Crude-Oil Operations"

Juan Ruiz

Advisor: Ignacio Grossmann. Title: "Global Optimization of Nonconvex Generalized Disjunctive Programs"

Congratulations to the following PhD students who graduated in August and September 2009. We wish them luck in their future endeavors.

Adam Bowles, PhD

Advisors: James Schneider and Lee White. Title: "Thermodynamics and Spreading Behavior of Thin Perfluoropolyether Films Investigated with Atomic Force Microscopy"

Drew Cunningham, PhD

Advisor: Michael Domach. Title: "Theoretical and Experimental Investigation of Increasing Therapeutic DNA Production using Engineered *Escherichia coli*"

Parag Jain, PhD

Advisors: Lorenz Biegler and Myung Jhon. Title: "Multi-scale Modeling and Optimization of Polymer Electrolyte Fuel Cells"

Andrew Kim, PhD

Advisor: Todd Przybycien. Title: "Rational High-Throughput Screening for Formulations that Physically Stabilize Recombinant Proteins"

JitKang Lim, PhD

Advisors: Robert Tilton and Sara Majetich. Title: "Design and Synthesis of Magnetic Nanoparticles with Gold Shells for Single Particle Optical Tracking"

Congratulations to the following MS students who graduated in August 2009.

Salvatore Farina, MS

Advisor: Spyros Pandis and Peter Adams. Title: "Modeling Global Secondary Organic Aerosol Formation and Processing with the Volatility Basis Set"

Xu Feng, MS

Advisor: Andrew Gellman. Title: "Enantioselective Decomposition of Tartaric Acid on the Chiral Cu(643) Surfaces"

Hakhee Park, MS-CPS

Advisors: Annette Jacobson and Myung Jhon. Title: "A Study of Perfluoropolyether Lubricant Nanofilms"

Yuli Wei, MS-CPS

Advisor: Annette Jacobson. Title: "Dynamic Wetting of Viscous and Viscoelastic Fluids"

Danan Wicaksono, MS

Advisor: Nikolaos Sahinidis. Title: "Protein-Ligand Docking under an Algebraic Modeling and Optimization System"

CHEGSA News

2010 ChEGSA Board Members

President: Rocco Panella

Vice-President: Reza Rock

Symposium Chairs: Anita Lee

Wilson Sung

Libby Booth Gauthier

GSA Reps: Matt Reichert

Ethan Demeter

Fundraising Chair: Ellis Robinson

Social Chairs: Max Fahrenkopf

German Patino

Anthony Kotula

Stacy Pustulka

Webmaster/ Secretary: Linlin Yang

CHEGSA Symposium

This year marks the **31st year for the CHEGSA Symposium**. The symposium was held on **October 1&2, 2009**. From Dow Chemical Company, this year's Keynote Speaker was Dr. Georges Belfort. For more information see: <http://symposium.cheme.cmu.edu/109/index.html>

CHEGSA SYMPOSIUM AWARDS

Parfitt Award: Theresa LaFollette

Symposium Awards: Nicolas Alvarez and Anshul Agarwal

Honorable Mention Awards: Teresa Kirschling and Lea Hildebrandt

Gary Powers Poster Award: Ethan Demeter

ChemE Softball Champions 2009



The Names from left to right, then top to bottom are: **Drew Cunningham, Casey O'Brien, Nick Brown, Brian Wood, Ethan Demeter, Ben Murphy, Frank DeCarlo, Nicole Green, Andy Kim, Scott Epstein, and Chris Wirth**. Not Pictured is **Chris Cleveland**.

Faculty Profile: Erik Ydstie

I started out my research and teaching career in the area of process control. My approach was based on the idea that the chemical process should be represented as an abstract mathematical object, such as a transfer function. The approach has the advantage that the issues of modeling and control are separate. Control engineers can focus their energies on control theory while more classical engineers can focus on modeling. The interface between the two disciplines is simply defined by the mathematical model. The approach, which is called abstract mathematical systems theory, led to work in many interesting directions. I worked on adaptive, robust and nonlinear control, model predictive control, learning control using neural networks and signal processing.

Pretty soon I found myself working on a wide range of different applications as well. The tools we developed were divorced from the application domain and applications could be found everywhere. My students worked on distillation, heat-exchangers, polymerization and various chemical reactors, including a bio-reactor (so frustrating that I vowed never to work on a bio-system again.) We used the same tools for aerospace systems. For several years I worked with a PhD student at Martin-Marietta in Denver CO on developing adaptive control systems for the Titan IV booster rocket. And I worked with another student on vibration control for space based telescopes with the imaging group at Kodak. The telescope was pointing down and was rather secret it turned out.

The aero-space experiences led me to question whether it makes sense to apply exactly the same design approaches for aerospace and chemical process control. I felt the process physics should play a more central role when we develop process control system and that more robust and better performing control systems could be developed if the process was integrated with the control design.

I discovered that thermodynamics and mathematical systems theory share a common foundation in the sense that they are ultimately asking questions about the stability and characterization of equilibrium points. It should therefore be possible to combine the two fields and derive control systems directly from process thermodynamics. This rather simple idea led us to a study irreversible thermodynamics, a field surely developed to confuse rather than clarify. We found cumbersome notations, curious statements about laws and principles, theorems without proofs and discontinuities of reason that appeared impossible to bridge.

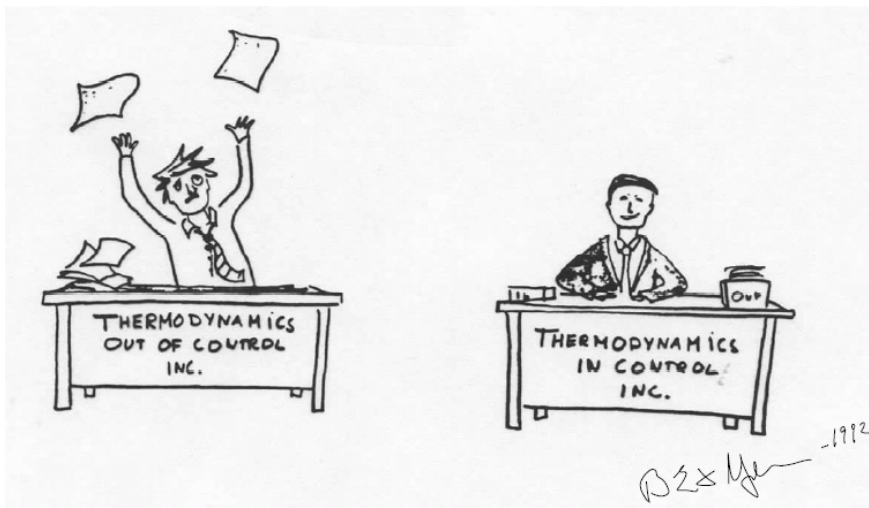
Nevertheless, over the years we learned to appreciate the beauty and generality of the basic principles of the classical thermodynamics of irreversible systems, the intuition of its founders and the precision of their methods. PostDoc and PhD students like Antonio Alonso, Chad Farschman, Duncan Coffey and Mohit Aggarwal succeeded taking these initial ideas and piecing together a coherent theory for how we can use thermodynamics to understand stability of process systems and derive controllers. PhD students Kendell Jillson and Michael Wartmann took these ideas and generalized them so that they can be applied to complex networks which integrate physics, computation and communication and even business decision making.

One very early success of the theory concerned the application of thermodynamics to design control strategies for PPG's float glass furnaces. The control system we developed is now used in all PPG production plants. Encouraged by these successes we used the same approach to derive control strategies for windshield bending for automotive and aerospace applications. Significant savings have been reported by PPG due to higher yield, fewer defects and better energy efficiency.

The practical experience my students and I had working with modeling and control system development with PPG and companies such as Alcoa, Emerson Process Management and REC Silicon led us to conclude that industrial practice is very different from the way we teach process control in the undergraduate class. Only very rarely did we come across the use of Laplace transforms and complex variables.

I decided therefore to revamp the control course to see if it would be possible to use our thermodynamic theories to bridge gap. Together with dedicated teaching assistants starting with Carl Laird (now professor at Texas A&M) we developed a curriculum which focuses attention on the process and the use of modern computer control rather than analog systems which are based on technology which is 60 or even 70 years ago. The road forward has been rocky. The first time I tried the new approach I won the "*What the '!@*!' is Going on Award*" at the senior banquet while my TA (Carl Laird) won the best TA award for having made clear my ramblings in class.

If at first you fail then try again. About 6 years later I have an outline for the control course, a set of course notes and homework problems which do not use Laplace variables in any way shape or form



My sabbatical leave was spent as Director of R&D with Elkem in Norway. Elkem was then the largest producer of metallurgical grade silicon in the world and the largest supplier of high grade silicon to the Japanese micro-electronics industry. I suggested in a board meeting that Elkem should move towards becoming a leading supplier of solar grade silicon. A major research program was put together with the aim of completing the development of a new process concept for making cheap silicon for solar cells by the end of 2005. This development effort was motivated by the rapid expansion of the solar cell market at 30% per year or more, a world-wide shortage of solar grade silicon and a desire by Elkem managers to get into new markets for their products. A brand new \$600M process capable of making 6000 tons solar grade silicon per year opened in Kristiansand in August of this year.

Our work with solar silicon and solar continues. While Christy Laird was a PhD student in our research group she developed models and control systems for a new fluidized bed reactor process for making solar silicon. Her models were used for scale-up and control design for pilot and commercial scale solar silicon processes by Fluor engineering and REC Silicon in Moses Lake WA. The work continues with PhD candidate Juan Du.

The work with industry made me interested in experimental work and wanted to start up some small scale experimental systems in area of photo-voltaics. During the past three years we have worked on modeling and experimentation to verify a new process (for making thin film silicon sheets suitable for solar cells applications. And PhD candidate Rocco Panella (co-advised by Dennis Prieve) is developing better processes for making dye sensitized cells suitable for roll-to-roll manufacture.