Getting a Whiff of PittCon

Since the organizers aren't fond of changing names every year, 30,000 technical types did not find themselves at ChiCon when they showed up at Chicago's massive McCormick Place-On-The-Lake earlier this month; they were at the Pittsburgh Conference. The annual gala, known in long form as the Pittsburgh Conference & Exposition on Analytical Chemistry & Applied Spectroscopy long ago outgrew its hometown and began its peripatetic wanderings to other cities with larger convention facilities. And next year, the conference's name gets officially shortened to "PittCon," in some measure to end the perennial need to explain why a conference with Pittsburgh in its title could happen anywhere else. But by any name, the Pittsburgh Conference can produce interesting ideas.

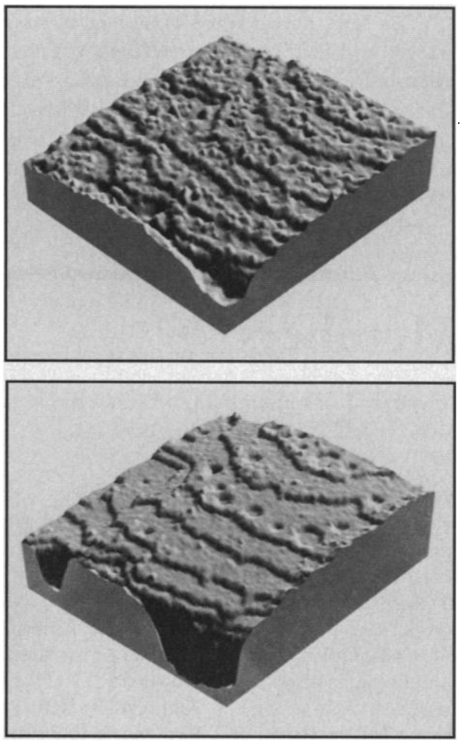
Using gold and silver to understand metal gone bad

In ordinary circumstances, corrosion of metals seems to occur slowly and insidiously. But materials scientists Chris Chidsey and Dennis Trevor at AT&T Bell Laboratories in Murray Hill, New Jersey, and Karl Sieradzki and Ivette Oppenheim of The Johns Hopkins University in Baltimore see a far more frenetic scene. By training their scanning tunneling microscope onto tiny regions of corroding metal surfaces, they are getting one of the first views ever of the atomic mechanisms of corrosion. It's more than intellectual curiosity that is driving the researchers, though. Chemists know very little about how corrosion occurs on the atomic scale, and that ignorance hinders their efforts to prevent a natural process that is costing society tens of billions of dollars a year.

It may be a while, however, before Chidsey and his colleagues can save that kind of money. The greatest part of these social costs arises from the corrosion of steel and aluminum, but STM images of these metals' corroding surfaces are hard to obtain and interpret. So Chidsey and his colleagues have focused for starters on a simpler model system, an alloy of gold and silver.

The researchers induce corrosion on the smooth surface of their alloy by bathing it with the strong oxidizing agent, perchloric acid, while at the same time subjecting it to a positive electrochemical potential. They then keep track of what's happening on the surface with intermittent STM scans. One of the first things they see is a vast atomic migration. "Thousands of atoms move in a few minutes," Chidsey notes.

As the silver on the topmost atomic layer oxidizes and dissolves into the overlying solution, the layer slowly roughens. Over a course of several minutes, the rough features coarsen to form atom-deep pits several or more Å across. As time progresses, the pits themselves migrate on the surface, merging with each other to form larger pits spanning up to several hundred Å. After an hour has passed, most of these have fused into atom-high ledges that form steps along the alloy's surface. This process returns the surface to a relatively smooth condition, though depleted in silver atoms.



Pit-watching with an STM. *Corroding surface at 10 minutes (top) and 1 hour.*

In the lab, corrosion will stop when the electric field is turned off. But real world corrosion may not stop until the bridge collapses—and that's why the researchers hope that their gold-silver model will be a bridge to understanding corrosion in the baser metals.

Evolving an Electronic Schnozz

No one knows how the nose knows. But that's not stopping Philip Bartlett and his colleagues at the University of Warwick in Coventry, England, from trying to make one of their own, an electronic one, that is.

The electronic noses that Bartlett described at PittCon would never fit onto the modest, though central, plot of facial real estate occupied by real noses. But the researchers' artificial olfactory systems are intended for more spacious settings such as factories where they might keep track of perfume composition, monitor food quality, and detect gas leaks. In addition, Jay W. Grate of the Naval Research Facility in Washington, D.C., told his PittCon audience about related devices that he and his colleagues are designing for a less benign role: alerting military personnel on air bases to the presence of chemical weapons.

The artificial olfactory systems are based on some of the same general design principles that Mother Nature used. In both cases, odors are detected by sensory components—neurons or chemical sensors—that relay signals to smell-interpretation centers—brains or computer processors. But while the nose contains a thin sensory carpet woven from millions of chemical-detecting cells, the Coventry group's apparatus has only 12 mushroom-shaped sensors all sealed within a 5-gallon flask. Grate's version has four sensors in a package the size of a shoebox. And unlike the nose's all-purpose chemoreceptors, the individual sensors in the electronic noses can be tailored to respond to specific odors. The ability to mix and match tailored sensors makes the designs promising for multipurpose artificial schnozzes.

At the heart of each sensor in the English device is a small ceramic tube, electrically heated to about 350°C and topped with a layer of semiconducting tin oxide impregnated with some metal catalyst. Differences in the composition of the tin oxide-catalyst layer make individual sensors more responsive to particular odors. For example, one sensor might respond strongly to Chanel #5, while another with twice as much catalyst might respond more to Obsession.

When sample gases enter the flask, they degrade at the heated sensor surfaces, thereby changing the sensors' electrical resistance. Then classical pattern recognition algorithms, or neural net techniques, interpret the pattern of resistance changes. Before the surrogate nose is asked to recognize odorants, however, it first has to be "trained" by exposing it to specific concentrations of known chemicals. The sensor responses are then stored for subsequent comparison with signals from sniffs of samples of related, but unknown, composition.

So far the Coventry crew has trained their 12-sensor device to distinguish among smokes from several varieties of tobacco, and aromas from five types of alcohol, including methanol and ethanol. A typical goal would be to develop the sensors into beer tasters. The brewing-company that has been partially sponsoring the group's research would like to use improved versions of such a device for maintaining consistent quality in its beers. A special challenge: consistency among beers brewed in different locations under the same label.

To push their artificial nose project further, Bartlett's team is shifting its attention to a more versatile category of sensor—"chemiresistors"—made with polymers. "You have an enormous variety of polymers you can make...and tailor to respond specifically to different odors," Bartlett says.

Moreover, the sensors are amenable to miniaturization so the group hopes to build a "nose on a chip." These might be custom-designed for almost any job a discerning canine nose might do—sniffing out truffles, say.

Like Bartlett's artificial nose, the chemical warfare detectors that Grate's group has made rely on several sensors—in this case surface acoustic wave (SAW) vapor sensors—made selective to different chemicals by a polymer coating. The detector's sniffer consists of a quartet of SAWs. Each is a match-head sized slice of quartz crystal driven electronically by on-board electrodes to vibrate at a characteristic frequency. Deposition of a chemical warfare agent onto the coated crystal increases its mass, and changes the quartz vibration frequency to a degree proportional to the mass of deposited material. The NRL detectors also rely on pattern recognition techniques to analyze the sensor's blend of signals, in this case vibration frequencies.

The NRL detector has done well in laboratory and field tests. It unerringly sounded alarms for trace levels of nerve agents and blister agents, even when the poisons were mingled with other noxious fumes from diesel, jet fuels and engine—the kind of environment one would expect around air bases under chemical attack, Grate notes.

What's more, the amounts of nerve and blister agents detected were well below the danger levels. Grate reported that the detectors never failed to find the nerve agents GD and VX at levels even below 0.01 milligrams per cubic meter of air, or a parts-per-billion level. VX is lethal at 100 milligrams per cubic meter. False alarms were rare.

SAW-based chemical weapons detectors, which could be smaller, more accurate and easier to maintain than the detectors now in the field, according to Hank Wohltjen, whose Virginia-based company, MicroSensor Systems, Inc., makes the SAW sensors that Grate's group uses. Even so, it could take decades before they see action, he says. In the more near term, SAWs probably will begin showing up in chemical detectors designed for environmental monitoring and industrial safety. "The clean air act has done a lot for business," Wohltjen says.

■ IVAN AMATO

NAE Elects New Members

The National Academy of Engineering has elected 77 new members and seven foreign associates. This brings total U.S. membership to 1580 and the number of foreign associates to 132. The new members are:

John E. Anderson, Union Carbide Corp.; **Donald W. Bahr,** GE Aircraft Engines; **James R. Biard,** Honeywell, Inc.; **Melvin Bobo,** GE Aircraft Engines; **Roger W. Brockett,** Harvard University; **Robert A. Brown,** Massachusetts Institute of Technology; **Edward J. Campbell,** Newport News Shipbuilding; **John M. Campbell, Sr.,** Campbell Petroleum Series Inc.; **Steve S. Chen,** Supercomputer Systems, Inc.; **Seymour B. Cohn,** S. B. Cohn Associates, Inc.; **Bruce G. Collipp,** marine engineering consultant, Houston, TX; **Dale L. Critchlow,** IBM Corp.; **Robert W. Dutton,** Stanford University; **Gerard M. Faeth,** University of Michigan, Ann Arbor; **Charles Fairhurst,** University of Minnesota, Minneapolis; **Edith M. Flanigen,** Union Carbide Corp.; **Maurice C. Fuerstenau,** University of Nevada, Reno; **Samuel H. Fuller,** Digital Equipment Corp.; **Alan N. Gent,** University of Akron; **James Gillin, Jr.,** Merck & Co., Inc.; **Richard E. Goodman,** University of California, Berkeley; **Bernard M. Gordon,** Analogic Corp.; **Meredith C. Gourdine,** Energy Innovations; **Donald P. Greenberg,** Cornell University; **Howard R. Hart, Jr.,** GE Research and Development Center; **George J. Hirasaki,** Shell Development Co.; **James F. Jackson,** Los Alamos National Laboratory; **Allen F. Jacobson,** 3M; **Rudolf E. Kalman,** University of Florida, Gainesville; **Frank E. Karasz,** University of Massachusetts, Amherst; **Thomas J. Kelly,** Grumman Corp.; **Robert P. Kennedy,** Structural Mechanics Consulting; **David J. Kuck,** University of Illinois, Urbana; **Leslie A. Lamport,** Digital Equipment Corp.; **Bernard LeMehaute,** University of Miami; **Walter B. Loewenstein,** energy technology consultant, Palo Alto, CA; **John L. Lumley,** Cornell University; **Thomas L. Magnanti,** Massachusetts Institute of Technology; **Frederick J. Mancheski,** Echlin, Inc.; **Robert C. Marini,** Camp Dresser & McKee Inc.; **James L. Massey,** Swiss Federal Technical University, Zurich; **Tony Maxworthy,** University of Southern California, Los Angeles; **Frank A. McClintock,** Massachusetts Institute of Technology; **Eugene R. McGrath,** Consolidated Edison Company of New York, Inc.; **James C. McGroddy,** IBM Thomas J. Watson Research Center; **Joseph Miller,** TRW Space & Technology Group; **James E. Monsees,** Parsons Brinckerhoff; **L. David Montague,** Lockheed Missiles & Space Co.; **Walter P. Moore, Jr.,** Walter P. Moore Associates, Inc.; **Van C. Mow,** Columbia University; **Earll M. Murman,** Massachusetts Institute of Technology; **Arthur A. Oliner,** Polytechnic University; **William H. Phillips,** NASA Langley Research Center; **Robert A. Pritzker,** The Marmon Group, Inc.; **Alvin Radkowsky,** Tel Aviv University; **W. Harmon Ray,** University of Wisconsin, Madison; **Kenneth F. Reinschmidt,** Stone & Webster Engineering; **Richard J. Robbins,** The Robbins Co.; **William B. Rouse,** Search Technology Inc.; **Harvey W. Schadler,** GE Research and Development Center; **Warren G. Schlinger,** Texaco, Inc.; **F. Stanley Settles,** Allied-Signal Aerospace Co.; **Richard W. Skaggs,** North Carolina State University, Raleigh; **Hermann Statz,** Raytheon Co.; **Richard S. Stein,** University of Massachusetts, Amherst; **William Streifer,** Spectra Diode Laboratories; **Werner Stumm,** Swiss Federal Institute of Technology, Duebendorf; **Robert L. Taylor,** University of California, Berkeley; **Robert W. Taylor,** Digital Equipment Corp.; **Donald O. Thompson,** Iowa State University, Ames; **Rao R. Tummala,** IBM Thomas J. Watson Research Center; **Irving T. Waaland,** Northrop Corp.; **Sheldon M. Wiederhorn,** National Institute of Standards and Technology; **Charles M. Wolfe,** Washington University, St. Louis; **Henry T. Y. Yang,** Purdue University; **John A. Young,** Hewlett-Packard Co.; **Charles A. Zraket,** The MITRE Corp.

The new foreign associates are:

Odd M. Faltinsen, Norwegian Institute of Technology, Trondheim; **Shoichi Saba,** Toshiba Corp., Tokyo; **Klaus Schoenert,** Technical University of Clausthal, Clausthal-Zellerfeld, Germany; **Tadahiro Sekimoto,** NEC Corp., Tokyo; **Helmut E. Sobieczky,** German Aerospace Research Establishment, Goettingen; **Gunnar H. Sohlenius,** The Royal Institute of Technology, Stockholm; **Zehev Tadmor,** Israel Institute of Technology, Haifa.