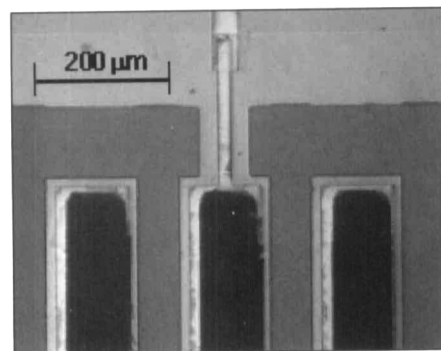
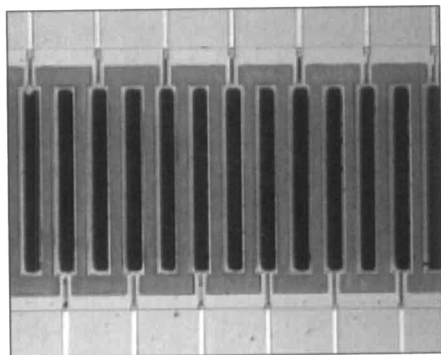


Low-Noise, Uncooled PZT Thin-Film Pyroelectric Detector Array Fabricated on Micromachined Silicon

Infrared gas spectrometers suffer from the fact that available detector arrays (semiconductors, thermopiles, bolometers) usually need an expensive temperature stabilization or cooling in order to yield a sufficient resolution in the ppm range. Pyroelectric detectors are known to have a very low noise contribution at room temperature, thus offering a high signal-to-noise ratio in the wavelength range of 3–12 μm .

The advent of thin-film technology makes it now possible to build those detectors very cost-effectively as arrays for spectrometry applications. The integration of a monolithic linear detector array as a thin film onto silicon offers a low thermal time constant, and the complete system is capable of simultaneous detection of different gases without any moving part or cooling equipment. The resulting system is very compact and yields a low-cost solution for industrial and environmental monitoring applications.

Bert Willing, Paul Mural, and T. Reimann of the Swiss Federal Institute of Technology in Lausanne and Oscar Oehler of Oehler & Fischer AG in Zürich have



Partial views of a fabricated 1×64 pixel pyroelectric detector array.

developed a 1×64 pixel pyroelectric detector array (sensitive area per pixel of $100 \times 1000 \mu\text{m}^2$) integrated on silicon (see Figure). The pyroelectric layer is a $\text{Pb}(\text{Zr,Ti})\text{O}_3$ -based film of typically 1- μm thickness deposited by sol-gel techniques. The demonstrators were done with $\text{Pb}(\text{Zr,Ti})\text{O}_3$ with 15% Zr and 85% Ti (i.e., PZT 15/85). The sol-gel technique consists of a spin coating on 4-in. wafers with crystallization in an RTA at 650°C. The sol was fabricated using a methoxy-route. The bottom electrode is Pt. The arrays are fabricated by photolithography and silicon micromachining on top of a thermally insulating membrane and show a high absorption coefficient from the visible to the far-infrared spectrum. Thermal crosstalk between adjacent elements amounts to 20%. Micromachining processes are mostly standard (lift-off, wet etching, dry etching) and backside etching by KOH.

The detector is mounted to an infrared spectrometer fitted either with a 50 lines/mm or a 20 lines/mm grating so that the 64 pixels of the detector cover the wavelength range of 3–5 μm and 8–12 μm , respectively. The infrared radiation is emitted by an aperture-matched thermal emitter, and readout of the pyroelectric signal is accomplished by a dedicated CMOS integrated circuit of 4×16 channels (digital 12-bit output). This ASIC, developed by the Electronics Laboratory, forms a substantial part of the product, as it is tailored to yield an internal noise smaller than the detector noise.

The performance of the spectrometer has been evaluated by reading out the ASIC signals by a simple RS232 interface card into a PC, thus recording the quantitative absorption spectra in the presence of different gases, including CO_2 , CO, and various solvents. The present resolution of this setup is about 3 ppm CO_2 and 40 ppm CO.

The detector unit will be commercialized by the beginning of next year through a start-up company at EPFL in Lausanne. The researchers have previously presented their results in *Infrared Physics & Technology* 39 (1998) p. 443 and at the Transducers 99 conference in Sendai, Japan, in June 1999.

Porous, Metallic, Nanostructured Material Formed on Colloidal Crystal Substrate

Using colloidal crystals as a substrate, researchers in the Department of Chemical Engineering at the University of Delaware have synthesized a class of porous, rainbow-colored, metallic, nano-

structured materials. As reported in the October 7 issue of *Nature*, the scientists formed the material from monodisperse, negatively charged polystyrene latex microspheres 300 nm to 1 μm across. They poured a watery solution containing the latex particles onto a polycarbonate membrane consisting of 50-nm pores. While the water escaped, the latex beads remained trapped on top. After depositing hundreds of layers of latex, gold particles 1/10th the size of the polymer beads were slowly filtered onto them to fill the gaps between neighboring spheres.

The scientists then removed the latex. They created multicolored metal with pores about 600 nm wide by heating the latex and fusing the gold for 30 min at 300°C. For a sample with both large and small pores, the researchers instead chemically oxidized and dissolved the latex.

Because the material is riddled with regularly spaced holes only slightly wider than the wavelength of light, it acts like a prism, diffracting a spectrum of colors from gold and blue to red, green, and purple. Research assistant professor and lead author Orlin D. Velev said, "It reflects different wavelengths of light, just like opal, only it's much sturdier."

Eric W. Kaler, the University's Elizabeth Inez Kelley Professor of Chemical Engineering and chair of his department, said that the holes in the material are 20,000 times smaller than the pores in an existing metal mesh that can be used to direct radar waves. He said, "It should help guide the much shorter light waves, perhaps in photo-optic computer components." He said that such devices will be crucial in next-generation computers because "fiber optics can't turn sharp corners, and you don't have much room to maneuver in nanoscale devices."

Velev said that in the past, researchers have used ion beams to drill individual holes into metals, one pore at a time. Kaler said, "Our system is a very powerful, versatile way to make porous nanostructures in a variety of materials."

ARPES Study of Cuprates Suggests Stripe Phase as Starting Point to Understand High- T_c

A team led by investigators from Stanford University and Lawrence Berkeley National Laboratory has gathered information about the electronic structure of the "stripe phase," described as a charge- and spin-ordered state of solids. Their report, in the October 8 issue of *Science*, may help resolve an apparent paradox between different theories of

superconductivity.

The researchers used angle-resolved photoemission spectroscopy (ARPES) to study the stripe phase in the compound Nd-LSCO [(La_{1.28}Nd_{0.6}Sr_{0.12})CuO₄]. Plots of the resulting "spectral weights" at high energies were consistent with charges moving through the Nd-LSCO sample along one-dimensional lines, so-called stripes, but at lower energies the pattern was more easily explained if the charges were moving in two dimensions—behavior that appears to require two different theoretical explanations.

The parent compounds of cuprates are insulators; their complex structure, similar to that of the mineral perovskite, alternates two-dimensional layers of oxygen and copper atoms with layers of other atoms. Cuprates are made more metal-like, and in some cases superconducting, by doping which contributes extra electrons or creates holes to carry negative or positive charges.

Xingjiang Zhou of Stanford said, "With Nd-LSCO we found that at about 1/8 doping level, the picture that best fits the data was the stripe phase—charge carriers segregating themselves into one-dimensional lines. In the regions between these lines, electronic spins are arranged antiferromagnetically," producing insulating regions.

Nd-LSCO has static stripes and is not superconducting, but in those cuprates that are superconductors, dynamic stripes may come into play and become associated with superconductivity. Whether the stripe phase is actually responsible for high-temperature superconductivity, however, remains the subject of vigorous debate. The underlying theory which gives rise to the stripe phase, mean field theory, paradoxically suggests that the stripe phase should always be insulating.

The traditional electronic theory of metals describes how quasiparticles experience the field of a solid's crystal lattice. At low energies, the charge carriers in Nd-LSCO appear to interact with variations in the field due to the crystal lattice. The carriers move back and forth in a two-dimensional manner and exhibit low-energy states comparable to those observed in good superconductors. But other expected two-dimensional effects are missing from the ARPES data.

Established theories also describe a characteristic Fermi surface that marks where (in momentum space) a given material's uppermost energy level is filled with electrons. At high energies, the Fermi surfaces in Nd-LSCO plot as straight lines set at right angles, indicating that the charge carriers move along one-dimensional bands—features which



Barbara Hope Cooper, a distinguished physicist and teacher, died on August 7. She had been under treatment for lung cancer for six months.

Born in Lancaster, Pennsylvania, on September 1, 1953, Barbara came to Cornell University for her undergraduate work, intending to prepare for medical school. Her studies were interrupted when she sustained a back injury from an accident during her sophomore year on the diving team. Unable to take classes for a semester, she obtained an undergraduate research position at the Laboratory of Nuclear Studies and fell in love with physics. She graduated from Cornell with a BA degree in physics in 1976 and went on for graduate study at the California Institute of Technology, where she obtained her PhD degree in 1982. She remained at Caltech as a postdoctoral fellow until she joined Cornell University as an assistant professor in 1983.

Barbara is best known for her work on the fundamental aspects of low-energy ion-surface collisions. Soon after joining the Cornell faculty, she and her students built a versatile apparatus for studying low-energy ion scattering, and successive generations of graduate students have worked to refine this system during the course of their theses. By choosing the scattering of alkali-metal ions from single-crystal copper surfaces as a model system, her research group was able to illustrate a wide range of phenomena associated with ion-surface collisions. The rich data sets from scattering experiments were used to derive highly refined interatomic potentials. The use of these interatomic potentials in trajectory simulations constituted an important step in her work. The simulations were used to elucidate many observed trends in scattering and trapping, such as the nonmonotonic energy dependence of alkali-ion trapping on copper. Also, her group's detailed measurements of the charge states of scattered species and of the production of excited neutral atoms in ion-surface collisions led to the development of a many-body theory of charge transfer by Brad Marston at Brown University.

Barbara recognized the diverse applications of energetic ions in materials research and extended her research program to investigate thin-film and surface phenomena. She began in 1988 by building a scanning tunneling microscope, at the time one of the few that used a thermally compensated tube scanner. The STM was used to demonstrate adsorbate effects on decay of monolayer deep pits and islands, an important issue for anyone studying surface physics. More recently, she led a collaboration to investigate the generation of nanoscale patterns by ion erosion. She had plans for combining x-ray scattering at the Cornell synchrotron facility with STM to obtain a detailed understanding of energetic beam effects on film growth, work that will be continued by her colleagues and graduate students.

Barbara Cooper's contribution to physics was recognized through the American Physical Society's Maria Goeppert-Mayer Award in 1992, a prize recognizing outstanding achievement in her early career. She was the recipient of the Presidential Young Investigator Award from the National Science Foundation and faculty development awards from IBM and AT&T. She published over 45 journal articles and scholarly reviews, and regularly received invitations to speak at conferences around the world.

Her scientific leadership was vital to two of Cornell's interdisciplinary research centers, the Cornell Center for Materials Research (CCMR) and the Cornell High Energy Synchrotron Source (CHESS). She had an unusual talent for organizing large, diverse groups of scientists and engineers into effective collaborations.

Barbara was the lead organizer for the Materials Research Society Symposium L on Low-Energy Beam-Modified Surface Growth and Processing at the 1999 MRS Fall Meeting. Her role was filled by the co-organizers Eric Chason (Brown University), Tomas Diaz de la Rubia (Lawrence Livermore National Laboratory), James Harper (IBM T.J. Watson Research Center), and Ramana Murty (Argonne National Laboratory). The *Proceedings of Symposium L* will be dedicated to the memory of Barbara Cooper.

A dedicated teacher, she rebuilt introductory physics laboratory curricula at Cornell, providing students with concrete examples of difficult physics concepts. Her eight-year-old daughter Katie motivated her to take a special interest in outreach programs aimed at young elementary-school students.

It was always a pleasure to talk to Barbara and her husband Chris, a research associate at the Cornell Theory Center, about anything from science to culture to sports. I first met Barbara when I was a graduate student at Caltech. She surprised me by saying that she had read my two papers and was familiar with my work, a great comfort for a graduate student wondering if his work was ever noticed. Barbara understood the tough demands on graduate students and postdocs. She sportingly accepted night shifts during beamtime at CHESS. While she was undergoing treatment for cancer, her home became the venue for discussions as she kept engaged in the activities in her lab. With her death, we have lost an advocate for basic science. Her leadership will be missed by colleagues and friends, but her contributions to physics and materials research will endure.

RAMANA MURTY

could not arise from the quasiparticles of traditional electronic theories.

To resolve the paradox, Zhou said, "Instead of the quasiparticles that are responsible for superconductivity in ordinary metals, in the cuprates one may have to start with the stripes themselves, along which charge flows freely. The stripes appear stable at high energies, but at lower energies they may exhibit quantum fluctuations that give rise to two-dimensional effects."

While the compound investigated is not a superconductor, the researchers said that by understanding its electronic structure, scientists may further their understanding of its high- T_c relatives.

Two-Photon Fluorophore Optically Tracks Chemotherapeutic Agent

Scientists at the University at Buffalo and Tulane University have optically tracked in real-time the pathway of a widely used cancer drug linked to a peptide hormone carrier as it is being taken up by a human breast-cancer cell. The research, published in the September 1999 issue of *Proceedings of the National Academy of Sciences*, provides researchers with evidence that the chemotherapeutic agent AN-152 directly enters cancer cells, accumulates in the nucleus and possibly associates with the cell's chromosomes, as had been suspected.

For this research, the scientists at the University of Buffalo custom-designed C625 [4-(N,N-diphenylamino)-4'-(6-O-hemiglutarate)hexylsulfanyl stilbene], which simultaneously absorbs two photons of light at 800 nm and emits light in the visible range. This allows it to be used with the two-photon laser-scanning microscope. The material's two-photon capabilities allow the scientists to use infrared light to cause C625 to fluoresce. The agent AN-152 was first synthesized by Andrew V. Schally, 1977 Nobel laureate in medicine, and Attila Nagy, associate professor of medicine at Tulane University. It is a combination of the commonly used chemotherapeutic agent doxorubicin (Dox), which is linked to a luteinizing hormone-releasing hormone (LH-RH) analog that targets only cells with LH-RH receptors on them. This makes AN-152 specific to cancers of the ovary, breast, cervix, and prostate, and possibly others possessing LH-RH receptors as well. The researchers conjugated C625 to the 3' amino group of the Dox part of AN-152. They also coupled the fluorophore to the primary amino groups on the LH-RH analog and Dox separately, which made it possible to

track each of the drug's components separately (i.e., AN-152:C625, LH-RH:C625, and Dox:C625).

E.J. Bergey, a research assistant professor in the Department of Chemistry at Buffalo, said, "The advantage of using two-photon laser-scanning microscopy is that the short-pulsed near-infrared light used to excite the C625 avoids injury to the cell, thus allowing repeated examination of living cells." Generation of the

image is done by optical sectioning of cells treated with AN-152:C625, where a beam of light from the microscope is focused on different planes of the cell, one at a time. The researchers took time-sequence images of the cells every minute for more than 1 h. Paras Prasad, SUNY Distinguished Professor in the Department of Chemistry at Buffalo and executive director of Buffalo's Institute for Lasers, Photonics, and Biophotonics, said,

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"When the AN-152:C625 is outside of the cell, we do not see it because the concentration is too low. But you begin to see it accumulate on the cell, then in the cytoplasm, and finally in the nucleus. This whole process takes about half an hour."

The researchers reported that the LH-RH analog apparently facilitates the delivery of the agent to specific cell lines. Under certain conditions, the cells treated with AN-152:C625 and LH-RH:C625 became visible within 5 min, while those stained with Dox:C625 became visible after 15 min. After 30 min, the fluorescence intensity of LH-RH:C625 and AN-152:C625-treated cells was significantly higher than for those treated with Dox:C625. After 20 min, the researchers observed that the labeled AN-152 entered the nucleus in most cells. With further experimentation, the researchers also demonstrated that entry of the drug into the cell was not due to the attachment of chromophore.

The researchers said that these results pave the way for similar studies with other two-photon fluorescent probes. This allows cancer researchers to determine how cancer cells take up other chemotherapeutic agents as scientists aim to improve current methods for cancer therapy.

Tabletop Laser System Utilized for Isotope-Separation Process

Using an ultrapowerful laser system that sits on a tabletop, researchers at the University of Michigan have demonstrated a way to separate different forms of the same chemical element. As reported in the September 27 issue of *Physical Review Letters*, this technique provides an alternative to the bulky Manhattan Project-era methods of separating chemical isotopes, and opens new possibilities for preparing medical compounds and making ultrapure thin films which can be used as electronic devices.

In their demonstration, Peter Pronko and his colleagues at the university hit BN and GaN targets with laser pulses of 150–200 fs at 780 nm wavelength, with typical laser intensities of 10^{13} – 10^{15} W/cm². When aimed at a target containing the isotopes of interest, the pulse vaporized some of the isotopes, which escaped in the form of ions. Intense magnetic fields associated with the pulses exerted forces on the ions which deposited them at different locations (depending on the isotope's weight) on a silicon disk placed 7 cm from the target.

With their technique, the researchers separated B¹⁰ from B¹¹ and Ga⁶⁹ from Ga⁷¹. When observed in a chamber, and with

the introduction of a background gas of 0.8 mTorr N₂ in the ablation chamber, the ratio of the total ion counts of B¹⁰ to B¹¹ was found to be 0.66 (vacuum) and 0.55 (N₂ backfill). In similar experiments performed with Ga, trends in the energy distributions for Ga were similar to that for B.

The researchers, P. Pronko, P.A. Van Rompay, Z. Zhang, and J.A. Nees, envision using their technique to deposit pure thin films of isotopes directly onto micro-electronic devices.

Bone Flute Found in China at 9,000-Year-Old Site Reveals Musical Capabilities during Neolithic Period

Recent excavations at the early Neolithic site of Jiahu, located in Henan Province, China, have yielded six complete bone flutes between 7,000 and 9,000 years old. Fragments of approximately 30 other flutes were also discovered. The flutes may be the earliest complete, playable, tightly dated, multinote musical instruments. As reported in the September 23 issue of *Nature*, the exquisitely crafted flutes are made from the ulnae, or wing bones, of the red-crowned crane (*Grus japonensis* Millen) and have five, six, seven, or eight holes.

The best-preserved flute, which contains seven holes plus an additional tiny hole near the seventh, has been played and tonally analyzed in tests at the Music School of the Art Institute of China. Tonal analysis of the flutes revealed that the seven holes correspond to a tone scale similar to the Western eight-note scale. Tests also showed that the tiny hole near hole 7 was probably drilled to correct the off-pitch tone of the original hole 7. The carefully selected tone scale suggested to the researchers that the Neolithic musician could play not just single notes, but music.

The excavations and ¹⁴C dating were carried out by researchers from the Institute of Cultural Relics and Archaeology of Henan Province, Zhengzhou, China; the Archaeometry Laboratory at the University of Science and Technology of China; and the Paleobotany Laboratory, Academia Sinica, Beijing, China.

To hear an audio recording of the flute, go to Web site www.bnl.gov/bnlweb/flutes.html.

Oxychlorate of Bohrium-267 Shown to be Volatile at 180°C

An international collaboration of radiochemists has used the cyclotron at the Paul Scherrer Institute (PSI) in Bern, Switzerland, to determine the volatility of bohrium, element 107, the heaviest element yet

whose chemistry has been successfully investigated. Crucial to the research was the use of an isotope of bohrium with a relatively long half-life of about 15 s, detected earlier this year by researchers at Lawrence Berkeley National Laboratory and the University of California—Berkeley. Although several elements heavier than bohrium have been identified, including the discovery within the past year of elements 118, 116, and 114, the correct placement of the heaviest elements in the periodic table is under study.

The cyclotron yielded about three atoms of bohrium during a day of beam time, but only four bohrium nuclei were detected in the first two weeks of the volatility experiment. The researchers used a beam of neon 22 to bombard a target of berkelium 249, which has a half-life of 320 days. Immediately after bombardment, the reaction products were swept into an automated isothermal system developed by Heinz Gäggeler, leader of the team, and his colleagues. There, reaction products formed molecules in oxygen-containing hydrogen chloride gas. These oxychlorides were then passed through a chromatography column, in which the more volatile species pass through at lower temperatures. In this system, the bohrium 267 compound was shown to be volatile at 180°C.

The four bohrium atoms were found only after they had passed through the chromatography column, when the oxychloride molecules containing them were deposited on a rotating detector that carried each small sample under a set of radiation detectors. Bohrium 267 was unambiguously identified by the pattern of its alpha decay, first to dubnium 263, then to lawrencium 259, and subsequently to mendelevium 255.

Because the positive charge of a heavy nucleus is so great, the electronic structure of the atom is distorted. These so-called "relativistic effects" can produce unexpected deviations from chemical properties extrapolated from the element's lighter homologues in the periodic table.

Bohrium may also prove to deviate in this way. The oxychloride of bohrium was shown to be volatile at 180°C, similar to its lighter homologues in Group VII of the periodic table, such as rhenium and technetium. Continuing experiments will determine whether bohrium is also volatile at lower temperatures. Technetium, for example, is volatile at 50°C, and rhenium at 75°C, under the same conditions.

The need to develop techniques for understanding the chemistry of the heaviest elements is partly driven by the search for the "island of stability," a group of

superheavy elements whose nuclear-shell structure is predicted to make them stable for hundreds or thousands of years or longer, instead of for mere seconds or milliseconds. Isotopes with the number of neutrons required to reach the island of stability have not yet been created.

Meanwhile, however, there is a region of relative stability due to "deformed shells" at lower neutron and proton numbers, which include bohrium 267. Thus chemical studies of bohrium are not only intrinsically interesting, but also aid in the quest for the island of stability.

Gäggeler said, "In the discovery experiments of new elements, only the existence of a new, very heavy atomic nucleus is demonstrated, but no information about its chemical properties is obtained." To date, the heaviest element whose chemical properties have been widely investigated by experiment is seaborgium, element 106.

Darleane C. Hoffman of UC—Berkeley and a longtime collaborator with Gäggeler's team said, "Elements beyond 100 are made an atom at a time, with very low production rates, and have very short half lives. The chemistry of the heavy elements requires separations that come to equilibrium very rapidly, and these must be valid on an atom-by-atom basis." Such atoms are created in the laboratory by bombarding heavy target nuclei with an

accelerated beam of projectile ions. The nuclei of interest, which are created by the evaporation of a few neutrons, are only a very small fraction of the huge number of reaction products produced.

Quinoline Contaminant Found Likely to Become Strongly Bound to Soil in Absence of Humus

A group of researchers from The Pennsylvania State University and Ohio State University has shown that, for some fossil-fuel-based pollutants, increasing the humus content of the soil increases, rather than decreases, the likelihood that the contaminant will move to ground water. Jon Chorover, assistant professor of environmental soil chemistry at Penn State, said, "The general belief is that, as you increase the organic matter in soil, you increase the retention of contaminants. We found that that is not always the case. It depends on the nature of the compound."

Chorover and his colleagues looked at quinoline, a nitrogen heterocyclic compound (NHC) that has been little studied to date. Quinoline belongs to the broad group of environmental contaminants termed ionizable PACs (polycyclic aromatic compounds), often found in sites polluted by fossil fuels, solvents, greases, creosote, and coal tar. They found that if a

kaolinitic clay soil is low in organic matter, quinoline is more likely to become strongly bound to the soil and less likely to move to ground water.

As reported in the October 1999 issue of the *Soil Science Society of America Journal*, mineral interactions with humus were key to whether quinoline was retained in soil. When humic substances coated the kaolinite specimen, quinoline was less likely to adhere. However, when the mineral phase was uncoated, quinoline bound strongly. The data also suggest that quinoline is relatively mobile in subsurface soil environments. The researchers measured the adsorption of quinoline and background electrolyte (LiCl) onto the specimen clay as a function of surface-bound humic acid (HA) concentration ($f_{OC} = 0-0.5\%$), pH (3-10), and ionic strength (1-10 mM). Coating the kaolinite surface with HA reduced the point of zero net charge for the sample by more than one pH unit and increased the negative surface charge. The researchers found that adsorption of organic matter on the surface increased the negative charge on the surface, but this did not result in an increase in retention of the cationic quinoline ("quinolinium ion," QH^+). When studying the effects of ionic strength, f_{OC} , and pH on quinoline sorption to kaolinite-humic complexes, the researchers found that increasing the ionic strength and f_{OC} prevented quinoline sorption. "For f_{OC} values of 0% and 0.43%, the tenfold increase in ionic strength resulted in 36% and 47% reductions in [sorption], respectively." At intermediate HA coverage, the researchers found that changes in ionic strength had no apparent effect on quinoline sorption.

The researchers furthermore found that the NH_4^+ exchange of quinolinium is less than 100% effective at low pH. They reported that in the acid pH range, adsorption of ionized quinoline (QH^+) predominates during a $Li^+ \rightarrow QH^+$ exchange. When studying quinoline sorption to HA, the researchers found that quinoline sorption decreased up to 55% with increasing ionic strength from 1 to 10 mM because of increased Li^+ competition for sorption sites. The researchers account overall for the differential sorption of the quinolinium cation to kaolinite, HA, and kaolinite-humic complexes due to competition with Li^+ on cation exchange sites. Quinoline, they said, is competitive for sorption which is less reversible on negatively charged sites of the specimen clay surface than on dissociated functional groups of HA.

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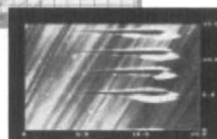
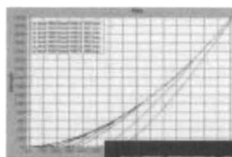
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Fused Silica Microdevice Aids Sequencing of DNA

In the September issue of *Genome Research*, researchers at Whitehead Institute for Biomedical Research in Cambridge, Massachusetts, reported the sequencing of "real-world" DNA samples with a microdevice fabricated from glass wafers. Dieter Schmalzing, Daniel Erlich, and colleagues set the goal of using a microdevice to sequence "typical" human DNA samples, as prepared for the Human Genome Project. To make the device, they chemically etched fused-silica wafers (150 nm in diameter) with long, microscopically thin channels 0.01 cm wide and about 12 cm long. The 1.0-cm-long loading channel intersects the separation channel at 0.5 cm below the cathodic end and connects the sample and waste reservoirs. Using short side channels that are 0.5 cm long, 40 μm deep, and 90 μm wide, the researchers injected plugs of DNA, labeled with fluorescent dyes, at one end of the channels. They then applied an electric field to the device to separate and move the DNA strands down the length of the channels, over a fluorescence detector that identified the components of the DNA. The researchers analyzed 12 samples of chromosome 17, six sequenced under Condition 1 of 4% (wt/vol) linear polyacrylamide (LPA) at 200 V/cm and six under Condition 2 of 39% LPA at 150 V/cm. They reported that electrophoresis of the first condition resulted in an average read length of 460 bases in an average total run time of 21.7 min. The second condition produced an average read length of 505 bases in an average 26.7 min. The researchers said, "The extended read of C2 [Condition 2] can be attributed to relative reductions in voltage and LPA concentration, which usually improve the electrophoretic separation of longer DNA fragments."

An analysis of errors showed that most of the runs were error-free between 100 and 450 bases. They attributed the majority of errors (19 of 23) from 451 to 500 bases to multiplets and suggest that "further adaptation of the sequencing software for microdevice electrophoresis could reduce this type of error and lead to longer average read lengths."

The signal-to-noise ratio was reported to vary between 30 and 70 from run to run, which the researchers noted as an improvement over the use of capillary machines: "The signals remained relatively stable in amplitude during the microdevice runs and did not decrease with increasing DNA fragment size, as is often

observed for capillary electrophoresis."

With use of the microdevice, no sample clean-up is necessary other than ethanol precipitation, and the researchers attribute the reduction of DNA fragment blasing to the injection mechanism of the device. They reported that the unique injection mechanism "led to increased signal strength for long fragments, which is of great importance for the high performance of the microdevice." Their research demonstrates possibilities for convenient, low-cost sequencing machines.



Merton C. Flemings Receives National Materials Advancement Award

The National Materials Advancement Award was presented by the Federation of Materials Societies to Merton C. Flemings of Massachusetts Institute of Technology at a reception at the National Press Club in Washington, DC, on December 8, 1999. The National Materials Advancement Award recognizes individuals who have demonstrated their outstanding capabilities in advancing the effective and economic use of materials and the multidisciplinary field of materials science and engineering generally, and who contribute to the application of the materials profession to national problems and policy.

Currently director of the MIT Center for the Singapore-MIT Alliance, Flemings' career at MIT has ranged from Assistant Professor to Toyota Professor of Materials Processing. He established and was the first director of the Materials Processing Center at MIT in 1979. He was Visiting

SBIR Update

Diversified Technologies, Inc. (DTI) (Bedford, Massachusetts) is the recipient of six Small Business Innovation Research awards. Five of the grants, from the Department of Energy (DOE), call for DTI to apply solid-state switching technology to DOE development programs. Each grant carries an initial value of approximately \$100,000. The sixth award is a Phase II SBIR contract from the Office of Naval Research, having a value of up to \$2 million. Under this contract, DTI will build an advanced transmitter for compact, high-power radar systems.

Professor at Cambridge University, Tokyo University, and École des Mines.

Flemings' research and teaching concentrate on engineering fundamentals of materials processing and on innovation of materials-processing operations. He is active nationally and internationally in strengthening the field of materials science and engineering and in the delineation of new directions for the field. He has worked closely with industry and industrial problems throughout his professional career and currently serves on a number of corporate and technical advisory boards. He chaired the 15th Biennial Conference on National Materials Policy, sponsored by the Federation of Materials Societies. He is a member of the National Academy of Engineering and the National Academy of Arts and Sciences. Among his awards is the Materials Research Society's (MRS) 1997 David Turnbull Lectureship.

The Federation of Materials Societies is a consortium of technical and professional societies and associations whose constituencies include scientists, engineers, and other professionals active in the areas of materials policy as well as research and development, processing, manufacturing, recovery, and resource availability.

Dierk Raabe Named Director of New Department at Max-Planck-Institut für Eisenforschung, Düsseldorf

Dierk Raabe has moved from the Department for Materials Science at Carnegie Mellon University, Pittsburgh, to a new position as director and department head at Max-Planck-Institut für Eisenforschung in Düsseldorf, Germany. The new department, named Microstructure and Metal Forming, will cover a broad range of aspects from microstructure theory to applied issues associated with industrial casting, forming, and thermal process operations. The department has four scientific groups—Theory and Simulation, Diffraction and Microscopy, Thermomechanical Processing, and Metal Forming—and four service groups in the fields of Materials Testing, Metallography and Diffraction, Computation, and Processing. The basic idea behind the new department structure is to establish a highly interdisciplinary research center which aims at merging microstructure research and materials processing on the one hand and theory, simulation, and experiment on the other hand. Concerning the materials, emphasis will be placed on steels, intermetallics, and non-ferrous alloys. □