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In This Issue

4
Investigating a Viable Fuel Form for ATW

Focus on Students:

6
Students are Vital to the Lab

8
Nuclear Engineer Steven Alferink

10
Social Scientist Andrew Koehler

12
Chemist Susan Oldham

14
Newsmakers

Improved Differential Scanning Calorimeters Enable Scientists to Make More-Accurate Studies of Plutonium and Its Alloys

The Stockpile Stewardship Program has created a renaissance in plutonium materials science at Los Alamos with its mandate to manufacture new pits as well as to understand in detail the effects of aging on older stockpile weapons.

Scientists conducted research on metallic plutonium and plutonium alloys throughout the 1950s, '60s, and early '70s, but materials research in this area slowed significantly in the following years. The Lab's commitment to stockpile stewardship has mobilized a strong effort in the Nuclear Materials Technology (NMT) and Materials Science and Technology (MST) divisions to push the understanding of plutonium and its alloys to a new level.

Researchers are using a technique called power-compensated differential scanning calorimetry to study phase transformations in plutonium. In this close-up, a capsule containing a plutonium specimen (the small white container held in the tweezers) is being loaded into one of two furnaces in a calorimeter. The furnaces are the recessed areas in the center of the photo. The plutonium specimen will be placed in the furnace on the left; the furnace on the right remains empty and is used as a reference.

continued on page 2

Differential Scanning

This article was contributed by **Dan Schwartz** (NMT-16) and **Tom Zocco** (NMT-5).

continued from page 1

One area of materials research receiving renewed attention is the thermodynamics of phase transformations and self-irradiation in plutonium and its alloys.

This area of study is particularly interesting to researchers because plutonium undergoes more phase transitions than any other element. It transforms through six different crystal structures (alpha, beta, gamma, delta, delta prime, and epsilon) at atmospheric pressure as it is heated from room temperature to its melting point.

Researchers are using a powerful technique, differential scanning calorimetry, or DSC, to further the understanding of the plutonium's phase transitions and study the transformation phenomena in detail.

The type of DSC primarily used here, "power-compensated" DSC, was developed in the mid-1960s to improve measurements of key thermodynamic properties of materials.

In recent years, DSC has undergone significant improvements in sensitivity and control, allowing researchers to revisit old areas of plutonium research with new levels of accuracy.

The improved instruments also are allowing scientists to explore new areas of research that previously were beyond the capability of older DSC instruments.

The state-of-the-art differential scanning calorimeter used today at the plutonium characterization laboratories in the Chemistry and Metallurgy Research (CMR) Building is composed of two independent furnaces. One furnace contains a specimen for analysis while the other is empty and used as a reference.

The furnaces are heated by separate elements that follow a programmed temperature vs. time profile.

A compensating circuit maintains the temperature difference between the specimen and reference furnaces as close to zero as possible, while the instrument measures the amount of power input that is required to keep the temperature difference to a minimum.

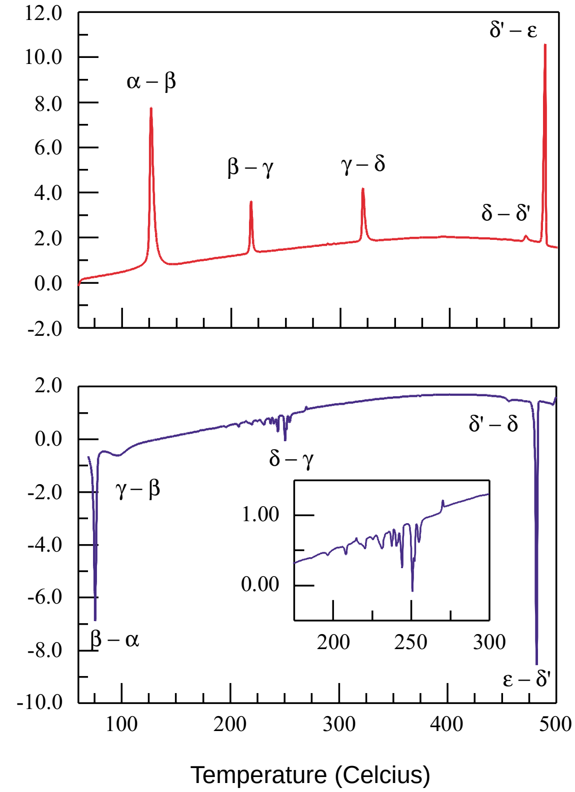
This power input is directly related to the heat required to change the temperature of the specimen—a quantity called the heat capacity of the specimen.

A simple integration of the power input over time yields another important thermodynamic quantity—enthalpy. When a material undergoes a phase transition (for example, when it melts or changes crystal structure), it either releases or absorbs heat.

Researcher Dan Schwartz of Nuclear Materials Science (NMT-16) loads a capsule containing a plutonium specimen into the furnace of a differential scanning calorimeter. Once Schwartz loads the specimen, he will close the cover over the furnaces and begin the measurement. Everything is done in a ventilation hood to protect the operator from the plutonium specimens during the loading and unloading process. The equipment is located in the plutonium characterization laboratories in the Chemistry and Metallurgy Research (CMR) Building.

In power-compensated DSC, this causes the instrument to increase power input to compensate, until the phase transition is complete. The DSC instrument in the CMR Building is capable of measuring with high purity standards the onset temperature for phase transitions to an accuracy of plus or minus 0.05 degrees Celsius, and heat capacity and enthalpy to plus or minus 2 percent.

The instrument also is capable of



These graphs show heat flow as a function of temperature for pure plutonium. The top graph shows the heating curve; the bottom graph shows the cooling curve.

making these measurements at temperatures ranging from minus 150 C to 730 C.

Recently, the availability of very high purity zone-refined plutonium, manufactured by Jason Lashley of Structure and Property Relations (MST-8), prompted researchers to remeasure the onset temperatures and enthalpies for all the phase transitions in plutonium.

The measurements resulted in slightly different values for temperature and enthalpy, and are considered by many researchers to be the most accurate values measured to date.

A DSC scan of a plutonium sample showed some unusual features of the phase transitions. When heated from room temperature to about 500 C, the phase transitions appeared normal and well defined. However, when the sample was cooled to room temperature, things changed drastically.

In the scan, the delta-to-gamma cooling transition was no longer seen as a single distinct peak, but instead was seen as a set of small, irregular peaks that occurred over a broad temperature range.

In addition, the gamma-beta transition was seen to be much broader than usual after cooling and suppressed by approximately 100 C below its heating onset. Los Alamos researchers are making detailed studies of this anomalous behavior.

Delta-phase plutonium is desirable for use in many weapons systems because it is tough and malleable. However, the delta phase isn't stable at room temperature unless the plutonium is alloyed with elements such as aluminum, gallium, or indium.

Because of differences in diffusion rates for these alloying elements in the high-temperature phases of plutonium, they can be unevenly distributed in the plutonium. This inhomogeneous distribution of alloying elements is generally undesirable, because regions of the material that are low in alloy content will behave more like pure plutonium, while the regions high in solute content will be delta-stabilized.

DSC scans of these inhomogeneous materials show phase transition peaks expected for pure plutonium, and measurement of the heat released during these transitions can be used to calculate the volume fraction of material that has a low solute content.

This volume fraction is a quantitative measure of how inhomogeneous the plutonium alloy is, which is important to know when manufacturing with plutonium alloys.

DSC also may prove useful for observing homogenization in action. When an inhomogeneous plutonium alloy containing aluminum, gallium, or indium is heated, solute begins to diffuse and redistribute itself evenly throughout the material.

This solute redistribution process, called homogenization, releases heat that the DSC instrument can measure. By observing changes in the heat released during homogenization, researchers hope that the rate of homogenization can be quantified.

For a variety of reasons, however, this kind of measurement pushes the limits of sensitivity and stability for even the most advanced DSC instruments. Recent results suggest that

continued on page 15

Fuel Form for ATW

This article was contributed by **Robert W. Margevicius** (NMT-15).

Researchers Investigate a Viable Fuel Form for Accelerator Transmutation of Waste

NMT Division Assists R&D Effort in Advanced Nuclear Fuels

People in the United States currently get about 20 percent of their power from the approximately 100 operating commercial nuclear reactors in this country.

There are more than 400 commercial nuclear reactors supplying energy around the world. Nuclear power is economically competitive and has several advantages over fossil-fuel-burning plants, including no carbon monoxide and nitrous oxide emissions.

However, among the disadvantages, the "waste product" from nuclear power—namely spent nuclear fuel—represents the remaining significant technical challenge to the nuclear-power industry.

Los Alamos is assisting in an international effort to concentrate the toxins from spent nuclear fuel into a special fuel form and to burn that fuel. The project aims to develop ways to extract the toxins and to make the fuel.

A number of methods for dealing with spent nuclear fuel have been advanced. Two prominent methods under consideration are direct disposal in a geological repository after a once-through burn and a waste-minimization approach known as accelerator transmutation of waste (ATW).

Both disposal paths will require some type of repository. The repository for the first disposal path will need to provide isolation for 10,000 to one million years, while that of the second will need to provide isolation for a few thousand years.

In the near future, approximately 87,000 tons of spent nuclear fuel will exist in the United States alone; the worldwide inventory will be closer to 250,000 tons.

Under the current disposal scenario, 60,000 of the 87,000 tons in the United States are slated for disposal at Yucca Mountain in Nevada. However, current conservative projections estimate that by 2050 nearly one million tons of spent fuel could exist throughout the world.

Those levels of discharge would require the construction and commission of a repository on the scale of Yucca Mountain every three or four years somewhere around the globe.

Nearly all health-related risks arising from long-term disposal of spent nuclear fuel are attributable to about 1 percent of the fuel's content. This 1 percent primarily consists of plutonium, neptunium, americium, and curium (called transuranic elements), and long-lived isotopes of iodine and technetium created as products from the fission process in power reactors.

When the transuranics are removed from discharged fuel destined for disposal, within a period of several hundred years the toxic nature of the spent fuel drops below that of uranium ore, which occurs naturally in Earth's crust. In addition to a lower toxicity, removing the transuranics eliminates concerns related to the need for centuries-long heat management within geologic environments.

Removing neptunium, technetium, and iodine renders negligible the possibility of radioactive materials penetrating into the biosphere far in the future. Finally, removing plutonium negates any incentive for future intrusion into repositories driven by overt or covert recovery of material for nuclear proliferation.

The potential payoff of ATW is huge. Instead of requiring a geologic repository that must stay intact for one million years (about the time *homo sapiens* has existed), ATW requires a repository that must last a few thousand years (or as long as some of the buildings currently on Earth—the Egyptian pyramids and the Colosseum in Rome, for example—have lasted).

In transmutation, the nucleus of an atom undergoes a change to form either a new element or a new isotope. Some of the processes that cause transmutation include natural radioactive decay, nuclear fission, nuclear fusion, and neutron capture.

Transmutation uses neutrons, produced either in a nuclear reactor or in an accelerator-based system, to transmute the plutonium, long-lived fission products, and minor actinides.

One current method of transmutation under development involves a two-stage waste program. Spent nuclear fuel would be reprocessed to separate out the plutonium portion and some of the long-lived fission products, as well as the minor actinides (neptunium, americium, and curium) and other long-lived fission products.

The plutonium-bearing portion could be efficiently transmuted in a nuclear power reactor, while the minor-actinide portion would be transmuted in an accelerator-based system.

The vital aspects to the accelerator system are the operating conditions—namely a subcritical system with a fast neutron flux. This flux will change how transmutation occurs and the fission products generated.

There are a number of fuel options being considered that could meet transmutation program objectives.

One fuel form could be chosen for transmuting plutonium or plutonium with minor actinides in commercial power reactors (called Tier I transmutation). This fuel form may be either an oxide pellet or a tri-isotropic (TRISO) particle fuel and could be made with or without depleted uranium oxide.

The fuel made without depleted uranium oxide will use another matrix diluent such as zirconium oxide because depleted uranium produces more plutonium while under irradiation (fertile) and zirconium is inert (nonfertile).

Another fuel form could be chosen for transmutation of plutonium and minor actinides in the accelerator-driven system (called Tier II).

Tier II systems are fast (high-energy) neutron systems and there are several potential fuel forms under consideration: metal alloy fuel segments, nitride or oxide pellets, or oxide or nitride particle fuel in a metal matrix (composite fuel).

The diluent for each fuel form will likely be zirconium metal or the appropriate zirconium ceramic. Since much of the technology for commercial fuel already exists, most of the research and development effort for transmutation fuel is being directed toward the accelerator-driven systems.

Nuclear Materials Technology (NMT) Division and its predecessors have conducted research into advanced nuclear fuels for many years. The research began in the 1950s with the development of very high temperature particle fuels for the Rover space reactor program. Since then, Los Alamos has continued to be on the cutting edge of research into nuclear fuel.

The most recent major fuel program, SP-100, was a development and production program for a space nuclear fuel. Uranium nitride was the obvious choice for the project because of its favorable properties: a high melting point, excellent thermal conductivity, high fissile density, lower fission gas release, and good radiation tolerance.

Several years of development culminated in the production of a fully qualified core of advanced nuclear fuel. However, the choice for a fuel form for accelerator transmutation of waste has not been decided.

While nitrides have a number of favorable qualities, making them leading choices for the ATW fuel form, some yet-to-be-determined factors come into play, such as the fuel temperature in the accelerator-driven system, the required fissile density, and the degree of fuel burnup.

Until a better determination of the operating conditions of the

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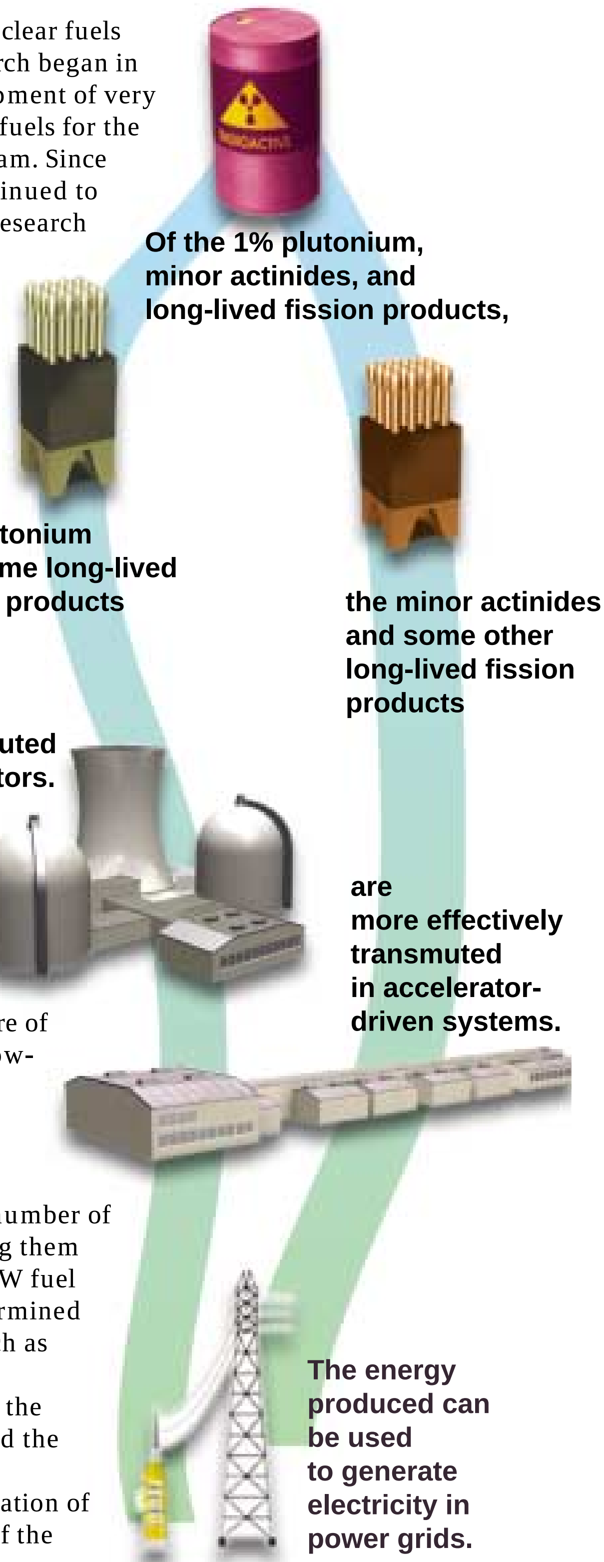


Editorial

Allen Hartford, director of Science and Technology Base (STB) Programs.

We focus part of this issue of "The Actinide Research Quarterly" on students. Allen Hartford, director of the Science and Technology Base (STB) Programs office, which oversees student programs at Los Alamos, leads off with some thoughts on students, mentors, and the importance of students to the Laboratory as a whole. His editorial is followed by stories highlighting three students in the Nuclear Materials Technology (NMT) Division: graduate research assistant Steven Alferink, postdoc Andrew Koehler, and former postdoc now staff member Susan Oldham. While their areas of study vary greatly—nuclear engineering and applied mathematics, social science, and chemistry—the three had one thing in common: dedicated mentors. Read on for a glimpse of them, their research, and their mentors.

Student Programs are Vital to the Laboratory, the State, the Nation

Exposing Students Early to the Excitement of Research May Lead More into Careers in Science and Engineering

Los Alamos has a long history of hosting students who engage in our scientific and engineering research and development activities as well as the work that keeps the Laboratory functioning—our business and operational efforts.

Students at all levels work here and virtually every organization uses students in some capacity. During the past summer, we employed 66 high school students, 930 undergraduate students (UGS), and 391 graduate research assistants (GRA)—almost 1,400 students. Los Alamos also employs about 275 postdoctoral fellows and research associates.

These programs represent a substantial commitment on the Laboratory's part. The costs are substantial, resources must be made available so that the students can accomplish their assigned work, and mentors must devote time to ensure that the students have meaningful work and a positive learning experience.

So, why do we take on such a significant undertaking each year? The reasons are many. Students bring fresh ideas and enthusiasm, and challenge our employees, thereby keeping them on their toes.

Also, students make important contributions in meeting the Laboratory's programmatic goals. Clearly, they contribute to maintaining an invigorating environment here.

Another reason we want to bring students to the Laboratory is to encourage more young people to choose careers in science and engineering. We hope that by exposing students to the challenges and excitement of research and development early in their studies, more of them will choose this path.

There is ample evidence that the United States is not producing an adequate supply of graduates with degrees in science and engineering to meet the country's needs. For example, only five of every one hundred 24-year-olds in the United States have science and engineering degrees. Compare this with nine of one hundred in South Korea and the United Kingdom, and eight of one hundred in Germany.

Student programs also are a key element of the employment pipeline at Los Alamos. Competition for the best science and engineering graduates is intense. Organizations that are the most successful in attracting recent graduates frequently establish relationships with students early in their education, both at the undergraduate and graduate levels.

Many companies offer students internships and some support for their education. By becoming familiar with an organization, students develop a level of comfort and loyalty that makes them more inclined to choose that organization over those with which they are less familiar.

Our postdoctoral program is a prime example of this pattern. Over the past five and one-half years, 32 percent of the Laboratory's total technical staff-member hires has come through the postdoctoral program.

We must ensure that we develop ongoing relationships with students who demonstrate interest and promise in science and engineering careers.

We also must develop ongoing and strategic relationships with prestigious colleges and universities most interested in collaborating with our student programs.

This means not only bringing students and faculty here during the summers, but also bringing them here for extended periods during the academic year as part of an educational and research experience.

We also must maintain contact with these students when they are back at school, to ensure they are reminded that we value them and they view us as their employer of choice.

Our student programs also need to be measured by their impact on the communities surrounding the Laboratory and New Mexico in general. We must be a good neighbor and corporate citizen. As one of the largest employers in the state, the Laboratory needs to provide career opportunities to the state's residents. We need to be part of the effort to retain local talent in the state.

Stories by Meredith S. Coonley
Photos by Mick Greenbank (NMT-16)

Student programs are one mechanism that can aid in developing the wealth and diversity of talent in New Mexico.

While our student programs have been generally successful, there is room for improvement. The Lab assesses the experiences and concerns of the students through annual surveys, and Director John Browne also meets annually with the students.

In addition, this past year the Ombuds Program Office established a Student Program from which we have gathered further general information about student issues.

Among the primary concerns that have surfaced are misunderstandings about the nature of the work the student is to do, which leads to unfulfilled expectations; the case of the "disappearing mentor," when the student doesn't get sufficient interaction with the mentor; and housing.

If I could do something about the latter, I'd probably be canonized. Nonetheless, we are working to find solutions to the perennial problem of affordable student housing.

To address the matter of well-defined work assignments, mentors and students are developing somewhat formal agreements that spell out the assignment(s) in which the students will be involved. This will avoid most of the situations where the students feel misled about what their assignments will entail.

We also are offering mentor training so that mentors recognize the responsibilities they assume when they hire a student and their obligations to that student.

The student programs cannot succeed without the commitment of the Laboratory's organizations and, more specifically, without the involvement of dedicated mentors.

Students will form opinions about the Laboratory based on whether they have an enriching experience here, and much of this will depend on the nature of the work they become involved with and the quality of the mentoring they receive.

We are well aware that being a mentor requires additional effort, particularly when the staff have so many other responsibilities. However, the rewards are enormous for the Laboratory, and especially for the mentor and the student.

On a personal note, I had the privilege of working this past summer with the Student Program Advisory Committee, which suggested the concept of a Student Distinguished Performance Award. We were able to bring this to fruition this past summer and made three awards—one each to a high school co-op student, a UGS, and a GRA.

Not only did these three recipients make important and impressive contributions to the Laboratory during their stays, all 31 of the nominees did exceptional work. I think this speaks highly of the positive impact the students have on our work.

Winners of the student awards were Anabel Guerra, a high school co-op student with the Bioscience (B) Division Office; Apara Dave, a UGS in Materials Technology: Metallurgy (MST-6); and Gang Xie, a GRA in B Division.

Science and Technology Base (STB) Programs, working with technical organizations as well as the Human Resources (HR) Division, the Diversity Office (DVO), and the Office of Equal Opportunity (OEO), is committed to enhancing the quality of student programs, both from the perspective of the Laboratory and the students.

If we are to remain a premier research institution, the Laboratory must be aggressive in identifying the best talent available and succeed in bringing that talent to the Laboratory. Our student programs are important vehicles for cultivating that talent. ■

—Allen Hartford

Three of the best and the brightest: Andrew Koehler (standing), Susan Oldham, and Steven Alferink, all of the Nuclear Materials Technology (NMT) Division. To remain a premier research institution, Los Alamos must aggressively identify the best talent and bring that talent here, according to Allen Hartford, head of Science and Technology Base (STB) Programs.

Focus on Students

Steven Alferink

Nuclear Engineer Steven Alferink

Improving on Existing Plutonium Isotopic Analysis Codes

Steven Alferink first heard about Los Alamos at a career fair at the University of Missouri-Rolla. "It sounded like a good opportunity for me, so I jumped at it," said Alferink.

Since then, he has spent four summers at the Lab, two as an undergraduate student (UGS) in Space and Remote Sensing Sciences (NIS-2) and two as a graduate research assistant (GRA) in ^{238}Pu Science and Engineering (NMT-9).

His initial work in NIS-2 focused on satellite software programming, something completely new to him at the time. The algorithm he worked on his first summer is running aboard the Multispectral Thermal Imager satellite, which launched in 1999.

His work in NMT-9 has included writing an instruction manual for the Solution In-Line Alpha Counter (SILAC), which provides alpha activity measurements of aqueous solutions in glove boxes at the Plutonium Facility (TA-55).

He also created a document control database that tracks more than 200 documents used in NMT-9, including safety procedures, hazard control plans, training plans, drawings, equipment manuals, and lab notebooks.

Alferink currently is working on a method to improve on existing plutonium isotopic analysis computer codes for plutonium-238 samples.

The goal is to determine a correlation for the weight percentages of plutonium-240 and -242 in plutonium-238 oxide materials. Alferink is hoping to implement this correlation into a new version of PC/FRAM to automatically determine the isotopic composition of plutonium-238 oxide materials.

PC/FRAM, developed by Safeguards Science and Technology (NIS-5), is an isotopic analysis software package used mainly for plutonium-239 and uranium materials.

By analyzing gamma-ray spectra of a sample, the PC/FRAM software helps researchers determine nondestructively the percentage of weight composition of a sample.

If the isotopic composition of plutonium-238 samples can be determined accurately by this nondestructive method, it could save time and money, according to Alferink.

The current analytical method for determining the isotopic composition of plutonium in samples requires chemical separations and analysis by thermal-ionization mass spectrometry. The technique is very accurate and precise, but time-consuming, expensive, and requires destroying the sample.

Nondestructive analysis techniques based on gamma-ray spectroscopy have been developed to measure large quantities (tens of grams to kilograms) of plutonium-239 or uranium for safeguard and security purposes, but haven't been tested and applied to small samples (milligrams to nanograms).

Alferink's project will extend the use of the nondestructive analysis technique to analytical applications to provide rapid (a few hours or less) and accurate isotopic composition data for plutonium-238.

There is very little data on plutonium-238 because of the lack of a strong gamma-ray signature of plutonium-240 in plutonium-238 materials. Alferink is using historic data from the heat sources manufactured at Los Alamos for the Cassini probe to Saturn as a basis for his algorithm.

Alferink rates his student experience at Los Alamos as very positive and credits his team leader and mentor in NMT-9, Amy Wong, with making the past two summers so productive.

"She leads by example," said Alferink, "and she's always there when I need her. She's also very supportive of my working on the project back in Rolla during the school year."

He enjoys the relaxed atmosphere of the group and the people he works with.

"I think I'm one of the few nonchemists in the group, but they don't hold that against me," he said.

If there's been a downside to Alferink's student experience, it's the time it has taken to get a clearance (he's still waiting), and the training required at the beginning of his assignment (which he politely referred to as "dry"). But he understands why the training is required: "After all, TA-55 is a nuclear facility."

On the upside, Alferink didn't experience some of the problems that may affect students: inadequate housing, loneliness, and adjusting to small-town life. He easily found housing his first summers through the Lab's Housing Office and the University of New Mexico-Los Alamos. Last year's Cerro Grande Fire burned the apartment he was planning to rent, so he lived in a motor home—along with his girlfriend and three cats.

"I'm pretty much of a loner and Rolla is a small town, so I was prepared for the smallness of Los Alamos, but I do miss green grass," Alferink said.

Yet he admits luck was with him four years ago when, on his first day of student orientation here, he met fellow GRA Beth Schlapper. The pair have been together ever since.

With summer over, Alferink is back in Rolla pursuing master's degrees in nuclear engineering and applied mathematics. He will continue his work on the plutonium isotopic analysis project during the school year and hopes to return to Los Alamos next summer.

Schlapper, who earned a master's degree from UMR in nuclear engineering in December 2000, is starting another master's program in environmental engineering.

And both are settling into a new life together—they got married July 28. ■

Beth Schlapper and Steven Alferink met on the first day of student orientation four years ago. They got married this summer.

Photo by Kevin Kessler, Another Perspective

Mentoring: An Investment in the Future

Amy Wong, a radiochemist who joined the Laboratory in 1994, believes in the importance of mentoring. For Wong, mentoring is as much about on-the-job training as it is about developing an employee and looking toward the future.

"We need to invest time at the beginning, especially with new technicians at TA-55, as well as with other new hires, to make sure they learn all the basics of safe operations," said Wong. "In the longer term, we're much better off spending time early on helping them learn the right way to do things.

"But mentoring is also about helping an employee discover what direction to take in his or her career. It's an investment in the future to help them develop their personal skills as well as their technical skills," said Wong.

Wong doesn't have to look far for a role model: her group leader, Liz Foltyn, won a mentoring award this year from the Women's Diversity Working Group for promoting the advancement of women in the workplace.

More information about mentoring and tools to perform self-assessments are available at learning@lanl on the Training and Development (HR-6) web site. The address is www.hr.lanl.gov/TD. ■

Amy Wong has mentored Steven Alferink for the past two summers. He says she "leads by example" and credits her with making his work experience so productive.

Focus on Students

Andrew Koehler

Social Scientist Andrew Koehler

Creating an Integrated Facility-Program Model for the Modern Pit Facility

Andrew Koehler isn't in a scientific discipline you'd expect to see in a student in Nuclear Materials Technology (NMT) Division—he's a social scientist.

But while his research is unusual for NMT Division, what he's proposing will help the Laboratory's nuclear weapons program better plan for the future.

As a postdoc in Pit Disassembly and Nuclear Fuels Technologies (NMT-15), Koehler is looking at institutional issues, Laboratory organization, the Department of Energy regulatory environment, and program execution to create an integrated facility-program model for TA-55's Modern Pit Facility.

His goal is to come up with something the Laboratory can use to make long-range strategic plans to ensure performance, analyze regulatory compliance issues, and train personnel. His simulation model will take into account possible shifting regulatory and social mandates, as well as changing government support and shifting priorities.

"You can look at it like enterprise modeling in the private sector," said Koehler. "Take UPS, for example. It tracks how a package moves, the errors that might occur, and the costs, as well as random events that may affect getting the package where it should go.

"Los Alamos has a process system with lots of uncertainties, just like UPS, only the Lab's system involves hazardous materials, waste streams, lots of regulations, and changing government priorities," said Koehler. "These things change all the time, and they cost time and money."

Koehler's integrated facility-program model would bring together several established simulation techniques to create an interactive, realistic simulation.

Process modeling would be used to analyze fabrication activities to describe the flow of materials through the operations steps performed at the Modern Pit Facility.

Visualization and sound modeling, like that used in commercial entertainment software, would capture the experience of working in the facility.

Agent modeling, used in military simulations, would describe how information is managed inside the facility, and how regulators and other sources of requirements actually behave.

Koehler has worked at Los Alamos for four years. He spent several summers as a graduate research assistant, 18 months as a GRA in NMT Division's Office of Planning and Scheduling, and began his postdoctoral appointment in April.

He attended the University of California-Berkeley, where he earned a bachelor of arts degree in economics and a doctorate in public policy from the Goldman School of Public Policy. His dissertation, based on research performed at Los Alamos, was titled "Design For a Hostile Environment: Technical Policymaking and System Creation."

Koehler calls K.C. Kim and Sophie Vigil of the NMT Division Office his guardian angels. "Sophie because she made dealing with many of the complexities of the Lab easier; K.C. because he helped guide my research. He went above and beyond his duty in making my dissertation happen," said Koehler.

Koehler's current advisor, Caroline "Cas" Mason, is helping in a similar way. "She's very easygoing, but extremely protective of my time and opportunities as a postdoc," said Koehler.

Mason, a chemist, was recently named team leader for Russian Programs–Plutonium Conversion Project in NMT-15. She has mentored numerous students, from summer students to postdocs, in her 26 years at the Lab.

While every student has different needs, she describes her basic mentoring style as one of "benign neglect," especially when it comes to postdocs.

"My philosophy with postdocs is that they can run their own lives," said Mason. "They've received doctorates, which require a great deal of self-motivation, and I don't think they need very close attention.

"In Andrew's case, if I attend a meeting with him, it's not because he needs the guidance, it's because I find his research interesting," said Mason. "Of course, I try to be available for him whenever he has questions or concerns."

On a scale of one to ten, Koehler rates his Lab experience as eight and one-half. "The Lab has opened up research opportunities I wouldn't have had otherwise," said Koehler. "Social scientists don't often get to work at national laboratories."

As to life in the town of Los Alamos, Koehler admits it's "unlike any place I've lived before."

A native of the other LA—Los Angeles, he currently lives in Santa Fe with his wife, Rosemary Sallee.

Koehler summed up his Los Alamos experience this way: "I see my research project as a way to pay the Lab back—to help it do what it does and do it more robustly. It's a win-win situation." ■

Andrew Koehler and his advisor Caroline "Cas" Mason discuss Koehler's integrated facility-program model. Mason describes her mentoring style as one of "benign neglect" when it comes to self-motivated postdocs like Koehler.

Focus on Students

Susan Oldham

Chemist Susan Oldham

Conducting Basic Research in the Fundamental Chemistry of Actinide Elements

As a postdoctoral chemist in Weapons Component Technology (NMT-5), Susan Oldham spent two years doing basic research in the fundamental chemistry of actinide elements.

Her research into organometallic complexes of uranium, neptunium, and plutonium will increase the understanding of these elements and how their chemical behavior compares to other, more extensively studied, elements in the periodic table.

"Making these new complexes may spark interest in other scientists to take the research to another level, which could result in new uses for these complexes or new ideas for making other new complexes," said Oldham.

One of the projects she was involved with was investigating actinide amido complexes to explore the electrophilic chemistry of the actinide elements. These types of complexes are interesting to researchers partly because of their rich reaction chemistry, including potential activation of molecular nitrogen.

The work, in collaboration with researchers in Nuclear Materials Technology (NMT) and Chemistry (C) divisions, shows promising results and has extended the library of actinide complexes. (For more on the research, see "The Actinide Research Quarterly," 4th Quarter, 2000.)

Oldham also has participated in a project to synthesize extremely novel uranyl carbene complexes. These complexes represent the first examples of actinyl-to-carbon bonds and suggest an unexpectedly rich diversity in actinide structure and bonding.

This project was also in collaboration with researchers from NMT and C divisions.

Oldham's mentor was Ann Schake of NMT-5, an inorganic chemist who started her career at the Laboratory 11 years ago as a postdoc. Schake believes that good mentoring is a way for Los Alamos to attract and keep the best and the brightest, whether postdoc or staff member.

"I try to be hands-off and leave the postdoc free to do research," said Schake, "but I would never turn anyone loose in PF-4. I'm much more hands-on in that area. Conduct of operations is very important in an organization like ours."

Susan Oldham works inside a glove box while her mentor, Ann Schake, looks on. A former postdoc herself, Schake believes that good mentoring is a way for Los Alamos to attract and keep the best talent, whether postdoc or staff member.

Oldham appreciated Schake's method of mentoring. "She didn't try to control my research, but she was always there to answer questions, help me understand Lab bureaucracy, and discuss ideas," said Oldham. "She gave me ideas and suggestions and let me explore on my own."

Oldham graduated from Bowdoin College, a small liberal arts college in Maine, in 1994 with a major in chemistry and a minor in math. She received a master's in chemistry from the University of Washington in 1996 and a doctorate in inorganic chemistry in 1999 from the University of Rochester.

She lives in White Rock with her husband, Warren, also a chemist and former postdoc, and now a staff member in Pit Disassembly and Nuclear Fuels Technologies (NMT-15). (Warren is pictured at right with other participants at the ATOMICS student poster session.)

With her postdoctoral appointment over, Oldham has accepted a staff member position with NMT-5's plutonium casting team. Her priority and focus has shifted to providing technical support and guidance to the casting team. She will be involved in the casting of plutonium into shapes, and ensuring that the products meet specifications and the instruments used are correctly calibrated.

But Schake's mentoring will not stop because Oldham is no longer a postdoc. The two share an office in TA-55, where Schake will be on hand to guide Oldham as she learns the ropes of working in PF-4.

"One of the things I've liked most about working here is that there are so many different people doing so many different things. It's nice to be able to have all of those resources together," said Oldham. "There are lots of people studying actinide chemistry, but for different reasons—stewardship, separation technology, weapons production."

A highlight of her postdoctoral appointment was the opportunity to attend technical symposia, especially those given by Nobel laureates. "It's a great experience for young scientists, and older scientists, too," said Oldham.

"Being a postdoc in NMT was an interesting balance of basic research and working toward NMT's mission and goal," said Oldham. ■

First Annual ATOMICS Student Poster Session

Students working in the Nuclear Materials Technology (NMT) Division had the opportunity to meet with division staff and discuss their summer research at the first annual ATOMICS Safety Process Office student poster session held in July at TA-55.

Students presented posters on a variety of subjects, including chemical engineering applications, actinide chemistry, computer programming, and safety in a nuclear facility.

Photo by Michelle Stump (NMTDO)

In the top row, from left to right, are: Mandy Cortez, Pit Disassembly and Nuclear Fuels Technologies (NMT-15); Julie Fife, Isotope and Nuclear Chemistry (C-INC); Crestina Vigil, NMT ATOMICS; and Warren Oldham, NMT-15. In the front row, from left to right, are: Stephanie Lopez, Weapons Component Technology (NMT-5); Dustin English, Actinide Chemistry Research and Development (NMT-11); Lecroy Raynes, NMT-11; and Willie Montoya, NMT-15.

The mission of ATOMICS (Allowing Timely Observations Measures Increased Commitment to Safety) is to continuously improve the health and safety of the NMT Division workforce by reducing at-risk behaviors through ongoing behavioral observations.

Organizers are already planning next year's poster session, and want to enlarge the event and encourage a more complete representation of students throughout the division. ■

Newsmakers

David L. Clark has been named a Laboratory Fellow.

NMT-DO's David L. Clark Named Laboratory Fellow

David L. Clark has been selected by Director John Browne as one of six new Laboratory Fellows.

The honor is made yearly to technical staff members who sustain a high level of excellence in programs important to the Laboratory's mission, make important scientific discoveries that lead to widespread use, or are recognized as leaders in their fields both within and outside of the Laboratory.

Only 2 percent of the Laboratory's current staff may hold the title of "Fellow" at any one time.

Clark, a member of the Nuclear Materials Technology Division Office (NMT-DO), was named for his work in the structural inorganic and environmental chemistries of the actinides and his stewardship of the Seaborg Institute.

He is recognized internationally for his efforts to bring state-of-the-art molecular science concepts in structural characterization and theory of inorganic chemistry to the chemistry of the actinide elements.

Clark has been involved in the development of a new research field known as molecular environmental science, where molecular level understanding is used to unravel the fate and transport of actinide ions in the environment.

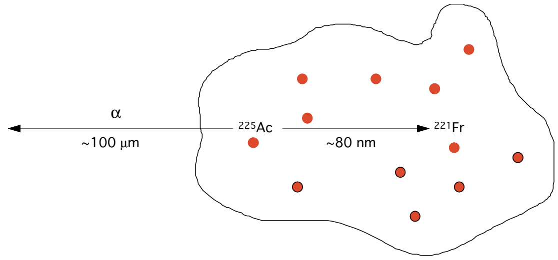
Cancer Therapy Research Receives LDRD Funding

A project to develop a new class of radioisotope delivery systems for high-dose localized cancer therapy has received Laboratory Directed Research and Development (LDRD) funding under the exploratory research category. The project, Polymeric Chelators for Radioisotope Delivery Systems, will be led by Mary Barr of Actinide Chemistry Research and Development (NMT-11).

Co-investigators on the proposal were Louis (Pete) Silks and Robert Atcher of the Leo Szilard Resource (B-3), and Kent Abney, who was with Isotope and Nuclear Chemistry (C-INC). Abney now is with Actinide Process Chemistry (NMT-2).

The new class of radioisotope delivery systems will be based on amorphous, water-soluble polymeric chelators. The project proposes a new approach to radioisotope delivery that will enable users to efficiently use isotopes that emit multiple alpha particles during their decay sequence.

This work will increase the applicability of alpha-emitting radioisotopes for therapy, particularly for difficult-to-treat solid tumors. Other applications of include cellular-level and localized therapy, and enhanced diagnostic and imaging capabilities.



Polymeric chelator with multiple binding sites

NMT Division Becomes Part of New Directorate

In an effort to make the Laboratory a more unified, customer-focused organization, Director John Browne has realigned divisions into new directorates. Nuclear Materials Technology (NMT) and Engineering Sciences and Applications (ESA) divisions comprise the new Weapons Engineering and Manufacturing Directorate.

Richard Mah has been named associate director. Louis Salazar and Van Bynum have been appointed principal deputy and deputy for pit manufacturing, respectively. As associate director, Mah will be a member of Browne's new senior executive team. ■

Editor's note: The caption on Page 2 of the last issue was incorrect. The photograph was a view inside the chamber of a scanning electron microscope, not an ultrahigh-vacuum Auger spectrometer / energy loss spectroscopy instrument.

Improved Differential . . .

continued from page 3

the heat of solute redistribution can be measured, but it remains to be seen how accurate this measurement is.

Another area where DSC has proven to be a useful tool is in making a rough measurement of the extent of internal damage in old plutonium.

Plutonium is an alpha-emitting radionuclide and is continually being damaged uniformly throughout its bulk because of recoil from the uranium daughter product of the alpha-emission events. This damage accumulates over time, and its exact nature is key to understanding the aging effects that may occur in the nuclear weapons stockpile.

Self-irradiation damage comes in a variety of forms, such as vacancies, interstitials, dislocations, and voids , all caused by atoms being knocked into or out of sites that they do not normally occupy. When a radiation-damaged material is heated, it eventually reaches a temperature where its constituent atoms can move freely enough to repair this internal damage.

The process of self-repair, called annealing, releases a quantity of heat that can be measured by DSC. While the measurement of the heat does not give specific information about the type of damage present in the material, it does give a good indication of the total amount of annealable damage present.

Researchers are making measurements of this type on stockpile plutonium materials of various ages. ■

Improved differential scanning calorimeters

Fuel Form . . .

continued from page 5

accelerator is made, the best fuel type cannot be decided upon. Therefore, the research and development effort will consider the four fuel types in parallel, including nitride, metal alloy, oxide, and dispersion (ceramic particles in a metal matrix). NMT Division will focus its efforts on development of ceramic-based and dispersion fuels.

The Advanced Accelerator Application (AAA) Program—consisting of Accelerator Production of Tritium (APT) and Accelerator Transmutation of Waste (ATW)—is truly a national and international effort.

While the program director, Edward Arthur, is headquartered at Los Alamos, many of the project leaders are located at other institutions.

Los Alamos is working in close collaboration with Argonne National Laboratory (East and West) to determine a viable fuel form.

Experimental fuel pellets fabricated at Los Alamos and metal segments fabricated at Argonne are scheduled to be inserted into the Advanced Test Reactor (a thermal-spectrum research reactor at Argonne-West) late next summer.

Internationally, the U.S. program is interacting with the European and Japanese transmutation programs.

The near-term goal of the fuel development effort is the insertion of a final (or near-final) fuel type into the Phenix Facility in France sometime after 2004. Exposure to Phenix's fast neutron spectrum will help determine a given fuel type's ultimate performance.

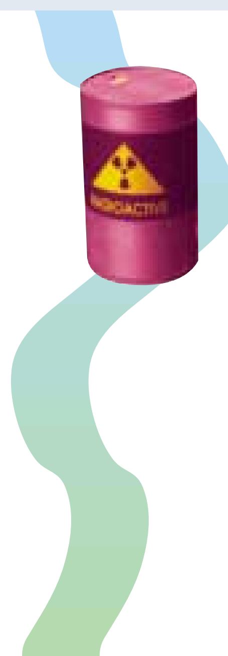
Many challenges to fully implementing ATW remain. They range from political (addressing reprocessing of spent nuclear fuel) to social (public acceptance of nuclear technology) to technical (fabricating fuel from very radioactive minor actinides).

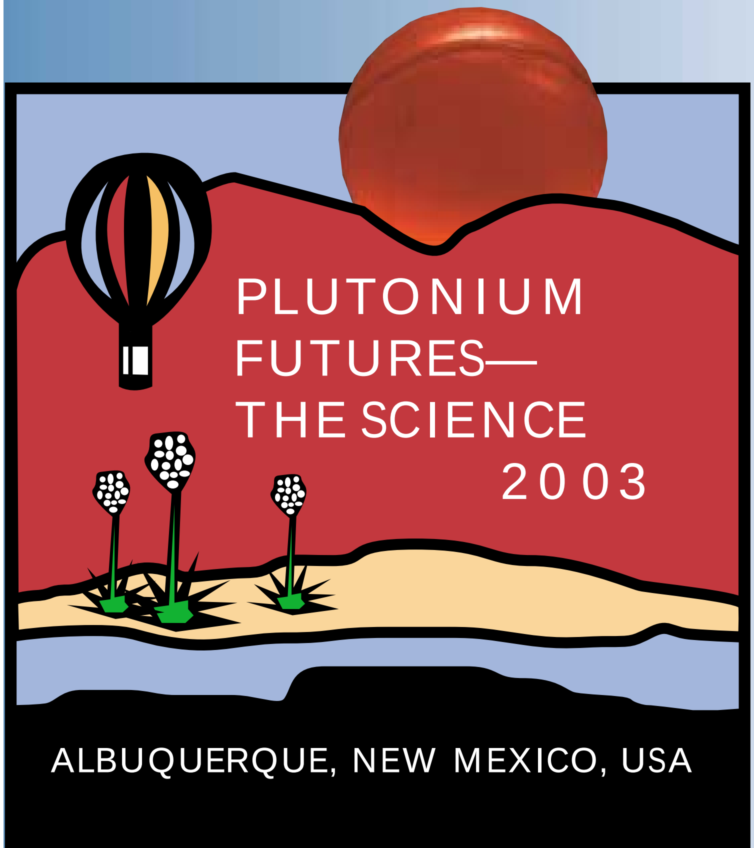
But the consequence of not pursuing ATW is significant because spent fuel buried in geological repositories will require safe containment for tens of thousands of years.

However, if ATW is implemented, the nuclear fuel cycle will be nearly complete, and nuclear power can retain its position—and potentially increase its appeal—as a means for power production for many years to come. ■

For more on spent nuclear fuel reprocessing, see "The Actinide Research Quarterly," 2nd and 3rd Quarter, 2000.

Fuel Form for ATW





The conference, third in a series, will provide an international forum for presentation and discussion of current research on physical and chemical properties and environmental interactions of plutonium and other actinide elements.

For more information, visit the **Plutonium Futures—The Science** homepage at www.lanl.gov/pu2003.

A Four-Day Topical Conference on Plutonium and Actinides

July 6–10, 2003

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