Ames Laboratory research that's ...

Out *of this* World

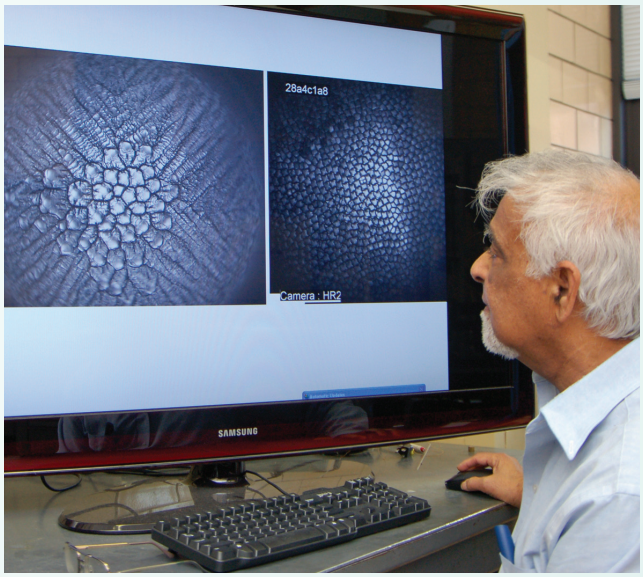
BY KERRY GIBSON

The International Space Station carries equipment for an Ames Laboratory research effort.

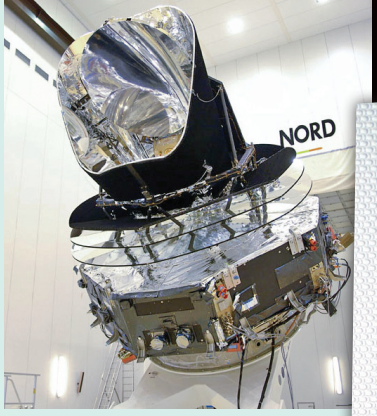
A RESEARCH PROJECT 10 YEARS IN THE MAKING IS now orbiting the Earth, much to the delight of its creator, Ames Laboratory senior metallurgist Rohit Trivedi. Equipment aboard the International Space Station will soon allow the Earth-bound Trivedi to conduct crystal growth experiments he first conceived more than a decade ago.

The equipment, actually a mini laboratory, known as DECLIC – DEvice for the study of Critical LIquids and Crystallization – will allow Trivedi to study and even control crystal growth pattern experiments, in real time, from his laboratory in Wilhelm Hall in Ames. The goal is to use the microgravity environment on board the Space Station to determine how materials form crystals as they move from liquid to solid and what effect variations in growth conditions have on crystallization patterns.

"When materials 'freeze' there are specific crystalline growth patterns that appear," Trivedi says, "and there are fundamental physics that govern these patterns. However, small effects can have significant influence on the patterns that form. Snow flakes, for example, form the same basic six-sided pattern, but because of minute variations, no two are exactly alike. These crystallization patterns play a critical role in governing the properties of a solidified material."



Ames Laboratory's Rohit Trivedi compares normal crystallization (left) with a test photo sent back from space.



The Planck satellite, with Ames Lab-made materials on board, is orbiting around the second Lagrangian point, located about 930,000 miles from Earth.

So why conduct the experiment in low gravity? Trivedi hopes that the low gravity will "erase" the effects of convection, the natural circulation of fluid.

"On Earth, the small effects are masked by convection," he says. "We hope that in a low-gravity environment, convection will be minimized so that we can more clearly see the importance of the small effects and see how the experimental data match our theoretical modeling."

Much of that modeling has been done by collaboration with Trivedi's long-time colleague, Alain Karma, a theoretical physicist at Northeastern University in Boston. The pair has also collaborated closely with the Centre National d'Etudes Spatiales, or CNES, the French government space agency that, along with NASA, helped fund the work. The investigators on the French side are Bernard Billia and Nathalie Bergeon, University of Aix-Marseille.

Alain Karma

After preliminary testing last fall, DECLIC has been used for other experiments. At press time, Trivedi's turn was expected to come in late March and run through spring 2010. Through a connection with the computation center in Toulouse, France, Trivedi's research group will be able to view video of the material as it solidifies. To pick up the necessary detail, Trivedi's lab is outfitted with a big-screen, high-definition monitor. But they won't be just passive spectators.

"If we see something unusual, we can repeat the experiment, all in real time," Trivedi says. "Likewise, if we don't see much happening, we can alter the conditions and move on."

The DECLIC lab is equipped with two cameras and a laser source to image the interface shape of the material in three dimensions. A continuous stream of video of the pictures from these cameras is downloaded in real time to a computer in Trivedi's lab. All the video from the DECLIC experiments will also be captured and stored for future reference by CNES in Toulouse.

Trivedi's research proposal was originally selected by NASA for funding back in 1998, receiving approximately $2 million in total through Iowa State University's Institute for Physical Research and Technology, and was later selected as one of only six projects in materials science selected for actual flight. To now be this close to seeing the project in operation is exciting for Trivedi.

"It's been a long time since we started," Trivedi says, "but it's also given us time to finalize the experiments and work on the theoretical side. Now we're just anxious to get experimental results to see if things behave as we expect."

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Materials Preparation Center-made alloy is aboard Planck satellite

Materials produced by Ames Laboratory's Materials Preparation Center were launched into space on May 2009 with the European Space Agency's Planck Mission. The MPC synthesized over 20 kilograms of a lanthanum-nickel-tin alloy for use in a metallic hydride sorption cryocooler system built by NASA's Jet Propulsion Laboratory. The cryocooler is cooling instruments on the satellite.

The Planck satellite is collecting precise measurements of Cosmic Microwave Background, the remnants of radiation that filled the universe immediately after the big bang. Scientists will use the data to help answer questions about how the universe began, how it evolved and how it will continue to evolve.

The MPC not only cast the lanthanum-nickel-tin alloy for the Planck cryocooler systems, but it also produced the high-purity lanthanum and refined the nickel, all with the precision required to meet stringent purity and homogeneity specifications.

The project drew on a significant range of MPC skills: high-purity rare earths production, electron beam melting, arc casting, interstitial gas tests, electron-microprobe tests, metallography, rolling mill work and annealing furnaces.

Creating the materials was a big job. To ensure quality, MPC staff had to make the 20 kilograms in 50 gram batches, for a total of 400 batches.

Casting large amounts of the alloy caused inhomogeneity within ingots, and gas-atomized particles proved very homogenous but didn't provide the needed performance, in this case. So small ingots were created in an arc melter, a type of furnace that melts metals with a 400-500 amp electronic arc through argon gas. The components of the alloy posed another challenge: their varied melting points required some special preparation of the materials.

"We rolled the nickel and formed it into a dish-like shape. Then we put the tin and lanthanum in the nickel dish and heated the nickel from the edges," says Trevor Riedemann, manager of the MPC's rare-earth materials division. "As the nickel got hotter and hotter, the other two materials melted on the dish and created an intermediate intermetalic. From there, we melted the whole thing several times in the arc melter."

"The project was a chance for everyone at the MPC to do some arc melting or to weigh materials while someone else ran the arc melter, so we could make as many ingots as possible," Riedemann says. "It was a great project because it fully engaged the MPC, and everyone had a role."