

OUTLOOK

PRODUCERS AND FABRICATORS OF REACTIVE AND REFRACTORY METALS AND CHEMICALS

ALLEGHENY TECHNOLOGIES**Allegheny Technologies**

Specialty Materials That Make Our World

Cast Titanium Spheres Keep Pressure and

Corrosion *at Bay in Deep Ocean Applications*

Page 3

MBARI engineers Paul McGill (left) and Jon Erickson (right) teamed with ATI Wah Chang to develop this cast titanium sphere that protects delicate seismological instrumentation destined for the ocean's floor.



PHOTO BY TODD WALSH. COPYRIGHT © MBARI 2005

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ATI to Expand Titanium Production Capabilities in Albany, Oregon

Allegheny Technologies Incorporated recently announced a major expansion of its titanium production capabilities.

These investments are aimed at significantly increasing ATI's capacity to produce titanium and titanium alloys used for aero-engine rotating parts, airframe applications and in other robust global markets.

Major strategic capital projects that are part of this expansion include:

- Upgrading and restarting ATI's idled titanium sponge facility. ATI expects an annual production rate of 7.5 million pounds of titanium sponge from this facility beginning in the first half of 2006. Titanium sponge is a critical raw material used to produce titanium mill products.
- Constructing a third plasma arc melt cold-hearth furnace. ATI expects this new furnace to be qualified for production by late 2006. Plasma arc melting is a superior cold-hearth

melt process for making alloyed titanium products for aero-engine rotating parts and biomedical applications.

- Expanding high-value plate products capacity by 25%. ATI expects this expansion to enable it to continue to grow in its high-value specialty plate products business, including titanium plate used in airframe, armor, power generation, and corrosion applications.
- Continued upgrading of ATI's cold-rolling assets used in producing titanium sheet and strip products.

Also included in this titanium capability expansion is an approximate 25% increase across ATI's titanium production system, including increases in vacuum arc remelt capacity, electron beam cold hearth melting capacity, and forging reheat capacity.

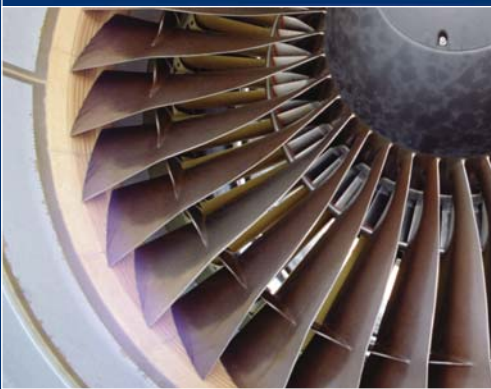
"We expect over \$200 million of annual revenue growth with attractive after-tax returns from these capital projects when they are fully implemented in 2007," said Pat Hassey, Chairman, President and Chief Executive Officer of Allegheny Technologies. "As a result of investments ATI has made during the past several years, we currently have unparalleled finishing assets for titanium straight length and flat-rolled products. The new capital

investments announced today add much needed titanium raw material, melt, and remelt capacity to help optimize market opportunities for ATI. These strategic investments confirm ATI's commitment to profitably grow our high performance metals business."

"The excellent combination of high strength to weight ratio, corrosion resistance, and biocompatibility make titanium an ideal specialty metal for many sophisticated and challenging twenty-first century applications. Titanium demand from the aerospace market, for both aero-engine and airframe applications, is expected to continue to be robust for the next several years. ATI is a leading producer of premium titanium alloys used in aero-engine rotating parts used for both original equipment and spare part applications. Airframe and airframe components offer significant growth potential for ATI. The industry trend towards the use of composite materials in airframes increases the need for our titanium alloys."

"Biomedical is another buoyant market for titanium products used for medical prosthesis such as hips and knees. ATI is a leading producer in this market segment and works closely with end users to develop new materials for longer lasting implants with improved biocompatibility. Armor for the government defense market is an emerging new application for titanium. In addition, demand for titanium for corrosion applications, particularly from the chemical processing and oil and gas markets, is expected to continue to be strong. Forecasted demand for titanium products is growing and exceeds current global capabilities."

Allegheny Technologies is a leading producer of titanium and titanium products. ATI manufactures titanium straight length products (long products), including ingot, billet, bar, and rod; titanium flat-rolled products, including sheet, strip, and plate; and specialty titanium products, including shapes, seamless tubing, castings, and wire. ATI is a technology leader in manufacturing and research and development for titanium products. ATI is the world's only titanium producer that employs both plasma cold-hearth and electron beam cold hearth melt technologies. ATI holds many patents for titanium products used for aerospace and biomedical applications. ✱



Titanium sponge is used in alloys for jet engine turbines (above left) and ultra light custom wheelchairs (bottom left).

Wah Chang Titanium Sphere Cast in Critical Role for Deep Sea Projects

BY: KIRK RICHARDSON — Wah Chang

At 7:58 AM (IST) December 26, one of the most powerful earthquakes to shake the planet, 9.0 at its epicenter, rocked the ocean floor 6.2 miles below the surface of the Indian Ocean, 100 miles off the coast of Indonesia's Sumatra Island. It was the largest earthquake measured since the Good Friday quake that devastated Fairbanks, Alaska in 1964 and the fourth largest on record. The quake generated deadly tsunamis that spread from its epicenter as far as Africa.

Halfway around the world at the undersea Endeavour broadband station, 300 miles off the coast of Washington state, a set of very sensitive seismological sensors in an 18-inch-diameter cast titanium ball took notice.

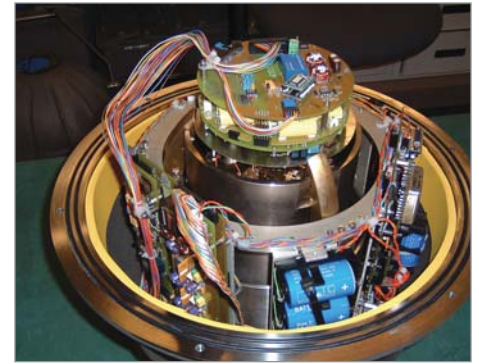
Meticulously engineered by staff at the Monterey Bay Aquarium Research Institute (MBARI) and funded by the Keck Foundation, the station is designed to measure activity between the local Juan de Fuca and North American plates. The equipment is so sensitive that it records background noise, such as rolling waves on the surface of the Pacific Ocean 7800 feet above, and can register geological events, like the Indonesian quake, thousands of miles away.

"We had this delicate seismometer," says Paul McGill, Project Manager and Electrical Engineer at MBARI. "It's called a broadband seismometer because it receives seismic energy over a very broad frequency range. You can't just set something like that on the bottom of the ocean because the water currents are going to move it around in the exact band of frequencies that you're looking at for earthquakes. To correct for this, we had to bury the sensor in a shallow hole in the seafloor sediment to keep it quiet. This thing can record earthquakes from the other side of the world."

"The reason for this is the low frequencies travel much farther than the high frequencies. An analogy here is, if a car is going by with the sound system turned up and the rap is going, when it's parked next to you, you hear the whole band, but as it drives



Machining the inside of a Ti 6-4 casting (above left) at the Monterey Bay Aquarium Research Institute. MBARI will join the machined dome with a sister half using compatible titanium hardware to create a water-tight, corrosion resistant sphere (below center) that houses very sensitive (and very expensive) seismological instrumentation (above right).



away, two blocks away, all you hear is that thumping bass. The low frequencies don't get attenuated as quickly."

Not surprisingly, MBARI guards its precious equipment with great care. The Grade 5 titanium (Ti 6-4) sphere that houses the instrumentation is all part of the project team's plan to protect the instrumentation from saltwater corrosion, harmful microbes, and crushing deepwater pressure.

As simple as creating a watertight container may sound, developing a titanium sphere wasn't an easy task.

Jon Erickson, the Mechanical Engineer and innovator who designed the MBARI spheres, hunted far and wide for an ideal material for the capsules. "We looked at a lot of options," he says. "Glass is very cheap, but glass is also very brittle," he says of an early possibility. "Glass spheres are so unpredictable that they don't even allow them near manned submersibles. When you've got a hollow space this big," his hands stretched apart about a foot and a half, "and there's hundreds of thousands of pounds pushing on it, it's in essence, an implosive danger." Erickson says that an implosion can cause a shock wave, and "if you're in a manned submersible, you don't want something like that anywhere near you."

Erickson soon turned his full attention to metals. He quickly ruled out aluminum, a premier material for applications where strength-to-weight is key, but a potential liability where corrosion is a factor. "Salt water corrosion will eat you alive," he warns. In addition, ocean floor sediments pose a threat. "Where beautiful stainless steel housings would last a long time in open water, we'll stick them in a hole in the rock, and in three months there are pits in them so deep that the housings are throw-aways," says McGill.

Erickson narrowed his focus to a metal with a history of successes in applications where high strength and corrosion resistance were key considerations: titanium. "Since this was going into the sediment, it had very stringent anti-corrosion requirements, and we knew we

[continued on page 4]

This cast titanium sphere is able to withstand the rigors of deep ocean service, which includes saltwater corrosion, microbiological attack, and ultra high pressures (thousands of pounds per square inch).



Wah Chang Titanium Sphere Cast in Critical Role for Deep Sea Projects

[continued from page 3]

were safe with titanium," says McGill.

"There's simply no other material, ceramics and glass aside, that you can put in the sediments for those kinds of long periods of time," says Erickson, reminding that with glass and ceramics you have to beware of the potential for fracture and other failures. "The titanium sphere is robust enough that it needs no shell around it," says McGill. "The glass spheres almost worked, but we didn't want to experiment with what this would do buried in sediment. The instrument is \$60,000 to \$80,000." He adds that the transport ship time is also very expensive and scheduling a boat can be a challenge.

The team faced other pressures as well, including designing a structure that would withstand deepwater applications. "We built an earlier cylindrical housing for Monterey Bay for 1000 meters depth," says Erickson. He points out that the cylindrical design, with its flat end caps, posed a problem. "The tube is inherently strong because it's an arch all the way around," he explains. "They're good at holding back the pressure, but to take a cylindrical design of this size to 3000 or 4000 meters means the end caps needed to be over 3 inches thick."

"At 4000 meters there is 6000 pounds (of pressure) per square inch," says McGill. "You can imagine how many square inches an end cap like this has - that is a lot of force." When you do the math, he says, it's a little like balancing a locomotive on the end of the metal container. "It's got to be a thick piece of metal to handle that," laughs McGill. "It takes two people to lift one. Now, the ROV (the Remotely Operated Vehicle that maneuvers the instrumentation into place) can't work with such a thing. You've just exceeded the capability of the equipment."

Erickson continued to tinker with the design of the container, ultimately opting for domed end caps that could be machined from thinner material, but withstand tremendous pressures. "We ended up with a pill," says McGill. How to best produce that pill was yet another challenge. He and the MBARI team eventually cut out the middle of the capsule-shaped design and settled on a sphere. Erickson concentrated on developing a cost effective approach to economically and efficiently produce the two halves of the spheres that, flanged together, comprise the whole unit.

Initially, MBARI considered buying slugs of

Ti 6-4 and having them machined. "I think the raw material was \$30,000 for the slug," says McGill. That figure doesn't even take into account the time and money required to machine the metal into a housing and the low yield. "You're buying 100% of the titanium, and the housing that you deploy is maybe 15% of that," says McGill. Erickson explains that scheduling is another big factor: "It's weeks and weeks and weeks of machine time."

Worst of all, "aside from the fact that we're machining 85% of the material away, the supplier could not guarantee the material properties in the core of the slug," says the animated Erickson. "They're extruding a slug that is 19 inches in diameter, and under those conditions, they can't guarantee the material properties. Well, I'm sorry, I need to know what those material properties are."

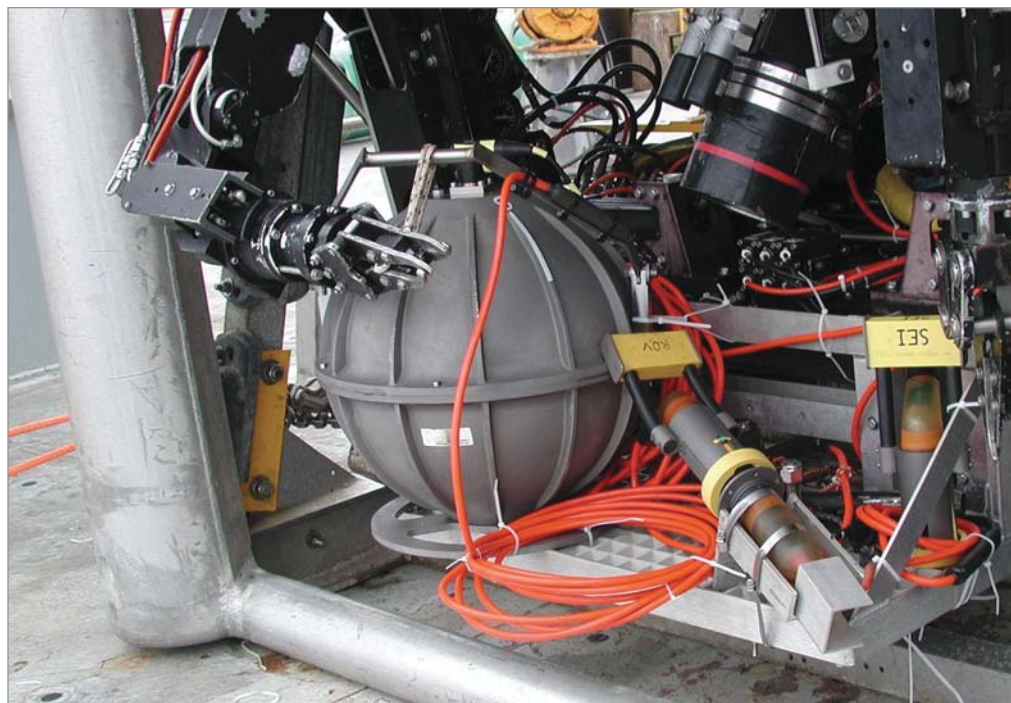
"The solution was to extrude the slugs to size, turn them up on end, and upset forge these into squat billets, and then re-extrude them. At that point they could guarantee the material properties. It also tripled the cost. It was a budget buster."

Just when it seemed the light at the end of

the tunnel was dimming, "the light bulb came on, and we started looking at casting," says Erickson. "Wah Chang was doing rammed graphite and would guarantee the material properties of the casting as it came out; and it wasn't a one-off, such as lost wax casting. There are all kinds of people doing all kinds of casting processes. What we could do here was produce a pattern that was re-useable, so our expense was a non-recurring engineering (NRE) expense. The NRE was up front, and it was one time only. We could amortize it over three cases, so suddenly it got a lot cheaper. We calculated that, using this method, we've saved around \$100,000 over building our housings the traditional way, and the results wouldn't have been as good. So the project managers were very happy."

Not that there weren't concerns with the casting process. "Castings have voids," says Erickson. "There was a guarantee on minimum void size, and I did a great deal of engineering looking at voids. Yes, we could x-ray the castings, but that's a huge expense also. What do we do if we end up with a flaw in the wall that is 0.020 of an inch? We actually modeled that, and it turned out it wasn't a killer. It was

A titanium sphere and its precious seismological cargo packed onboard a transport ship bound for the Endeavour broadband station 300 miles off the coast of Washington state.



Cast in Critical Role for

something we could live with. Given all that, suddenly it was an affordable project because we could ignore the flaws."

Hot isostatic pressing ensured any flaws were minimal. "Everyone that I've mentioned casting to has said that you're going to get flaws that are bigger than you can tolerate, but the HIP compresses those or collapses them," says McGill.

"It was a process that I had not heard of, but it changed it from not worth it to 'hey, this can work'" and eliminated the risk of having to scrap bad parts.

The production process decided, Erickson developed a drawing from which Wah Chang created a pattern. "It was really, really quite

easy," he says. In fact, the whole sphere production process has become very efficient. "We're taking near net size parts, and all we're asking our shop to do is machine the fine features in it," says Erickson. "What we do is basically take what will become the top or bottom hemisphere and machine the equator. They're (3/10 in.-thick) hemispheres with a flange attached - that's basically the pattern. There was a learning curve, but we're down now where we can almost machine one of these hemispheres in a day."

Erickson says that the castings come to MBARI in near-finished form. "We simply leave the vast part of the casting as cast. There is no point in cleaning an unused surface because it's not an issue. Yes, weight's an issue, but we're not doing aerospace and going to the moon. In fact, the displacement is enough that they'll float if you don't put anything in them."

McGill thinks that there could be many applications for the spheres. For example, MBARI has already re-applied the original design for a project named MOOS (or MBARI Ocean Observing System). "We're building a seafloor network with a limited amount of power, 20 watts to spread around," says McGill. He explains that the network

controller and its housing needed to be relatively inexpensive and customizable (the current housing design requires a second hexagon-shaped casting pattern with 12 penetrations). "That's why we're recycling this sphere that Jon came up with, repurposing it."

McGill would like to see the technology that he, Erickson, and Wah Chang helped develop

repurposed to earthquake-prone regions. "In general, developing techniques for putting these instruments on the bottom of the ocean opens up a lot of the world that is not accessible now," says McGill. "Right now, broadband seismometers can only be put on islands, and they tend

to be noisy because of the waves crashing on the shores. Or they can be put in the middle of a continent, but that leaves a lot of the world uncovered. This helps us understand the whole world seismic environment. For instance, it would help to better understand the faults that generate tsunamis if they had more broadband instruments. It's important to the seismologists. As it is now, they do the best they can, but they always want to be closer to the action, and being able to put these on the bottom of the ocean gets them that much closer to the origins of some of these events."

For now, he and Erickson are satisfied working with spheres, instrumentation, and many other MBARI projects that affect their corner of the globe. Success stories like the cast titanium spheres help keep them looking forward, searching for the next innovation. "We took a risk... and these guys delivered," says McGill.

To find out more about the fascinating research going on at the Monterey Bay Aquarium Research Institute, visit www.mbari.org. For information about Wah Chang's reactive and refractory metal products, including rammed graphite castings, visit www.wahchang.com or call 541-967-6977. ★



An ROV (Remotely Operated Vehicle) carefully positions a titanium sphere in a hole carved into the Pacific Ocean floor, over a mile below the surface.

PEOPLE

On the Move at ATI Wah Chang



Wah Chang is pleased to announce the addition of **Jon Haffner** to its titanium sales department. Before working in Wah Chang's

cost accounting department for the past four years, Mr. Haffner worked in cost accounting at Consolidated Freightways, and received his B.S. in Business Administration from Walla Walla College. "Mr. Haffner's previous experience at Wah Chang gives him a familiarity with its products and systems," says Carl Shawber, Titanium Sales Manager. "This has made for a quick transition into his role as Senior Inside Sales Representative for Industrial Titanium Tubing and Pipe." Mr. Haffner can be reached at 541-812-7496, or at jon.haffner@wahchang.com.



Patrick Snow recently accepted an offer to join the Wah Chang Technical Services group as a Corrosion Specialist, and

will be responsible for designing and running various corrosion tests on reactive and refractory metals. "We are pleased to welcome Mr. Snow to the Wah Chang Technical Services Team," says Corrosion Lab Manager Steve Sparkowich. "Patrick has a B.S. in Chemical Engineering from Oregon State University with experience in the nuclear and pulp and paper industries. His background in chemical process development, laboratory methods, and project management make him particularly qualified for his work in the Wah Chang Corrosion Laboratory and many of our other technical service activities." Mr. Snow can be reached at patrick.snow@wahchang.com, or at 541-812-4211 x6384. ★

2005 Corrosion Conference to Cover Broad Range of Topics

The 2005 version of ATI Wah Chang's Corrosion Solutions® Conference, the company's fifth biennial event, will include papers from the world's leading chemical companies, fabricators, and engineering firm. This year's conference takes place September 11-15 in Sunriver, Oregon.

The following abstracts provide a taste of what is to come this fall. Topics range from Welding of Titanium and Zirconium to Materials

Selection of Subsea Systems to an interactive panel session on Doing Business in China (note that conference presenters are underlined). In all, Corrosion Solutions® offers over 30 technical presentations and 5 hot topic panel sessions.

Chemical, oil and gas, and mineral processing companies planning to participate in the event include Agrium, Albemarle, Bayer, BP Amoco, Dow Chemical, DuPont, Eastman Chemical, ExxonMobil, Lyondell Chemical, Monsanto,

Phelps Dodge, and Statoil among others. Even NASA is sending a representative to this year's conference.

Interest in the event continues to grow. After looking over a sampling of the conference abstracts, we invite you to www.corrosionconference.com for more information or to register for the event. We hope you'll choose to join us in picturesque Sunriver this fall. ★

SAMPLE ABSTRACTS:

Corrosion and Hydriding of a Titanium Column in Acetic Acid Service

BY: MICHAEL M. JAMES
— *DuPont Engineering Technology*

During a recent internal inspection general corrosion and severe hydriding were found on the titanium trays of a process column containing acetic acid. Although corrosion and hydriding were a known problem in this column, the difference at this inspection was that the rate of corrosion and hydriding had significantly increased to a rate that caused catastrophic failure after one year of operation. This presentation will show details of the investigation into the cause of the corrosion and hydriding.

operate under similar acidic conditions with high oxygen partial pressures. However, titanium is subject to ignition in the oxygen rich environment where damage to titanium's protective oxide layer occurs. When monolithic titanium components are used, this can result in complete burning of the component and sometimes drastically unsafe conditions. This experience has limited the acceptance of titanium clad autoclaves in this service (except for some small laboratory units). To provide increased confidence in these applications, a study of the effects of the substrate metal upon the outcome of an ignition event were investigated. Studies included evaluation of carbon steel base metal, stainless steel base metal, and oxidation resistant-chilling interlayer metal layers between the titanium and steel. Preliminary testing was performed using conventional oxy-fuel cutting equipment. More definitive testing was performed using a small test autoclave at a respected ignition testing laboratory.

The presented material selection is based on experiences with materials for offshore oil and gas production during 30 years from the North Sea and the Norwegian Sea, and today's availability of corrosion resistant alloys.

Titanium Clad Ignition Studies in Simulated POX Environments

BY: JOHN BANKER — *DMC Clad Metal*
JENNIFER DEFREYNE — *Cominco Engineering Services Laboratory*
ROMAN STOIBER — *Cominco Engineering Services Laboratory*
RENATO DE SOUZA COSTA — *CVRD*
NATHAN WEYANDT — *Southwest Research Institute*
JAMES MCMASTER — *M C Consulting*

Abstract: For large Pressure Acid Leaching (PAL) autoclaves, titanium clad steel construction offers significant cap-ex and maintenance cost benefits. Titanium is the material of choice from the corrosion perspective. The exceptional corrosion resistance of titanium (including Pd and Ru alloys) in this lean sulphuric acid environment has been demonstrated over several decades. Similar Pressure Oxidation Leaching (POX) extractive metallurgy processes

Material Selection of Critical Piping Systems on Platforms Offshore Norway

BY: DR. TORFINN HAVN — *Aker Kvaerner Norway*

An overview of material selection for various critical piping systems topside of a modern offshore oil and gas-producing platform is given. The corrosivity of the various systems is discussed, and the needed properties of selected materials are outlined. Impact of temperature, pressure, lifetime and costs, on material selection is highlighted. The need of additional requirements to the standard ASTM material codes is shortly explained.

Materials selection for Subsea Systems and Equipment

BY: ØYSTEIN STRANDMYR — *Statoil*

Materials selection for subsea systems and equipment will be presented and evaluated based on Company practice. For template systems are mainly corrosion resistant materials (CRAs) used, but for subsea pipelines will carbon steels with or without corrosion inhibitors be evaluated as well as lined carbon steel, flexible pipeline structures and use of corrosion resistant materials (CRAs). Other type of subsea equipment such as subsea production separator systems for a new subsea field tie-in will also be evaluated. Some subsea field cases will be included in the presentation.

Process Chemistry Determines Metallurgy

BY: GORDON LENTZ — *Lyondell Chemical Company*

Changing operating chemistry in a large-scale commercial facility can have serious affects on that plant's metallurgy. A case study is presented on the feed stream methanol to an Acetic Acid Reactor. More than 25 years of history is followed from the original plant installation up to the present condition. This traces the piping system from stainless steel to zirconium to Hastelloy alloys.



Had enough excitement?

In today's
rollercoaster-like
marketplace, the
radical ups and downs in

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of corrosion resistant metals**

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Grubb Named to ASM 2005 Class of Fellows

ASM International established the Fellow of the Society honor in 1969 to recognize distinguished contributions to materials science and engineering.

ATI Wah Chang is pleased to announce that Dr. John Grubb, Manager, ATI Allegheny Ludlum Technical Center, is the latest person from Allegheny Technologies to be added to the 2005 Class of Fellows for his development, commercialization and promotion of corrosion

resistant duplex and austenitic stainless steels.

Grubb began at Allegheny Ludlum working on E-BRITE® and AL 29-4C® superferritic stainless steels, which led to several published papers on cathodic protection and hydrogen embrittlement. At the time, "there was also considerable work on development of carbide stabilization technology of the AL 29-4C alloy," says Grubb. "I became involved with the (then) recently-developed AL-6XN® alloy." The need



Dr. John Grubb

to publicize the product led to his publication of many technical papers on AL-6XN and other alloys. John has also worked with titanium, titanium alloys, mill processing issues such as annealing, pickling, and welding.

"The purchase of the Lockport melt shop in 1984 led to a greatly-expanded product line, especially in aerospace-type alloys and provided an opportunity to work on many processing-

and product-related problems with high strength and high temperature alloys," remembers Grubb. "Finally, the need to obtain code coverage for Allegheny Ludlum products led to my service on the ASME Boiler and Pressure Vessel Committee, where Rick Sutherlin of Wah Chang also serves."

Wah Chang congratulates Dr. Grubb on his accomplishments and this recent honor. Dr. Grubb can be reached at 724-226-6230 or at jgrubb@alleghenyludlum.com. ★

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OUTLOOK

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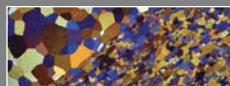
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