National Energy Technology Laboratory Albany, Oregon Site's Most Notable Research

Our Mission is to advance energy options to fuel our economy, strengthen our security, and improve our environment.

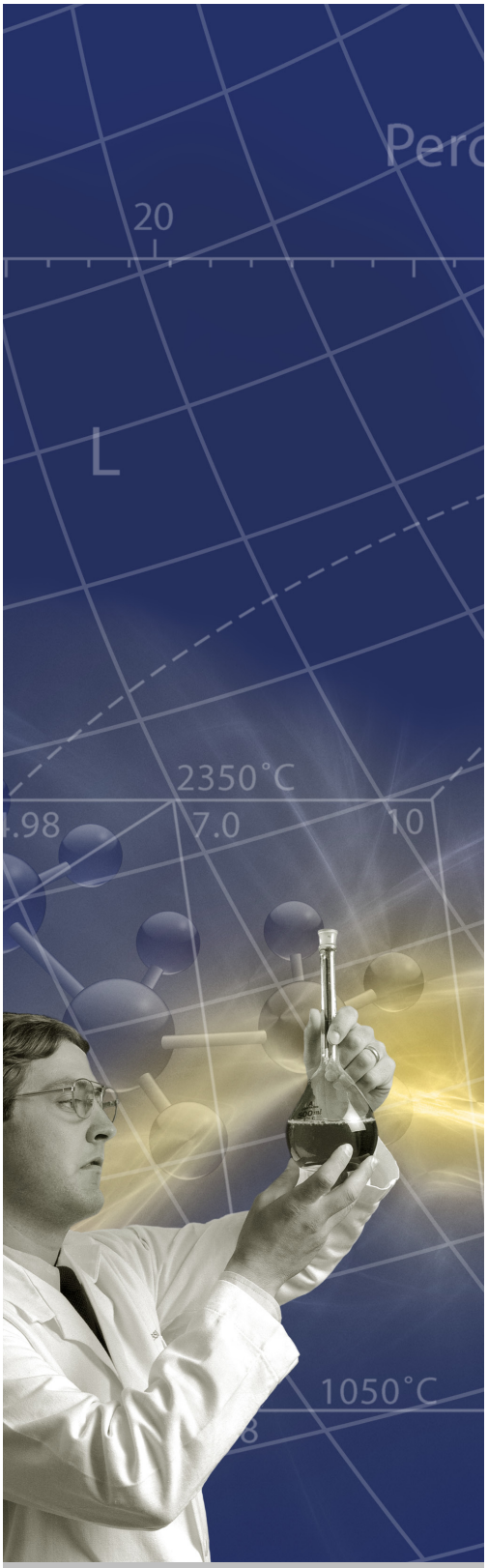
The National Energy Technology Laboratory (NETL) is a U.S. Department of Energy national laboratory and is comprised of three research laboratories—one in Albany, Ore., one in Morgantown, W.Va., and one in Pittsburgh, Pa. It is the only national laboratory that focuses solely on energy research and hence its tagline, "The Energy Lab."

NETL has a total of 1,800 employees. 700 are federal employees and 1,100 are contractors. At the Albany site there are 128 federal employees and contractors with a payroll of over $14 million. In addition to the in-house research performed at the Albany site, NETL supports the Oregon economy through the funding of over $136 million in multi-year agreements and contracts that provide Oregon with an estimated 776 job years.

Having a research laboratory situated in Albany provides several advantages. One is its proximity to two major universities—Oregon State University and the University of Oregon. Another is that the Pacific Northwest National Laboratory is just across the border in Washington and the Idaho National Engineering Laboratory is located in nearby Idaho. In addition, it is located in the heart of the reactive and other high-temperature metals industries, so critical to the Nation's economic health. Several of these industries were spun out of research done at this laboratory or were brought into existence by the laboratory and the metals manufacturers located in the vicinity.

As part of the NETL research complexes, Albany's researchers are currently developing high-temperature, corrosion-resistant structural ceramic composites and metal alloys to perform specific functions in advanced fossil energy systems such as coal gasifiers, turbines, combustors, and fuel cells. NETL's research also includes developing methods to safely capture, store, and utilize carbon dioxide, a greenhouse gas.

This laboratory has a history rich in research innovation. What follows are the accomplishments of which we are most proud.



U.S. DEPARTMENT OF ENERGY

A Brief History

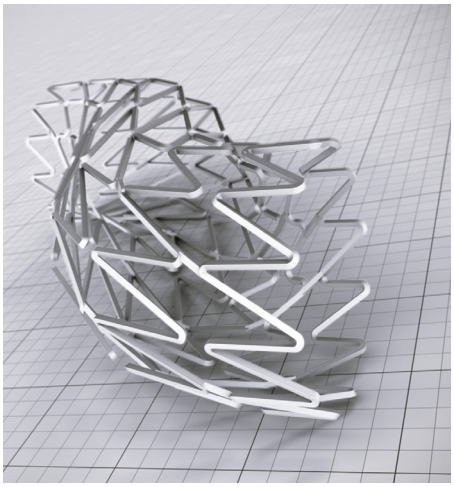
President Franklin D. Roosevelt announced in 1943 that the U.S. Bureau of Mines had selected Albany, Oregon, as the site for the new Northwest Electro-Development Laboratory. The laboratory fulfilled its role as a government research facility within the Department of the Interior by building and maintaining a unique suite of technologies, capabilities, and expertise that enabled the Center to respond rapidly to critical national needs.

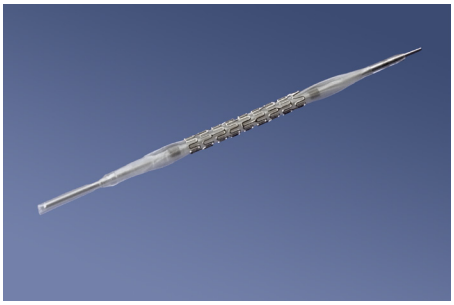
Over the years, our scientists and engineers have been awarded numerous patents, and have substantially contributed to the fields of metals and minerals research. In 1985, the Center was named an historical landmark by the American Society for Metals.

In 1995, Congress closed the U.S. Bureau of Mines and transferred the Materials Partnership Program in Albany to the Department of Energy's Office of Fossil Energy. In October of 1997, the Oregon State Historic Preservation Office declared this facility eligible as an historic district to the National Register of Historic Places.

In late 2005, the Albany Research Center was reorganized into NETL. This action aligned the Albany laboratory's expertise in materials performance and process development with NETL's mission to advance America's economic and energy security by resolving the environmental, supply, and reliability constraints of producing and using fossil resources.

Novel Platinum/Chromium Alloy for the Manufacture of Improved Coronary Stents (2011 R&D 100 Award winner)

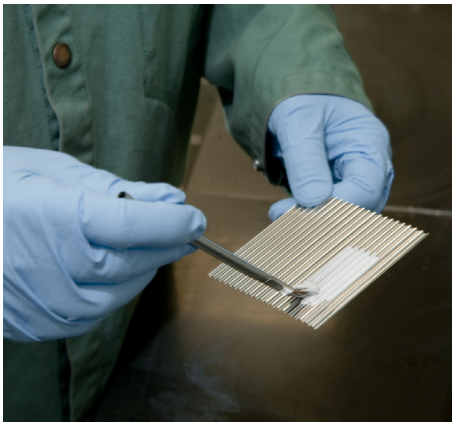




Jointly developed by NETL and Boston Scientific Corporation, Inc., (BSCI) this novel alloy is the first austenitic stainless steel formulation to be produced for the coronary stent industry, with a significant concentration of an element, platinum, with high radiopacity—high visibility with x-ray scanning. Better visibility means greater ease and precision in placement of the stent inside the patient's artery. In addition, the greater yield strength of the alloy allowed the stent's designers at BSCI to make a thinner, more flexible stent that is more easily threaded through the winding path of the artery without doing damage along the way.

The stents were first marketed in 2010, selling 206,000 units in Europe, the Middle East, and Africa up to December 2010—a 22 percent market share of coronary stents in these regions. On April 25, 2011, the stents, under the TAXUS ION™ label, were approved for sale in the United States. Total sales since introduction have exceeded $1 billion. BSCI now has a 45 percent share of the market for coronary stents since the 2010 introduction of the new stent using the NETL/BSCI-developed platinum/chromium (PtCr) alloy.

This 2011 R&D 100 Award-winning alloy will be used in making all of BSCI's future coronary stents, both bare and drug-eluting, according to a recent discussion with BSCI personnel. On October 17, 2011, BSCI announced that the PtCr alloy-based coronary stent had been approved for sale in China, the world's largest stent market, where over 550,000 are deployed each year. This market has a projected growth rate of 20 percent per year, making this product hugely successful.



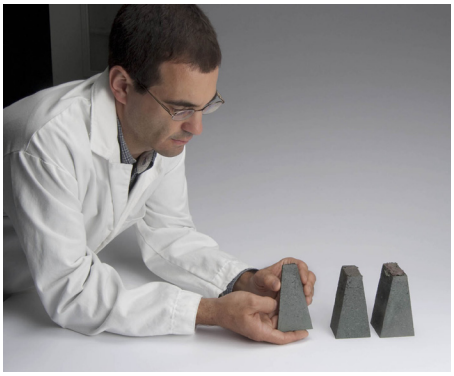
Cerium Oxide Coating to Reduce Oxidation in Stainless Steels and Nickel Superalloys (2010 R&D 100 Award winner)

To produce power more efficiently and cleanly, the next generation of power plant boilers, turbines, solid oxide fuel cells (SOFCs), and other essential equipment must be operated at extreme pressures and temperatures, in the "ultrasupercritical" range-pressures up to 5,400 psi and temperatures up to 1,400 °F. Even nickel-based superalloys and stainless steels suffer from excessive oxidation at these conditions, leading to the premature failure of components. A possible solution is to coat the metallic components with a protective layer of a ceramic oxide such as cerium oxide, then heat the alloy so cerium diffuses into the surface of the bulk metal alloy.

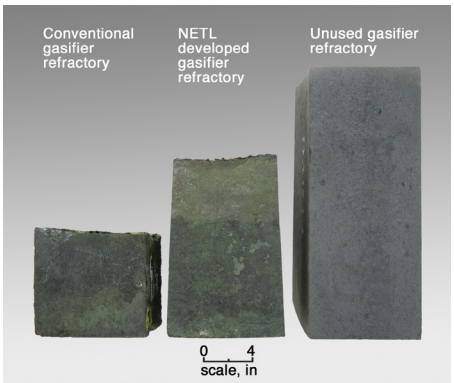
Researchers at NETL developed a simple and robust method of applying a cerium oxide slurry with an activator compound to the surface of a metal component by brushing, spraying, or dipping. This low-cost process ensures a uniform coating on parts of complex shapes that are difficult to coat using sputtering, vapor deposition, or traditional pack cementation. Analysis of the coatings after thermal treatment showed that a protective surface layer forms with a microstructure that greatly slows the oxidation rate. In most cases, the cerium surface treatment improved oxidation resistance by a factor of 2 to 3, and in a few alloys, it resulted in an order of magnitude improvement in performance.

This R&D 100 Award-winning technology was evaluated by the University of Oregon's Entrepreneurship Program for commercialization potential. Graduate students in this entrepreneurship program are working with NETL scientists to refine their Phase 2 business plan for the coating with application to cooking grills. Although the technology was developed for power generation applications, these young entrepreneurs recognized the application for these everyday devices and are pursuing this, both as a project toward their degrees, as well as for a new business start-up potential. This is Oregon innovation at its finest.

Improved Refractory Liner for Coal Gasification



Albany scientists developed a novel refractory material that could overcome one of the major challenges preventing widespread adoption of the next generation of advanced coal gasification power plants. The newly developed refractory material has a longer service life, leading to greater online availability of the gasifier for coal processing.



Coal gasification is important to obtaining the most energy from the nation's abundant coal supplies. It involves reacting coal with high-temperature, high-pressure steam in a shortage of oxygen to convert it into synthesis gas, or syngas—a carbon monoxide and hydrogen gas mixture. Gasification can be costly though, in part due to rapidly deteriorating heat-resistant refractory linings, which protect the metal gasification chamber from its service environment.

Once the technology was patented, NETL and Harbison-Walker Refractories Company agreed to scale-up the process for field trials. The resulting refractory was found to increase refractory service life by up to 50 percent. Harbison-Walker licensed the technology from NETL, conducted additional field trials, and commercialized the product as AUREX™ 95P. It has received reviews of "exceptional" and "excellent" at test sites and is the refractory of choice in high-wear areas of a gasifier.

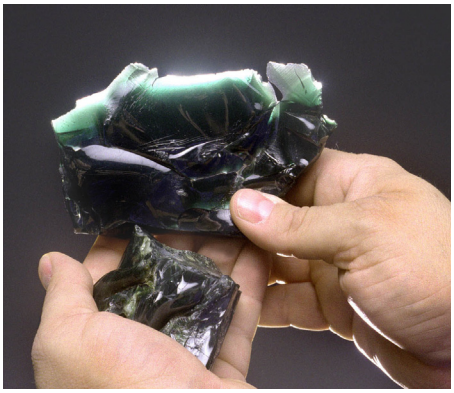
Recovering Precious Metals from Catalytic Scrap

In 2000, during an attempt by the Russians to corner the palladium market, which increased the price of palladium from $100 per Troy ounce to over $1,000 per Troy ounce in less than six months, Engelhard Corporation (EC) decided to build an onshore facility to provide a recyclable product as a feed for its Seneca, SC, hydrometallugical processing plant for it to stay profitable. Representatives from EC asked scientists from Albany's Thermal Treatment Technologies Division if they were capable of developing a process to convert spent catalytic materials from the petroleum and transportation industries into a recyclable metallic product. Lengthy negotiations resulted in a Cooperative Research and Development Agreement between EC and the Albany Research Center.

EC's goals for the project were that 1) the recovery of the precious metals be greater than 93 percent, 2) the product be an appropriate feed form (i.e., finely divided) for the EC proprietary hydrometallugical process that results in individual precious metals as products, 3) the process be scalable with enough engineering data to design and build the plant in Seneca, and 4) the process be developed to a scale that could be used for training an EC crew in its operation.

The pyrometallugical approach developed over the following 18 months yielded a product compatible with EC's in-house process and led to a plant designed, built, and operated by EC in Seneca. Because of the plant's successful recovery of over $15 million in precious metals, it is now undergoing a doubling of its capacity.

Vitrification of Municipal and Other Wastes



Heavy metal and toxic organic contamination of the biosphere by interaction with soil and groundwaters is a significant problem worldwide. Landfilling of these wastes has proven an inadequate solution. To help solve this problem, Albany Research Center scientists, in cooperation with the American Society of Mechanical Engineers, the Idaho National Engineering Laboratory, Southern California Edison Co., Westinghouse Hanford Co., and the Department of Energy (DOE), designed and constructed a pilot plant equipped with a specially built electric arc furnace.

Over 180,000 lbs of material from two sources were melted into a glassy or crystalline form. The materials treated included residues from waste-to-energy plants, which are fueled by municipal waste, and liquid and as-retrieved forms that represented radioactive and hazardous materials currently stored at DOE sites and at the Charleston Naval Shipyard.

This melting process, called vitrification, could solve the leaching problem inherent with landfilling municipal waste residues and is a means to decrease their volume by as much as 90 percent and makes them environmentally benign. In the case of radioactive wastes, the decrease in volume could dramatically decrease the size of radioactive storage sites or increase their useful lifespan. (1990-1995)

Armstrong Titanium Reduction Process (2007 R&D 100 Award winner)

NETL researchers worked with International Titanium Powder, LLC, (ITP) of Rockport, Ill., for nine years to refine ITP's method to reduce the cost of producing titanium and titanium alloys. The groundbreaking method, called the Armstrong Process, deviates from "traditional" methods for titanium production by being a continuous process—rather than a batch at a time—and eliminates the down-time associated with a step-wise batch process. Continuous production allows for lower temperatures and pressure, which in turn lowers cost. Recent efforts from the team have resulted in methods to economically turn Armstrong Process powders into usable, economical products for the automotive, defense, and aerospace industries.

Titanium is strong and lightweight and resists corrosion. It is stronger than steel in certain applications, but only about half as dense. Although the metal was discovered in 1791, it was confined to laboratory use until the invention of the Kroll process in 1946 because extracting titanium from ores was a long and expensive process. Even using the Kroll process, production is costly enough that titanium can only be practically used in specific, high-priced markets. The new cost-efficient Armstrong Process opens the material for use in a variety of applications.

NETL's work with ITP on the Armstrong Process eventually led to their collaboration on the development of armorplate. Not only does titanium armorplate possess the light-weight, high corrosion-resistance properties of titanium, it also has superior ballistic properties. ITP's first commercial plant is fully operational and a significant portion of its production is already committed under multi-year, extended contracts. Department of Defense contractors are planning to use this product in defense-related products. The Armstrong Process and applications for its products were developed by a team consisting of ITP, NETL, Oak Ridge National Laboratory, BAE Systems, AMETEK, and Red Devil Brakes.

Titanium and Cast Steel Armor

Funded by the U.S. Army's Tank and Automotive Research and Development Center, Ballistic Testing Laboratory, and Materials Testing Laboratory, Albany researchers developed both a low-cost titanium alloy that has been specified in U.S. Army and Swedish army applications and a complex steel cast armor with good surface finish, excellent dimensional stability, and high yield that has been adapted for military use. Armor from these processes is lighter and more ballistically efficient and costs less than conventional armor.

Armor developed by these processes or spin-offs from these processes was field tested in the First Gulf War and the involvement in Somalia, a ready reaction force in the Balkans, and for specialized applications in both Afghanistan and Iraq. Albany Research Center and the Department of Defense also partnered with the following companies during the development: FMC Corporation; General Dynamic Land Systems; International Welding, Inc.; RAMSTUD, Inc.; Lanxide Armor Technologies; Vanrich Foundry; Waukesha Foundry; and DuPont. (1991–2007)

Corrosion of Bridge Infrastructure

A 2002 U.S. Federal Highway Administration study on the direct costs associated with metallic corrosion revealed that approximately 15 percent of the nation's 583,000 highway bridges were structurally deficient due to corrosion. Annual direct costs to address these bridges amount to $8.3 billion. Indirect costs, such as traffic delays and lost productivity, were estimated to be as high as ten times the direct costs.

In Oregon, a series of related projects arose from the Oregon Department of Transportation's desire to preserve corrosion-damaged historic reinforced concrete bridges along the Oregon coast after the public outcry following the demolition of the Alsea Bay Bridge in 1992. To prevent rebar corrosion in the chloride-rich coastal environment, a cathodic protection (CP) system was used called "impressed current CP" consisting of a thermal-sprayed (TS) zinc coating on the exterior of the bridge and the application of a protective current between the rebar (cathode) and the zinc coating (anode).

The corrosion group at Albany was engaged to solve problems concerning the expected lifetime of the coatings and to examine the TS process for improvements and cost savings. Later, this research expanded to state, national, and international scope—anywhere in which coastal conditions or the use of deicing salts act to destroy the innate corrosion protection of steel in concrete.

Their research found that zinc anodes will eventually fail after about 25-27 years of impressed current service. The failure is a result of cracking within the reaction layer that forms between the concrete and the zinc. This led to improvements in how the zinc anodes were applied, and to methods to extend their life by periodic applications of humectants (compounds that help retain water) to the zinc anode surface and corrosion monitoring, which made possible only intermittent application of the impressed current.

Thermodynamic Research Associated with Metal and Mineral Processing

The Albany laboratory established a worldwide reputation for generating reliable thermodynamic data and making them available through books, bulletins, and research reports. Among some of the most notable are compilations of the thermodynamic properties of copper and its inorganic compounds, a similar compilation of nickel and its compounds, and several on the thermodynamic properties of 65 elements, their oxides, halides, carbides, and nitrides.

Authoritative thermodynamic data are one of the most effective guidelines for research and development leading to optimal use of mineral resources. These data establish minimum energy requirements, enable the calculation of maximum theoretical yields, and aid in process development by elimination of costly trial and error experimentation. (1967–1986)

Casting of Reactive or Refractory Metals

Based on evidence from some pioneering studies, the Albany laboratory responded to a request from the U.S. Army to develop a method for casting titanium without deleterious contamination. Commonly described as reactive or refractory, the technology for melting and casting metals such as beryllium, titanium, tungsten, and hafnium was then developed. The technology is also applicable to alloys of these metals and as alloying constituents for iron, cobalt, or nickel-based alloys.

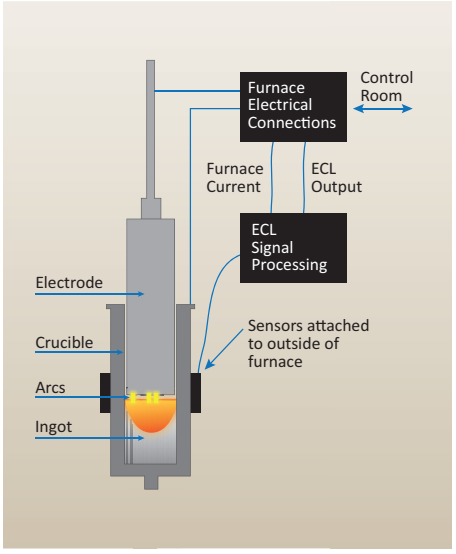
This technology has been the basis for development of the entire family of "space age" metals that has made possible the production of high speed aircraft and space re-entry vehicles. Prior to this development, casting technology for refractory and reactive metals was not available. Today, many reactive and refractory metal castings are produced commercially in the United States and Europe and are poured in equipment directly traceable to the laboratory's original research. (1954–1960)

Double Consumable Electrode Vacuum Arc Melting

In search of improved methods to prepare zirconium alloy ingots for use in the submarine reactor program, scientists at the Albany Research Center demonstrated the benefit of double vacuum arc melting. This method permitted the use of sponge zirconium rather than highly purified and expensive DeBoer process metal.

The techniques developed rapidly and spread throughout the titanium, as well as the fledgling zirconium industry. Today, many commercial alloys and other metals are produced using the Albany-developed double vacuum arc melting technique (VAR). (1949–1959)

Today, NETL scientists are working on an electric current locator which improves on the VAR process by allowing them to track the positions of the electric arcs inside the VAR furnace in real time. Knowing where the arcs are shows how energy is being distributed to the molten metal during the remelting process. "Seeing" the arcs is a first step toward controlling them and thereby controlling the melting process, which is necessary for consistently defect-free materials.



Kroll-Process Zirconium

Work on the production of zirconium was the most significant factor in making Albany a center for the fabrication of exotic metals. In 1944, the first attempt to produce zirconium from zircon-bearing beach sands in Coos Bay, Oregon, was unsuccessful. However, Dr. William J. Kroll, a noted metallurgist from Luxemburg, had perfected a method for reducing titanium tetrachloride with magnesium in an inert atmosphere. On the assumption that his process might be adopted for the production of zirconium, Dr. Kroll joined the staff at the Albany laboratory in January 1945.

Using Dr. Kroll's process, production of pure zirconium metal made possible one of the nation's finest technological achievements, the first atomic-powered submarine, the U.S.S. Nautilus. Attracted by the Bureau's accomplishments, the Atomic Energy Commission and the Bureau of Ships contracted with the Bureau of Mines in 1949 to supply zirconium for atomic reactor use. The program was enlarged in 1954 to supply sufficient additional material for wartime needs.

Once the Kroll process was perfected at the pilot-plant level, it was turned over to industry for commercial production. Albany's exotic metals industry began—Wah Chang Albany Corporation and Oregon Metallurgical Corporation—because the expertise resided here, despite the fact that all the mineral raw materials came from out of state.

Technology developed by scientists and engineers at Albany in those few years has been the basis for many industrial operations, and today nearly all the zirconium produced for reactor use is made using the Bureau-developed Kroll reduction process.

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