Pacific Northwest
NATIONAL LABORATORY

PNNL has developed several first-of-a-kind technologies and award-winning processes for the manufacture of high-performing materials that are available for licensing and R&D partnership opportunities.

Solid Phase PROCESSING AT PNNL

Pacific Northwest National Laboratory's (PNNL's) unique suite of Solid Phase Processing—or SPP— technologies is poised to provide the energy, automotive, aerospace, metal manufacturing, and other industries with the tools and processes to enable next-generation materials and components with revolutionary performance. These technologies—available for licensing—have the potential to provide higher performance, more efficient, and scalable manufacturing approaches that will allow these industries to incorporate higher-performance materials into their products.

Producing extrusions with unprecedented material properties

Shear Assisted Processing and Extrusion (ShAPE™)

DESCRIPTION

PNNL's patented and patent-pending technology, Shear Assisted Processing and Extrusion—or ShAPETM—offers a novel way to manufacture wire, bar, and tubular extrusions. These extrusions show significant improvement in properties—for example, magnesium extrusions have been manufactured with unprecedented ductility (how far the material can stretch before it breaks) and energy absorption (how much energy can be absorbed during compression of a tubular extrusion) over conventional methods.

In ShAPE™, a canister holding feedstock material, such as metal powder, flake, or billet, is forced into a rotating die. Frictional heating is generated at the interface between the feedstock material and die, which softens only the material being extruded, eliminating the need for feedstock pre-heating or application of external heat used in conventional extrusion. Spiral grooves on the die face feed the material inward toward the extrusion orifice, which significantly reduces the amount of force required to form the parts.

APPLICATIONS

ShAPE™ can be used to form fully consolidated wire, rods, tubes, or other non-circular shapes using powder, flake, machining waste (chips or swarf), or solid billet.

With this technology, further innovation is expected in the automotive, aerospace, oil and gas, electric power, medical, and semiconductor industries. It has been investigated as a viable method for production of creep-resistant steels for heat exchangers in the electric power industry and high-conductivity copper and advanced magnets for electric motors. It has also been used to produce high-strength aluminum rods for the aerospace industry. In addition, the solid-state cooling industry is investigating ShAPE™ as a method to produce semiconducting thermoelectric materials.

BENEFITS

As an example, using ShAPE™, nanostructured aluminum powder can be extruded directly into round bars using 50 times less force and much lower power consumption than conventional extrusion while achieving twice the ductility. Costly time-consuming steps required during conventional powder processing are entirely eliminated.

The lower force and power enable substantially smaller production machinery, lowering capital expenditures and operations costs. With an extrusion ratio of 200:1 demonstrated for magnesium, ShAPE™ achieves in a single pass what would take multiple passes with conventional extrusion. The technology's exceptional shearing conditions enable precise control over grain refinement and microstructure orientation in extrusions—which also is not possible with other extrusion processes. In addition, magnesium extrusions made by ShAPE™ do not require costly rare earth elements to produce extrusions with sufficient ductility and energy absorption for use in some structural automotive applications (e.g., automobile bumpers), allowing affordability in mass production.

AWARDS

ShAPE™ was a finalist for a 2018 R&D 100 Award that signifies the top 100 most innovative technological breakthroughs in the world.

TECHNOLOGIES AVAILABLE FOR LICENSING

Battelle IPID 30343 – patents: 10,189,063, 15/898,515, 16/028,173

System and Process for Formation of Extrusion Products

Functionally Graded Coatings and Claddings

Method for Forming Hollow Profile Non-Circular Extrusions Using Shear Assisted Processing and Extrusion (ShAPE)

Joining dissimilar materials for lighter-weight parts and components

Friction Stir Scribe

DESCRIPTION

Friction Stir Scribe is revolutionizing the way dissimilar materials are joined, allowing new materials and new combinations of materials to be incorporated into parts and components—without sacrificing strength and durability.

The process has transformed the way dissimilar materials are joined by incorporating a simple but extremely significant change to friction stir welding, a well-known process that effectively joins different thicknesses of materials but is less effective in joining materials with very different melting points—for example, steel and aluminum. The key to this new process is the attachment of a tiny device—called a scribe—that is similar in size and shape to a spark plug and is equipped with a tiny cutting tip on top. The scribe allows—for the first time—cutting of a harder material such as steel, creating a chemical bond and/or a mechanical interlock between it and a softer material placed on top of the harder material, such as aluminum. Friction Stir Scribe overcomes the issues created by chemical incompatibility and melting temperature variations between dissimilar material combinations, which results in a strong, continuous joint without any additional filler or fusion material.

APPLICATIONS

While developed primarily for the automotive industry, there are many potential applications in the transportation, energy, and consumer electronics industries, where the welding of very different metals or different materials, such as polymers to metals or composites, is needed.

BENEFITS

Friction Stir Scribe is the only technology that produces a continuous mechanical and/or chemical joint between significantly different materials, like polymer-metal or aluminum-steel. The materials can be joined in a continuous, linear, or curved manner without the need for adhesives, bolts, or rivets. Friction Stir Scribe is also the only technology that allows thin sheets of materials with drastically different melting points (as much as 800˚C difference) to be joined together in a strong, continuous seam, providing novel opportunities for joining steel to aluminum or metals to polymers. For companies that routinely use friction stir welding machines in their production, Friction Stir Scribe is a simple, inexpensive retrofit that unlocks the potential for incorporating new materials into their products.

AWARDS

This technology was the recipient of a 2017 R&D 100 Award, making it one of the top 100 most innovative technological breakthroughs in the world that year.

TECHNOLOGIES AVAILABLE FOR LICENSING

Battelle IPID 16697 – patent: 8,434,661

Friction Stir Welding Tool and Process for Welding Dissimilar Materials

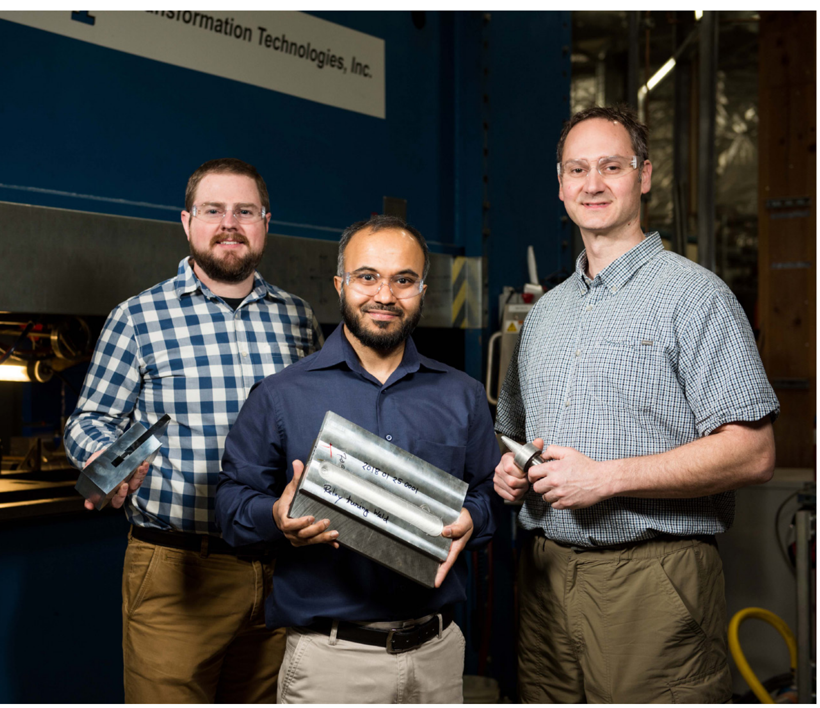
Friction Stir Dovetailing

DESCRIPTION

Friction Stir Dovetailing is a novel process that allows joining of thicker sheets of aluminum to steel. In woodworking, dovetails and glue are used to securely join pieces of wood together. Friction Stir Dovetailing is a similar approach for metals. Using a specially designed tool, aluminum is deformed into a steel dovetail groove to form a mechanical interlock. At the same time, the tool pushes along the bottom of the dovetail to form a thin metallurgical bond—or intermetallic compound—which “glues” the metals together within the dovetail.

APPLICATIONS

Friction Stir Dovetailing was demonstrated for the military, which is looking for ways to make lighter-weight combat vehicles that are more agile and fuel efficient—while still maintaining personnel safety. The technique is also relevant to offshore oil and gas, marine vessel, and large structural applications.



A unique process for joining large section dissimilar materials to steel

The research team is also refining the technique and expanding the process for other joint configurations and a multitude of aluminum alloy classes. In addition to aluminum and steel, other material combinations, such as aluminum to copper, aluminum to magnesium, and magnesium to steel can also be joined using Friction Stir Dovetailing.

BENEFITS

A combination of mechanical interlocking and metallurgical bonding formed during a single process produces joints of superior strength and ductility compared to joints created by other friction stir methods using dissimilar metals. In addition, unique to Friction Stir Dovetailing is the inhibition of intermetallic compound growth that causes joint brittleness and failure in other techniques. Because these compounds remain so thin during processing—one thousand times thinner than a human hair—they act as glue without causing embrittlement.

The technology shows not only superior joint strength, but also increased ductility compared to other aluminum-to-steel techniques, allowing the material to stretch further before the joint breaks. This is beneficial in, for example, cases of vehicle crashes or around oil, gas, or marine applications where a critical event could have a drastic impact on the structures.

TECHNOLOGIES AVAILABLE FOR LICENSING

Battelle IPID 30993– patent: 15/694,565 (pending)

System and Process for Joining Dissimilar Materials and Solid-State Interlocking Joint with Intermetallic Interface Formed Thereby

A new process for joining metals like aluminum and magnesium to composites and other non-metals

Friction Stir Interlocking

DESCRIPTION

Friction Stir Interlocking is a new solid-phase technique that has been developed for joining lightweight metals to composites, thermoset plastics, ceramics, or other non-metallic materials.

There are currently two Friction Stir Interlocking approaches to the joining of metal sheets and plates to non-metals. The first approach involves embedding metal inserts within the non-metal, and subsequently Friction Stir Welding the metal sheet or plate directly to the metal insert.

The second involves inserting metal pins through the non-metal, much like a rivet, and then Friction Stir Welding the metal sheet or plate directly to the metal insert to form a mechanical fastener.

APPLICATIONS

Friction Stir Interlocking is used specifically for light-weighting of automotive components or any application—for example, bridges—where robust joints between magnesium or aluminum and non-metals are required.

BENEFITS

This newer technology allows numerous interlocks to be created quickly and uniformly, in a single pass, offering reduced cost and improved process efficiency compared to conventional metal-to-non-metal fasteners like riveting, pillaring, and spot welding. Friction Stir Interlock also reduces the galvanic and pitting corrosion that can occur between metal fasteners and carbon fibers within composite materials thanks to corrosion barriers that can be formed as a result of heat generation during the friction stir process.

The process has advantages over current friction stir and other joining technologies in that it has demonstrated improved joint strength, reduced corrosion, lower processing temperatures (as low as 250oC), and greater processing speeds compared to spot welding techniques.

TECHNOLOGIES AVAILABLE FOR LICENSING

Battelle IPID 30020 – patent: 9,283,637, Battelle IPID 31183 – patent: 15/794,687

Friction Stir Interlocking of Dissimilar Materials

Cold Spray

DESCRIPTION

Cold spray is a solid phase deposition process. Metal particles are propelled at supersonic velocities and impact a surface with sufficient energy to form a bond. Low heat input and resulting highly cold worked microstructures allow cold spray to produce materials and coatings with excellent hardness, wear resistance, and corrosion resistance.

Over the last few decades, advances in cold spray technology were primarily developed by the Army Research Lab (ARL) for defense applications. PNNL is working with ARL, VRC Metal Systems, and Moog to develop cold spray applications for the energy sector that leverage Department of Defense-developed technical advances.

APPLICATIONS

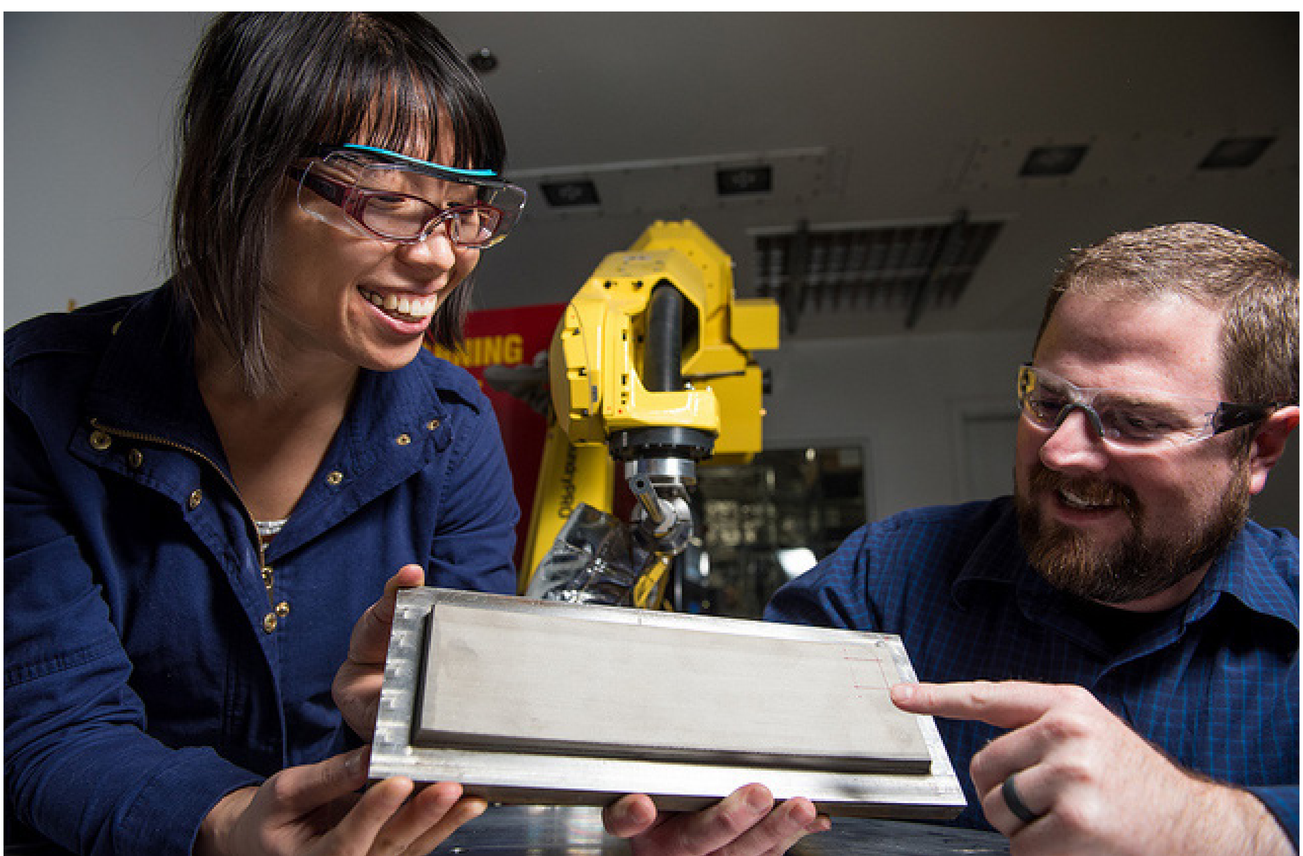
PNNL is actively developing cold spray solutions for hydropower, nuclear, and automotive applications.

BENEFITS

Recently, the project team demonstrated a cold spray process that delivered a material with three times improved cavitation erosion resistance relative to stainless steel plate or filler metal and about an eight times improvement compared to the heat-affected zone carbon steels common in hydroturbines. PNNL has recently obtained a next-generation cold spray system and believes that cold spray has potential to reduce cost and improve performance of new and existing components throughout the energy sector. This new high-pressure cold spray capability will support development of cold spray processes ranging from high-volume automated factory production to manual field repair.

This technology is not yet available for licensing—stay tuned.

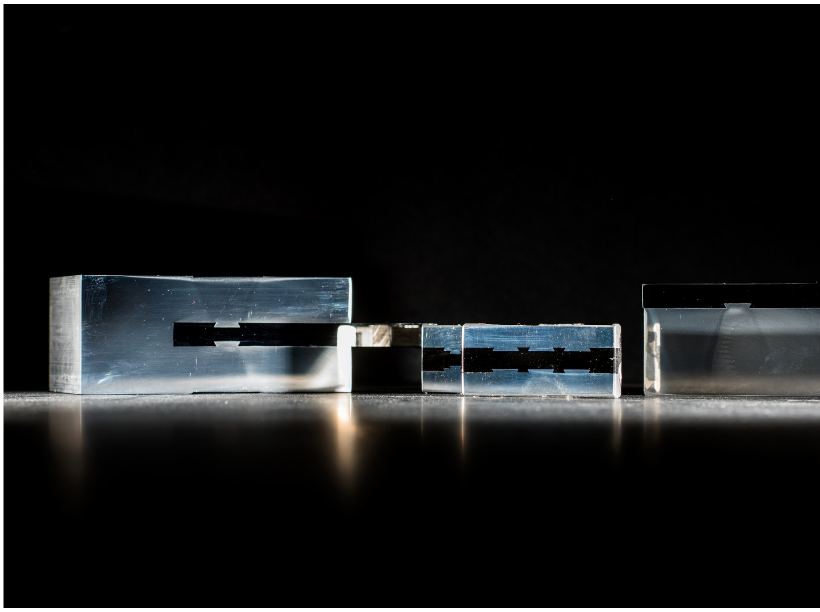
Producing materials and coatings that are durable and resist corrosion



Gaining A Competitive Advantage—License From Us

These innovative SPP technologies are available through a variety of exclusive and non-exclusive licensing options. PNNL also offers an exploratory license agreement that enables—for just $1,000—an organization to "test drive" a technology for six months, all while reserving the right to that promising innovation. To learn more, contact PNNL Commercialization Manager Sara Hunt (sara.hunt@pnnl.gov or 509-375-6555) or see our website: https://www.pnnl.gov/industry-partnerships.

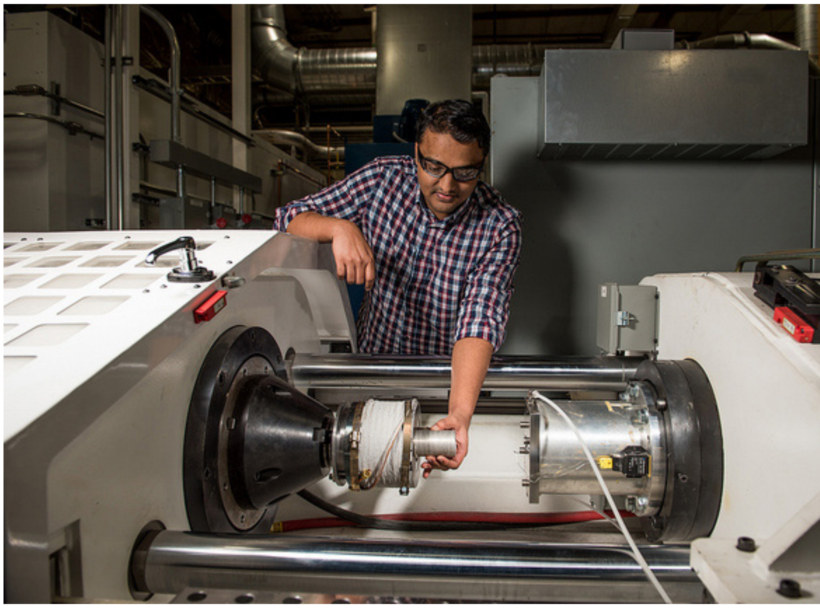
To learn more about our contacting mechanisms for industry, see the "Contracting Mechanisms for Work with PNNL" section of our website.



ABOUT PNNL

Located in southeastern Washington, PNNL researchers address many of America's most pressing challenges in energy, the environment, and national security through advances in basic and applied science. The national laboratory was founded in 1965 and currently employs 4,400 staff members with an annual budget of nearly $1 billion. Battelle operates PNNL for DOE's Office of Science—the single largest supporter of basic research in the physical sciences in the United States.

The majority of PNNL's SPP work is sponsored by DOE's Office of Energy Efficiency & Renewable Energy. Work on the Friction Stir Dovetailing process was supported by the U.S. Army's Tank Automotive Research, Development and Engineering Center.



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