THE BENEFITS OF

Bonded Bimetal in Aerospace

As aerospace expands to include ever more advanced technology, from space vehicles and moon landers to the necessary planetary sciences and new energy research, engineers are continually looking for materials that solve their design dilemmas. When it comes to metals, however, no single metal or alloy consistently satisfies all their requirements. The question is, how do we take advantage of the beneficial properties without being trapped by the limitations?

One solution is using dissimilar metal joining technologies to create bimetals or multi metals. This allows engineers to make components with vastly improved performance while minimizing the design trade-offs of any single metal.

BONDED METAL PROPERTIES THAT CAN BE APPLIED:

- Metals capable of maintaining mechanical strength at extremely high or cryogenically low temperatures
- Metals with high thermal conductivity versus others with insulative properties
- Metals with excellent strength-to-weight ratios compared to those with greater strength but with added weight
- Metals undamaged by specific chemical or environmental exposures versus those that quickly corrode in the same applications
- Metals that attenuate vibration and others that ring like bells

Useful Properties of Common Bonded Dissimilar Metals

Atlas Technologies

Al ALUMINUM
- High strength to weight
- High thermal conductivity
- Highly manufacturable
- Non-magnetic
- Corrosion resistant
- Excellent vacuum properties
- Low nuclear activation

Cu COPPER
- High thermal conductivity
- High electrical conductivity
- High thermal mass
- Corrosion resistant
- Strong
- Non-magnetic
- Antibacterial

Nb NIOBIUM
- Highly heat resilient
- Corrosion resistant
- Strong
- Superconductor at cryo temperatures

SS STAINLESS
- Strong
- Durable
- Corrosion resistant
- Temperature resilient
- Hygienic
- Easily weldable

Ti TITANIUM
- Excellent strength to weight
- Highly corrosion resistant
- Extreme temperature resilient
- Poor thermal conductor
- Non-magnetic

1 Ti + Al Fittings and Flanges
Aerospace, Energy, UHV, Semiconductor, Quantum

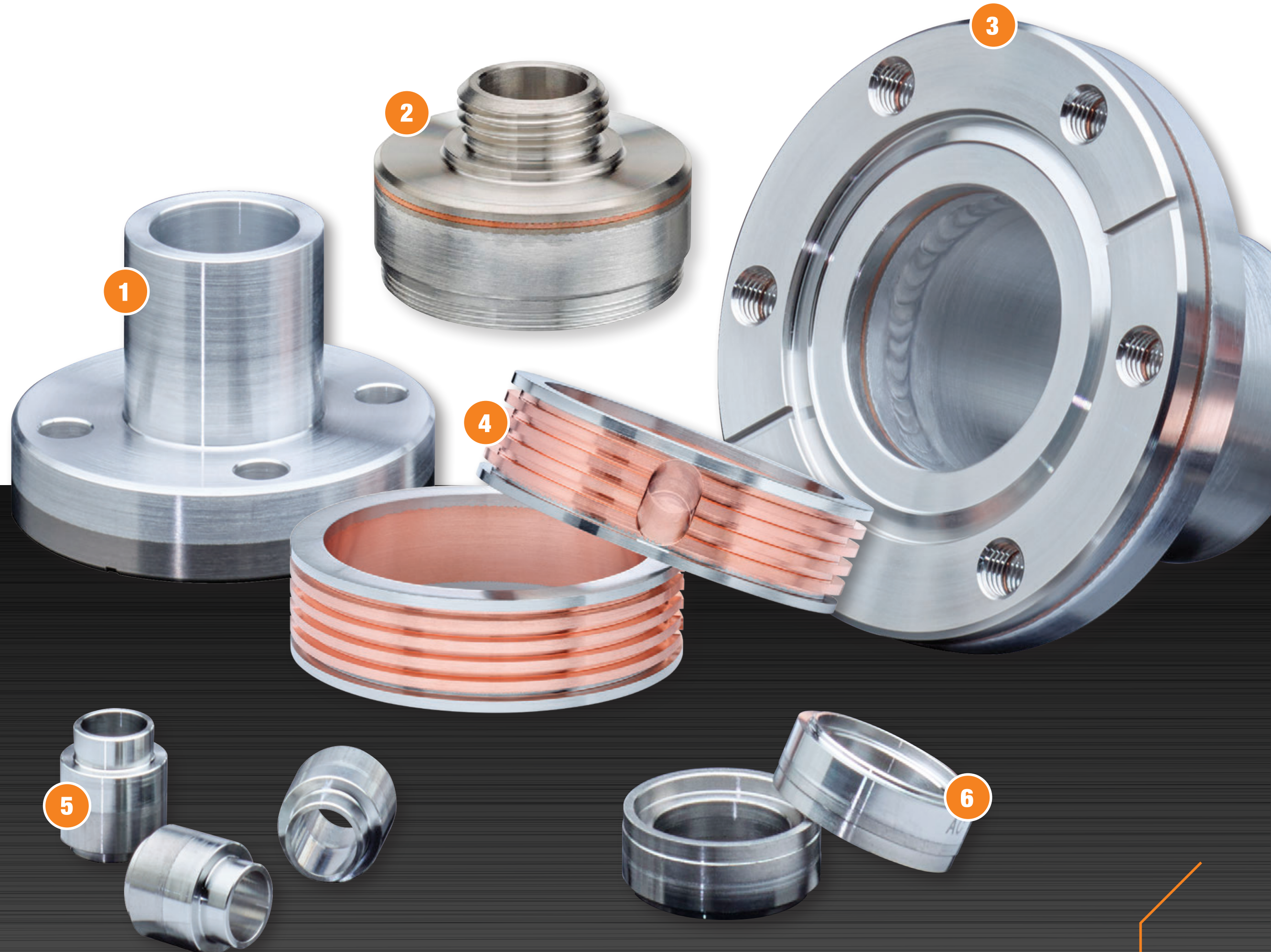
2 Al + SS Transitions
Aerospace, Energy, Research

3 Al + SS Flanges
UHV, Semiconductor, Quantum, Research

4 Cu + SS Transitions
Cryogenics, Energy, Semiconductor

5 Ti + SS Fittings and Flanges
Aerospace, Energy, UHV, Semiconductor, Quantum

6 Nb + SS Transitions
Aerospace, Energy, Optics, Cryogenics, Medical



Why Bimetal?

4 KEY BENEFITS

1

SOLID-STATE BONDS ARE RELIABLE AND LONG-LASTING

Solid state bonds—those created through explosion, diffusion, or roll bonding—provide a molecular bond that withstands extreme temperatures, corrosive environments and wrenching forces. These hermetically bonded metals can additionally be machined and welded to adjacent metals. This creates robust connections suitable for the demands of aerospace, cryogenics, chemical processing, semiconductor fabs, and particle physics labs where even infinitesimal porosity or leakage is intolerable.

2

CONTRASTING PROPERTIES IN ONE MACHINED COMPONENT

Metallurgically bonded metals can be designed and manufactured to exploit varied properties all in one component with no additional bonding methods or assembly. That means capturing the positive traits and/or reducing the negative impacts of each metal. For example, highly conductive materials bonded to poor thermal conductors control heat transfer, while a lightweight metal bonded to another stronger metal withstands wind forces.

3

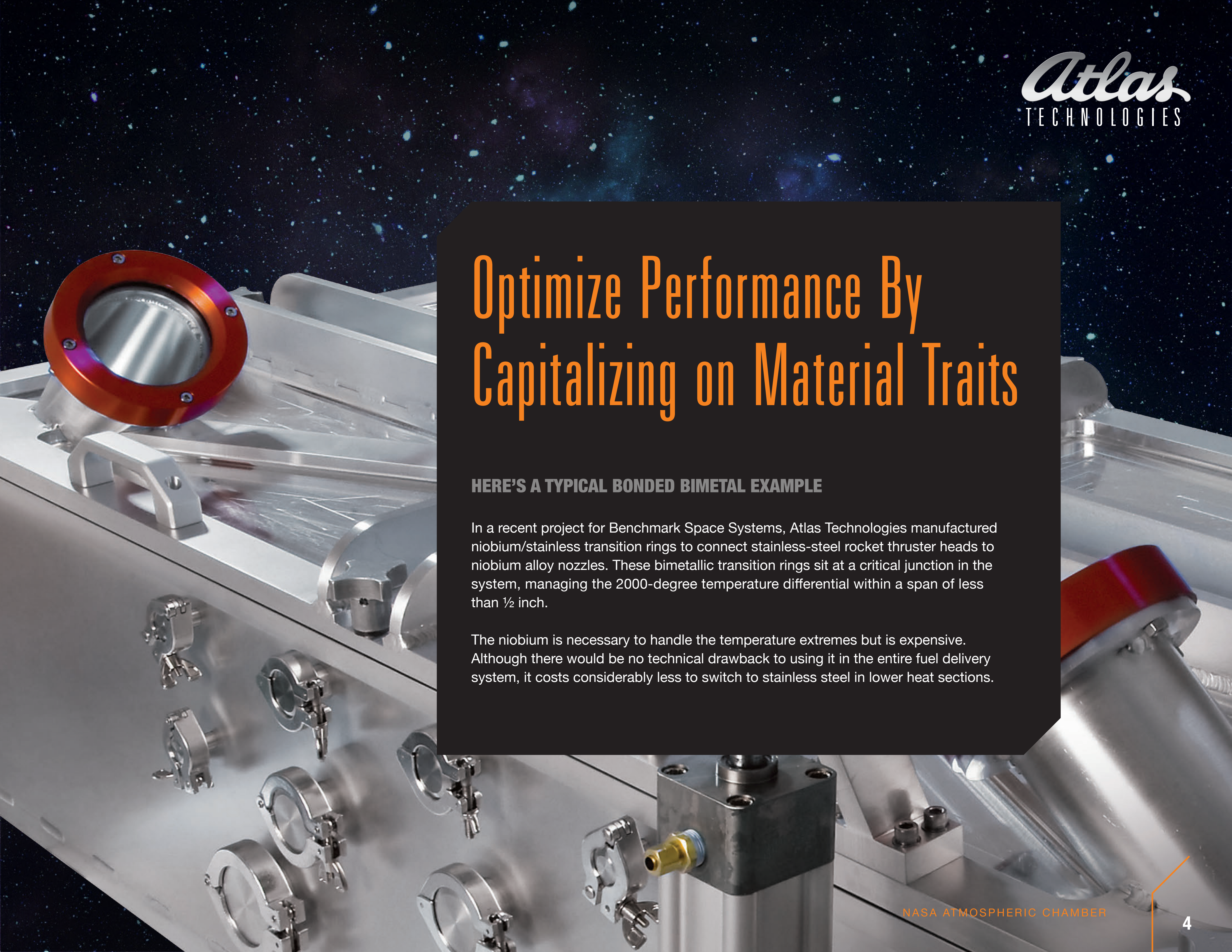
STRONGER, HEAT AND CORROSION RESISTANT TRANSITIONS

Bonded metals prevent corrosion in seams between dissimilar metals. A welded or glued transition at a critical connection may allow caustic liquids or gasses into the seam, facilitating deterioration. Similarly, a bonded metal transition in jet or rocket engine fuel lines can manage heat more effectively than standard welds between dissimilar metals. These bonded joints are also stronger.

4

REDUCED COSTS

By transitioning to a lower cost metal where allowable, overall project costs can be lowered. Other cost savings can be achieved through improved manufacturability. Metals that are difficult to weld or machine can be bonded to metals that are easily manufacturable to reduce costs.



NASA ATMOSPHERIC CHAMBER

Optimize Performance By Capitalizing on Material Traits

HERE'S A TYPICAL BONDED BIMETAL EXAMPLE

In a recent project for Benchmark Space Systems, Atlas Technologies manufactured niobium/stainless transition rings to connect stainless-steel rocket thruster heads to niobium alloy nozzles. These bimetallic transition rings sit at a critical junction in the system, managing the 2000-degree temperature differential within a span of less than ½ inch.

The niobium is necessary to handle the temperature extremes but is expensive. Although there would be no technical drawback to using it in the entire fuel delivery system, it costs considerably less to switch to stainless steel in lower heat sections.

Atlas TECHNOLOGIES

Bimetal Applications

While bimetal is found in nearly all industries, it is especially useful in aerospace. In addition, many companies cross lines between aerospace, research and energy. In fact, some OEMs cover them all.

AEROSPACE

Atlas bimetal components are found in lunar landers, rocket thrusters, and satellites, as well as research facilities studying space and atmosphere, national defense, gravity, new energy, and materials innovations.

NASA JPL, Blue Origin, SpaceX and various national labs working in aerospace and defense come to us for help designing and manufacturing complex products that need to perform relentlessly in the most demanding environments.

One of our customers who straddles aerospace, defense, and cryogenics fields, offers cold atom sensors for measuring gravity. This technology has proven useful in navigation and threat location as well as mapping materials found in the earth's crust. Atlas bimetal fittings withstand the temperatures necessary to achieve success. Another aerospace customer focused on rocket thrusters and engines uses our aluminum stainless demountable ATCR fittings in their test chambers.

Atlas soulutions are found in:

- Atmospheric and space simulation chambers
- Gravitometers
- Commercial and government satellites
- Moon landers
- Rocket thrusters

ENERGY

As new fuel types become available for use in aerospace, the possibilities for bimetal usage will expand. Meanwhile bonded metals are used to manage and withstand the heat, steam, and corrosives common in oil and gas extraction and refinement, as well as in nuclear facilities. Bimetals are also used in the research of emerging options like fusion and biogas, and in lithium battery production.

FUSION Numerous national labs and research facilities have reached out to Atlas for bimetal components and custom vacuum chambers to support their work.

ENERGY RESEEARCH Beyond fusion, Atlas aluminum chambers with bimetal connections are used to research new photovoltaics, methane and ammonia energy applications, and energy storage options.

OIL AND GAS Because pipes and critical transitions are often found in difficult to access locations, bimetal fittings make sense.

NATIONAL LABS/PHYSICS RESEARCH

What an exciting time to be involved in science and aerospace. Atlas bimetal solutions and aluminum vacuum chambers are used in every area of research and have been for decades. Below are a few of the labs and projects we've been a part of over the years. In truth, they don't always tell us what they are going to do with what we make for them, but knowing they are all about creating a better world, we are happy to help. Several are focused on innovations applicable to space travel or life, and off-planet manufacturing possibilities.

Brookhaven National Laboratory

Los Alamos NATIONAL LABORATORY

Lawrence Livermore National Laboratory

BERKELEY LAB

Fermilab

UNIVERSITY OF MARYLAND

BROOKHAVEN From disease vector research to ion colliders, climate research to nanoscale materials development

LOS ALAMOS Working on national security and the biotechnology, physics, energy and advanced sciences to support it

LAWRENCE LIVERMORE One of the earliest to reach break-even energy output in a fusion reactor, LLNL also focuses on global security, climate and energy, and physical and life sciences

LAWRENCE BERKLEY Focused on clean energy and a healthy planet, photovoltaics, bio manufacturing (biodegradable methane-based polymers for instance), and carbon negative materials

FERMILAB Learning how the universe works takes a lot of science, a lot of people, a lot of bimetals, and constant new innovations through particle physics research and accelerators

UNIVERSITY OF MARYLAND Their current research areas are batteries, environmental energy, nanostructures for energy storage, materials innovation, and renewable biomaterials

OEM

From tiny startups to vast organizations, our many OEM customers work across all industries, many applicable to aerospace:

- Semiconductor fabs
- New energy forms
- Analytical life sciences
- Quantum sciences
- Cryogenics
- Chemical manufacturing

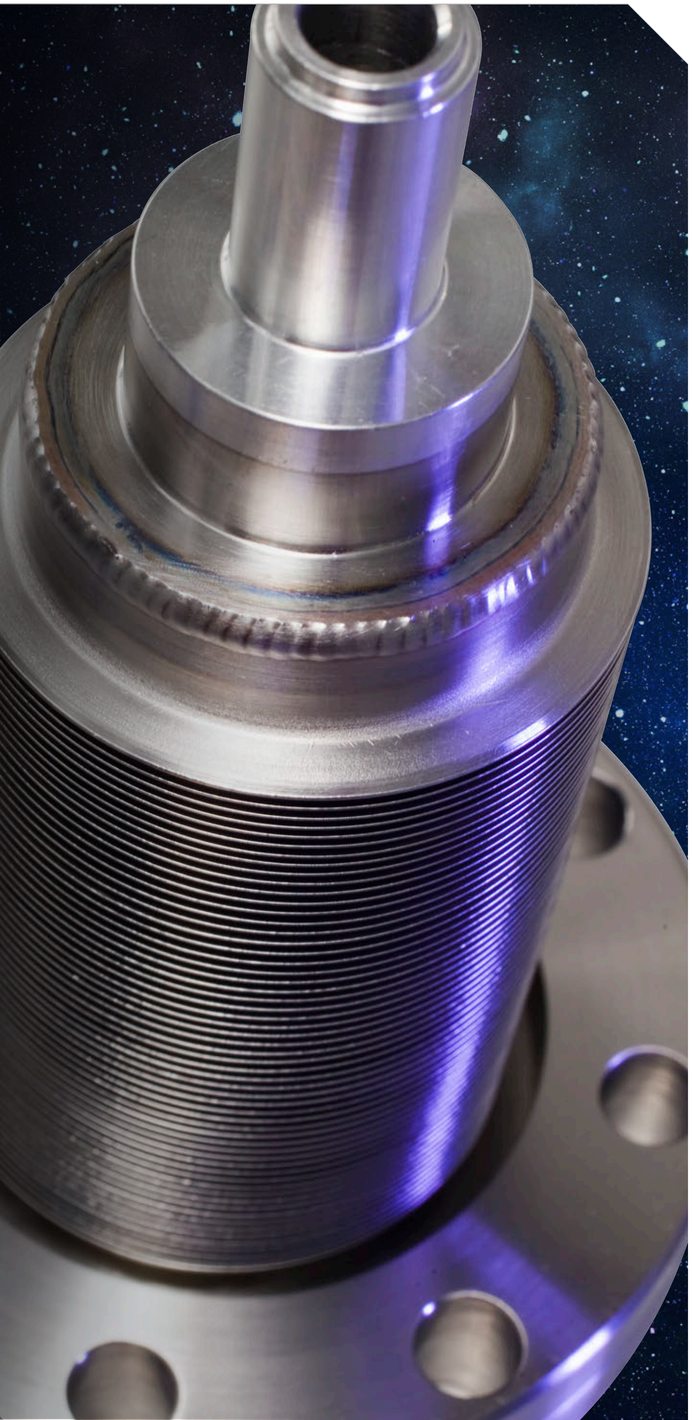
VOLKVAC CHAMBER

ALUMINUM/TITANIUM UHV

Aluminum is an ideal material to achieve and sustain ultra-high vacuum (UHV). Bimetal flanges facilitate easy connections to broader systems.

NASA has called on Atlas numerous times for specialized vacuum chambers for aerospace and atmospheric testing. Another customer, Volkvac Instruments develops specialized UHV suitcases that maintain chemical, medical, and physics samples under ultra-high vacuum independent of stationary power while being hand carried or shipped for hundreds or thousands of miles.

That means researchers can transfer samples from one vacuum system into the vacuum suitcase and then to another system in another location, whether that's down the corridor, across campus, or around the world, maybe eventually into space. A custom Atlas aluminum chamber with titanium flanges is a critical part of the UHV suitcase.



Bimetal Possibilities Expanded

CONTRASTING PROPERTIES

Take advantage of multiple metal properties in a single machined component

THERMAL CONDUCTIVITY	Bond highly conductive materials to poor thermal conductors to manipulate heat transfer.
THERMAL DISCONTINUITY	Sandwich a poor thermal conductor like Inconel or Hastelloy within another metal to limit the transmission of heat.
THERMAL EXPANSION	Design bonded metals to intentionally change shape with temperature differences.
THERMAL RESILIENCE	Sustain multi-thousand-degree temperature differentials with one resilient metal transitioned to another as heat is diffused.
VIBRATION ATTENUATION	Manage harmonics with contrasting high and low Youngs modulus metals to attenuate vibration.
X-RAY TRANSPARENCY	Utilize the X-ray transparency of aluminum combined with opaque materials like steels for x-ray optics.

CRITICAL TRANSITIONS

Hermetically bridge dissimilar metals for contiguously welded fabrication

LIQUID AND GAS TRANSITIONS	Prevent corrosion and/or thermal damage in seams between dissimilar metals. These hermetic joints are also stronger than typical joints.
ELECTRIC TRANSITIONS	Bonded aluminum-copper joints provide 100% contact with no oxide or corrosion build-up at the interface between the dissimilar metals for buss bar and thermal bridge applications.
THERMAL TRANSITIONS	For areas of extreme heat, one metal capable of withstanding the temperatures where needed and then transition to lower cost materials
CORROSION-FREE TRANSITIONS	Bonded metals prevent corrosion and/or thermal damage in seams between dissimilar metals.

Atlas TECHNOLOGIES

Bimetal Possibilities Expanded

REDUCED COSTS

Use expensive materials only where they are needed

EFFICIENT USE OF HIGH-PERFORMANCE METALS	Transition to lower cost metals where allowable, to lower the overall cost.
LOW-COST CORROSION RESISTANCE	Bond a corrosion resistant metal to another to prevent deterioration.
IMPROVED MANUFACTURABILITY	Bond metals that are easily manufacturable to metals that are more difficult to weld or machine.
ECONOMICAL MANUFACTURING ALTERNATIVES	Support other economical manufacturing methods – such as extrusion, casting, or forming – by transitioning from metals that don't lend themselves to these processes to those that can.
LOW-COST ELECTRICAL CONDUCTIVITY	Bond aluminum to copper to reduce cost and weight for electrical buss bars.

SPECIFIC FEATURES

Enhance critical features by adding a superior metal

RUGGEDIZATION	Bond hard metals to softer metals for robust performance.
DISTORTION CONTROL	Engineer materials to minimize distortion, misalignment, or movement caused by thermal expansion during heat cycling.
WEIGHT REDUCTION	Combine heavy, high strength metals with lighter metals to improve strength to weight ratio.
THERMAL EXTREMES	Multi metal transitions effectively maintain strength and ductility at extremely high or cryogenically low temperatures.

DESIGN • DEVELOP • MANUFACTURE • SUPPORT

Our customers count on us to design, develop, manufacture and support a broad range of bimetal and multi-metal assets. From napkin sketch to fully developed design, through machining, welding, testing, assembly and beyond, we're here for you.

EXPERTISE IN BIMETAL AND MULTI-METAL BONDING AND MANUFACTURING

It is challenging to join dissimilar metals so that bonds are mechanically robust, totally hermetic, and remain ductile in pyrolytic or cryogenic temperatures. That's where Atlas Technologies comes in.

With 30 years solid state metal bonding experience, along with our expertise in machining and welding those bonded metals, we understand the metallurgical challenges of joining dissimilar metals. We regularly bond and machine aluminum, titanium, niobium, copper, and stainless steel in our fully integrated facility located in United States, and we happily help customers with other metals as needed.

Let us help you solve your complex engineering problems.

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