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OUTLOOK

PRODUCERS AND FABRICATORS OF REACTIVE AND REFRACTORY METALS AND CHEMICALS

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Innovator Shaping Memory Metal Solutions

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Intrinsic Devices' Tom Borden, Lord of Nitinol Rings.

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Innovator Shaping Memory Metal Solutions for Industry

BY: KIRK RICHARDSON — *WAH CHANG*

Just down a city street, little more than a deep drive away from where Barry Bonds drops baseballs in the San Francisco Bay, sits an old brick building that was once a can factory. Today the two-blocks-long building is home to a hash of businesses, including an educational endeavor, a photographer (see his accompanying pictures), an aromatic coffee house, and as incongruous as its neighbors, Intrinsic Devices, manufacturer of shape memory alloy products for fastening, sealing, and electrical interconnection. Oddly enough, metals returned to the old factory in the form of nickel-titanium and other alloys as complex as the old tin vegetable cans were simple.

Intrinsic Devices' Tom Borden (right) and Mike DeLuca (left) utilize custom heat treatment equipment to control Nitinol properties.

The Bay Area fog has peeled away this morning as Tom Borden, President of Intrinsic Devices, steps out in front of his office and makes a beeline for the building's barista and a hot cup of coffee. He explains that he formed his company in 1994, buying the fastener portion of the business from Raychem, his former employer. "Once you work with shape memory, it gets into your blood," says Borden, who was first introduced to Nitinol (or Nickel Titanium Naval Ordnance Laboratory) at Raychem Corporation in 1981. "The biggest problem that we ever had is that the technology is so open-ended, there are so many possible applications that you didn't know what to work on," he says.

Some ideas were a little far fetched, like the one proposed by a bejeweled visitor from Las Vegas. "He had an engine that produced 50,000 horsepower that could fit in the palm of your hand, and he needed shape memory to make it better." Hmm. Other applications were slightly more plausible, according to Borden, like the distiller who came to the company in search of a method to attach a one-way valve for its bottles. "The idea was to prevent counterfeiters from refilling the bottles with a substitute (liquor) after the bottle was finished." According to Borden, lots of money was spent before the application vaporized.

Though they're still contacted with inventive ideas by overly creative minds, Borden and Co. have settled into a comfortable niche, selling fastening, sealing, and other devices to industries ranging from aerospace to oil. He says that it suits him well... that it allows him to concentrate his efforts.

"We're trying to focus as much as we can on having generic products that multiple customers could use as fasteners for multiple applications," says Borden. He likens his fasteners to generic nuts and bolts. "It could be used anywhere for you name it," he says. "It's a screw that, instead of applying an axial force, applies a radial force. It can be used just about anywhere."

Borden points out that word of his fasteners wide-ranging applicability has spread and the company has experienced steady growth, adding new customers at a comfortable pace. But he also confesses to spending so much attention to manufacturing that some of his growth initiatives are still just that. It doesn't seem to bother him a whole lot. "We've really focused on delivering on-time, with high quality," he says matter of factly.

Intrinsic Devices obtains quality Nitinol and other alloys (6 in. - 1 1/2 in. OD) from Wah Chang, which the innovator uses as is or works down to even smaller diameter bar and wire. "We've got several different processing routes for end product: machining, grinding, forging, forming and welding," says Borden. One of his company's shape memory tension rod products follows the machining route. "We machine the rods at a short length and then, at a controlled temperature, stretch them," he explains. "Our customer builds them into his device. Later when the rods are heated above 110ºC, they contract to their memory length, performing a locking function." According to Borden, the typical amount of shrinkage that would be specified is "on the order of 5%." He says that the market for these tension rods has potential, but is cautious with his predictions. "Our whole philosophy is just bait a lot of hooks, and get 'em in the water," he laughs, "but what that (application) is actually going to turn into, I have no idea."

What is a "known" is Intrinsic Devices' flagship product, the UniLok® ring, which the company touts as offering new ways to join and seal cylindrical components. If machining Nitinol devices like tension rods is difficult, transforming bar and wire into fasteners and seals isn't any easier. Borden, a "Lord of Rings" in his own right, says that typically the steps include fabricating a ring shape, heat treating it, then performing any surface finishing or coating operations. The final major step is deformation from the memory shape. "All of the heat shrinkable rings that we make have been expanded first," he explains.

According to company literature, "nickel-titanium rings shrink 4.5% in diameter when heated. Once shrunk, UniLok® rings apply a uniform gripping pressure that is seamless, powerful, consistent, and permanent. The gripping force can be set between 220 N (50 lb) and 130 kN (30,000 lb) by choice of the ring dimensions. UniLok® rings can clamp a

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holder to a delicate optical lens or swage a fitting onto a pipe to seal 400 bar (6000 psi)." Intrinsic Devices claims that "no other fastener system provides seamless radial pressure over these force levels with comparable radial close-up." The company touts other benefits that its fasteners offer over conventional techniques such as crimping, welding, adhesives, elastic assembly, and threaded fasteners:

- Operator insensitive assembly
- Low installation temperature
- Joining and sealing of dissimilar materials
- Verification of correct installation
- Repeatability
- Seamless clamping pressure
- Immunity to vibration, shock, and thermal cycling
- Chemical resistance
- Rotary balance

The multitude of applications for Unilok® rings includes hermetic sealing, where they are used to swage thin-walled metal cups onto headers. Intrinsic's rings are able to join dissimilar materials like aluminum and Kovar®, a decisive advantage in this application. This is possible since the UniLok® ring impales the cup on a sealing feature on the header, flowing metal to create the seal. Since the ring does not relax after installation, the seal is maintained.

The company's ring products are also used to attach small diameter cable electromagnetic shielding braids to connectors or other devices. "Metallic and polymeric braids serving mechanical functions can also be clamped," according to product literature. This feature offers advantages for applications that subject joints to thermal cycling, heat aging, vibration, and mechanical shock. An installed UniLok® ring has a large elastic interference with its substrate, about 0.5%. This stored energy allows the ring to maintain clamping pressure despite settling, creep, and differential thermal expansion of the braid and connector.

According to the company, other applications include:

- Pipe and tube joints — where brute strength and uniform clamping pressure are important.
- Piezoelectric, magnetic, and optical cluster assemblies — where controlled pressure and thermal insensitivity are often key requirements.
- Electrical interconnections — where the exceptionally high contact closure force generated by the ring produces a gas-tight seal between the contact surfaces, resulting in a stable, low-resistance connection.
- Shaft-mounted components — in which Unilok® rings can fix the location and angle of a component at any point on the shaft (axial preload force can be locked in).

Though focus and the present are paramount, the innovative Borden certainly isn't limiting his options. The future holds all kinds of possibilities. He points out that the company is working with not one but seven different nickel-titanium alloys. Borden lists them: "Nickel-Ti-Iron, Nickel-Ti-Niobium, and then five different binary nickel-titanium alloys."

One of these, NiTiNb ("It's our Alloy H," he says.), is Intrinsic's flagship alloy. The alloy has an exceptionally wide hysteresis. Hysteresis means "a retardation of the effect when the forces acting upon a body are changed."[1] On heating, a shape memory alloy transforms to its high temperature phase and returns to its memory shape at a particular temperature. On cooling, it returns to its low temperature phase and softens dramatically at a lower temperature. The difference in these temperatures is the hysteresis.

"In order to provide useful clamping force, a shape memory fastener must remain in its high temperature phase down to the minimum operating temperature of the device, say -55 °C for an

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Intrinsic produces Unilok® rings in an array of shapes, sizes, and alloys.

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New TiWire Info on Wah Chang Website

Wah Chang recently upgraded its web site to include detailed information on its Titanium Wire Division (TiWire), which (not surprisingly) produces titanium wire and bar product lines. TiWire operates a 55,000-square-foot facility in Frackville, Pennsylvania, where it manufactures mill products from bar to hair-thin wire for customers in a variety of industries, worldwide. The facility's custom equipment enables it to produce large diameter bar (.510 in. to .156 in.), with tolerances as tight as +/- .0005, as well as small diameter bar (.125 in. to .032 in.), with tolerances as close as +/- .0003.

Just of few of the many applications for TiWire's bar and wire include medical and dental products (e.g.: spinal cables), aerospace products (e.g.: hitch pins), industrial products (e.g.: weld wire), commercial products (e.g.: bicycle parts), and chemical products (e.g.: shafts). This list continues to grow.

For the nuts-and-bolts details (including a full list of products) about TiWire's bar and wire, surface-finish capabilities, and other vital data, visit alleghenytechnologies.com and click on the Wah Chang link under Operations. If you have an application for titanium wire or bar and want to "cut to the chase", contact Sales directly at 570.874.0311. ■

(Left) Wire Spool. (Right) Annealed wire.

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aerospace application," according to Borden. "For an alloy with a normal hysteresis, this means the initial shrink temperature will be below room temperature." Indeed, NiTiFe UniLok® rings are shipped in liquid nitrogen and shrink on warming to room temperature. "The wide hysteresis of NiTiNb allows us to make fasteners that can be shipped and handled normally, shrink on heating above room temperature and maintain clamping force to below -55C," he says. The innovator sees nearly limitless possibilities.

As with its "mother product" Nitinol, the list of uses for shape memory fasteners, seals, and devices like the tension rod continues to swell, with no end in sight. At the same time, the interest in shape memory devices is exciting to Borden and challenging. His mission is to listen carefully and ferret out ideas that will truly shape our future.

He laughs about a saying from an old engineering associate. "His famous quote was 'I don't understand how any self-respecting mechanical engineer could design something with no moving parts,'" Borden chuckles. "That's basically what he said about this stuff." "Then what keeps it interesting?" asks the visitor to the engineer. "Beats the hell out of me," he jokes. In college when Borden's Department Head encouraged him to get a PhD, he couldn't imagine something that he wanted to focus on, to study for five or six years. "Then, here it is," he laughs. He's having the time of his life. "It's fascinating, and it's fun." Like a true innovator once said, "it just gets in your blood."

For more information on Intrinsic Devices, contact the company by phone at 415.252.5902, by fax at 541.252.1624, or by e-mail at sales@intrinsicdevices.com. For more information on Wah Chang's nickel-titanium and other specialty alloys, contact Customer Service at 541.967.6977 or visit the company's website at alleghenytechnologies.com. ■

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1) Webster's New Collegiate Dictionary. G. & C. Merriam Co.. Page 565. 1977.

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