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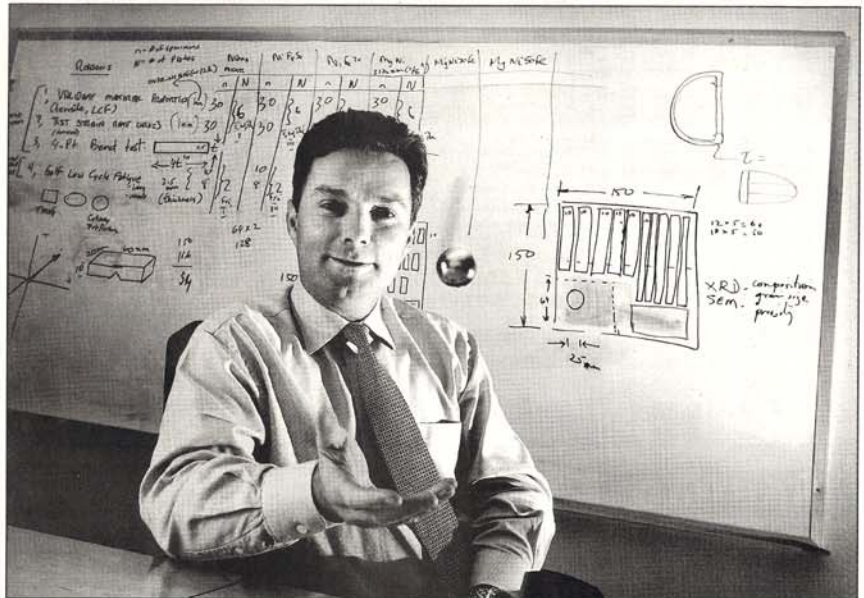
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Technology Inc. | NANOTECHNOLOGY



PowerMetal Technologies CEO Edward Hughes, shown here stacking weights on a nanometal-coated pingpong ball, seeks to improve golf equipment through nanotechnology. Howard Lipin / Union-Tribune



Edward Hughes, the president and chief executive of Carlsbad's PowerMetal Technologies, contends that nanotechnology represents the next step in technological innovations to improve the game of golf. Howard Lipin / Union-Tribune

Not-so-heavy metal meets golf

Startup company in Carlsbad using nanotechnology to make lighter but stronger shafts and club heads

By Bruce V. Bigelow
STAFF WRITER

When the late Ely Callaway tried to explain the mysteries of golf to uninitiated souls, he said most folks played the game for the physical and emotional gratification of a well-struck shot.

Providing that psychic reward, he said, was what motivated Callaway and other club makers to innovate as drivers evolved from tough apple wood to American hickory, steel, aluminum and titanium.

Now a startup company hopes to extend the evolution of golf's technical innovation by introducing golf clubs made with nanotechnology, an emerging field that focuses on making devices and materials at the molecular level.

The startup, PowerMetal Technologies, was founded in Carlsbad to make "nanometal" components for use in golf shafts, club heads and other sports equipment.

Nanometal alloys are both stronger and lighter than conventional metals made with the same alloys, according to Edward Hughes, PowerMetal's chief executive.

For example, a pingpong ball coated with a 3-micron layer of nanometal can support more than

200 pounds without being crushed.

In the same way, Hughes says, a golf shaft or club head could be strengthened by a nanometal coating. A shaft made of nanometal could be stronger and lighter than a conventional metal shaft, enabling golfers to swing their clubs at greater speeds.

"The nanocrystalline structure is what makes it intriguing," said Hughes, who left TaylorMade-Adidas Golf in 2003 as a senior vice president and general manager.

The crystalline structure of a conventional nickel-iron alloy typically consists of metal grains that are about 20 microns in size, or 20,000 nanometers. Using proprietary techniques, PowerMetal Technologies can make nickel-iron alloys with a crystalline structure that is 10 to 50 nanometers.

Nanotechnology takes its name from the nanometer, a unit of measure equal to 10 angstroms, or one-billionth of a meter.

The most advanced process for semiconductor manufacturing can create microcircuits spaced less than 65 nanometers apart. In comparison, the HIV virus is about 120 nanometers. A typical human hair

Getting to nano scale

A millimeter about this big — is equivalent to 1 million nanometers.

In comparison, a red ant — is about 5 millimeters, or 5 million nanometers, in length.

The crystalline structure of a conventional metal alloy is about a 50th of a millimeter. Using nanotechnology, PowerMetal can make the same alloy with a crystalline structure of 10 to 50 nanometers, or a 100,000th to 20,000th of a millimeter.

Other objects	Nanometers
Head of a pin	1 million
Human hair	80,000
Red blood cell	2,000
HIV	120
DNA	2.5

SOURCES: National Nanotechnology Initiative; PowerMetal Technologies Inc.

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Inside: Technology Inc.

Sony next-generation DVDs to cost 10 percent to 20 percent more. **C5**

Person of the week: Maxwell Technologies CEO Richard Balanson.

► POWERMETAL CONTINUED FROM PAGE C1 Other potential uses are seen for nanometals

is about 80,000 nanometers wide.

PowerMetal was founded in Carlsbad last year with \$10 million in venture funds led by Mosaic Capital Partners, a Toronto-based investment firm.

Mosaic also arranged to license the underlying technology to PowerMetal through its majority ownership of Integran Technologies, a Toronto metallurgical research firm that holds scores of nanotechnology patents.

"They are one of the first companies in the world to figure out how to do bulk nano-structured materials for specific structural applications," said

Ken Vecchio of the University of California San Diego. Vecchio, a professor of engineering and materials science, is a scientific adviser for the company.

While PowerMetal intends to supply its first products through partnerships with golf club makers, Hughes said the company plans to develop a broad array of products for use in sporting goods and consumer products.

The list includes nanometal components for baseball bats, skis, tennis rackets, lacrosse sticks and even components for luxury watches and eyewear.

The company has the ability to make nano-engineered metals in monolithic plates and sheets, or as foils, mesh, tubes, foams, powders and laminates, Hughes said.

Nano-engineered metals can make the gears inside watches stronger and harder, Hughes said. A watchband

made of 18-karat nano-gold also would be harder and more wear-resistant than ordinary 18-karat gold.

The process used by PowerMetal is well understood, although the company still faces some muddling technical challenges, said UCSD's Vecchio. "From their perspective, their single biggest hurdle is going to be whether they can speed up the process itself. The process can be very slow to make plates that are millimeters thick."

In the meantime, PowerMetal is focused on the golf industry. Production of some components has already begun with a manufacturing partner in Orange County, Hughes said.

Ron Farmer, a managing director at Mosaic, said PowerMetal represents the first in a series of specialized companies the private equity firm intends to launch to exploit its nanotechnology expertise.

He sees potential uses for nanometals in automotive, defense, biomedical and other industries.

"To really make sure that our inventions here were adequately commercialized, we became convinced we had to set up specialized companies with management teams that have deep expertise in their markets," Farmer said.

Whether golfers are willing to spend heavily to replace their existing titanium alloy and hardened steel golf clubs is a question yet to be answered.

Nanotechnology has been a buzzword among golf equipment manufacturers for years, although much of the attention has been focused on ultra-strong carbon nano-tubes used to reinforce composite golf shafts.

NanoDynamics, a firm based in Buffalo, N.Y., introduced a nano-engineered golf ball over a year ago, claiming

the ball can correct its own flight path so it flies straighter than conventional balls.

"So far, I have not seen anything that has taken this industry by storm or put it on its ear with regard to nanotechnology," said Terry McAndrew, editor of the online Web Street Golf Report.

"Whether it's a golf grip, golf shaft, a golf head or a golf ball, you're still chasing a finite amount of dollars," said McAndrew, adding that the industry as a whole is struggling.

It also seems unlikely that the introduction of nanometals will catch industry giants like TaylorMade or Callaway by surprise, McAndrew said.

"For their sake," McAndrew added, "I hope that PowerMetal Technologies has other irons in the fire — no pun intended."

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SEE PowerMetal, C5