"Starfire + Clariant = Clever Chemistry"

by Robert Warren

Article researched and written on behalf of
Primafila A.G. Corporate Publishing (Zurich, Switzerland)
and
Clariant International, ltd (Muttenz, Switzerland)

October 2005

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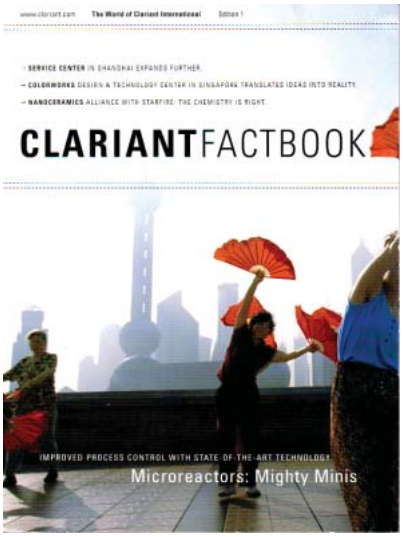

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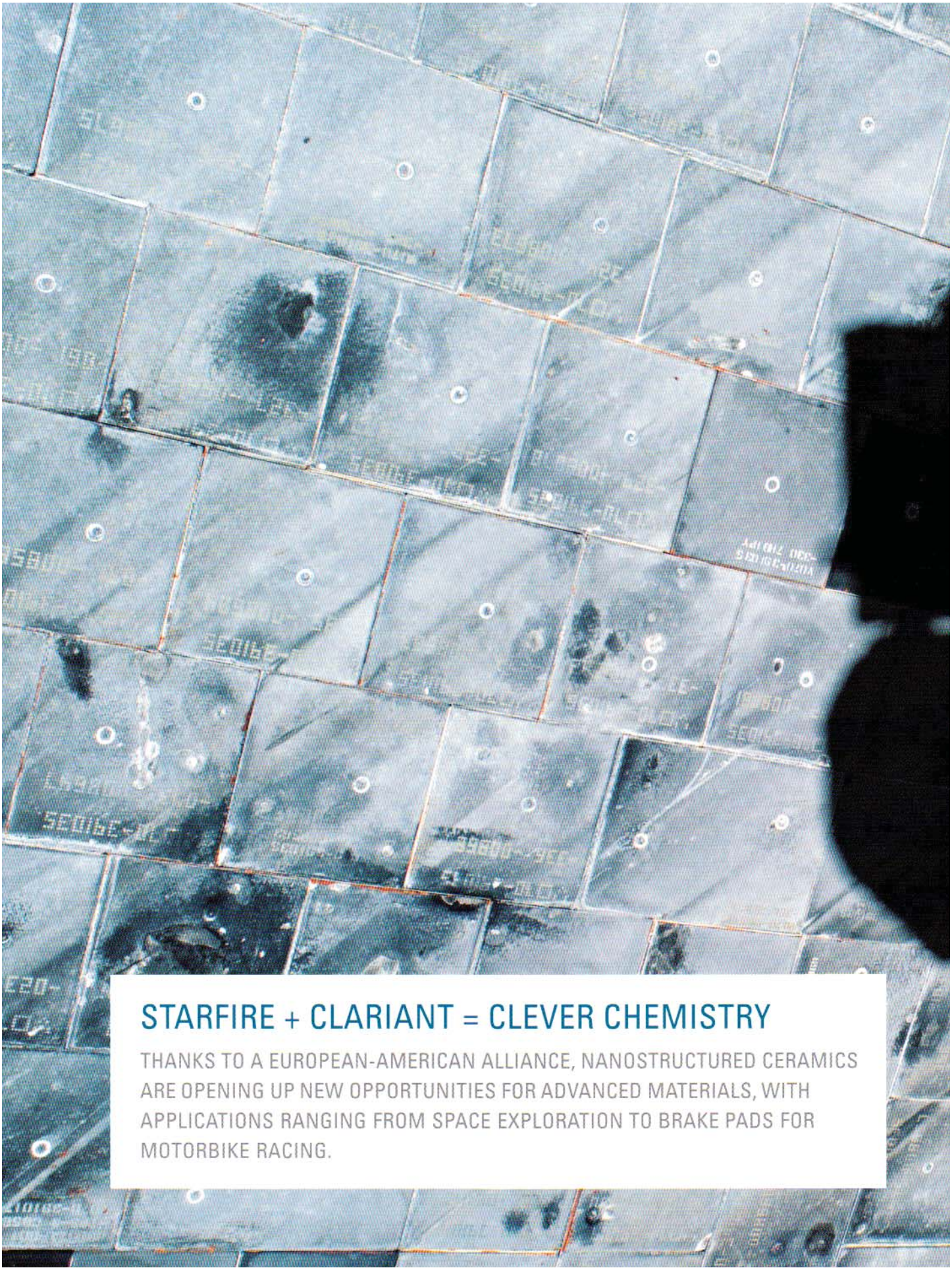

STARFIRE + CLARIANT = CLEVER CHEMISTRY

THANKS TO A EUROPEAN-AMERICAN ALLIANCE, NANOSTRUCTURED CERAMICS ARE OPENING UP NEW OPPORTUNITIES FOR ADVANCED MATERIALS, WITH APPLICATIONS RANGING FROM SPACE EXPLORATION TO BRAKE PADS FOR MOTORBIKE RACING.

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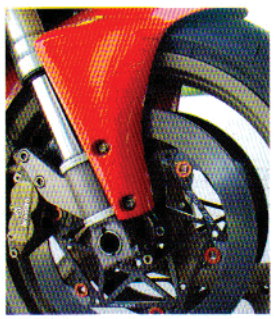


JUST SAY STOP
Ceramic brake pads won't take go for an answer, which is great for performance but tricky in manufacturing. Starfire technology can fix the problem.

"I think it's a very good demonstration of how quickly personal chemistry can play a role in real chemistry," says Hubert Liebe, Clariant's head of New Business Development, about Clariant's recently announced alliance with Starfire Systems, Inc. of Malta, New York.

At the core of Starfire's business – and of the new alliance – is a relatively new technology: nanostructured ceramics and composite materials, engineered at the atomic scale from polymers. Founded in 1988, privately owned Starfire Systems specializes in the development and production of patented silicon carbide (SiC) forming preceramic polymers and material systems, in applications including aircraft components, automotive friction products, and microelectronic coatings and circuit board packaging materials.

The match of Starfire technology with Clariant industry expertise and its capabilities to develop technologies into marketing ready products, both companies believe, is a natural – and highly symbiotic – relationship. "As you start to look closer and closer," says Starfire's VP of Marketing, Herb Armstrong, "there is a real convergence of the things that we are doing and Clariant has been doing for many years, to create new products and to accelerate the time it takes to bring these new technologies to market."

As part of the agreement, formally announced on 20 September, Clariant has completed a financial investment in Starfire Systems. The culmination of a negotiation process that began in a Newark, New Jersey, airport lobby in late 2004, the new alliance represents significant opportunities for both companies in the growing field of nanostructured ceramic systems.

LIGHTWEIGHT WITH A HEAVY ADVANTAGE

Current metallic and ceramic materials are reaching their design limits, says Starfire's President, Richard Saburro, particularly in applications that require extremely high resilience under harsh conditions.

"The leading aerospace companies – NASA, Lockheed, Boeing – are coming to us for material solutions for the next generation of spacecraft and aerospace vehicles, because current materials have gone as far as they can go. They have reached their design limits, and they just cannot go any further."

Unlike most current materials, nanostructured ceramics are formed from particles whose sizes are measured in nanometers – nearly atomic scale. By controlling the size and configuration of the material components on a nanoscopic level, chemists can control the material properties of ceramic compounds far more effectively than they can with conventional, metallic alloys. The resulting ceramics maintain extreme strength at higher temperatures, are more corrosion and wear resistant, are more versatile and they weigh significantly less than their conventional metal counterparts.

Starfire created the first nanostructured silicon carbide ceramic brake rotor system for motorcycles, which was recognized for delivering immediate apparent advantages over the metal rotors in older systems. At only a quarter of the weight of comparable metallic brakes, ceramic brakes perform more effectively and wear much longer; while conventional brakes become less effective under high temperatures (a phenomenon called "brake fade"), Starfire's ceramic systems demonstrate greater friction and control under similar conditions, and under more extreme conditions as well.

The new Clariant-Starfire alliance aims to bring those same technologies into the greater commercial arena with motorcycle brake rotors, passenger car friction material systems, microelectronics systems and other applications. The goal, however, is not to simply become another nanoparticle manufacturer, says Liebe.

While there is no shortage of nanoparticle manufacturers in the global marketplace, he says, most lack the ability to commercialize the technology in a comprehensive way. "There are lots and lots of nanoparticle manufacturers around – smaller ones, larger ones," says Liebe. "But they do not really know what you can do with nanoparticles. Or what we at Starfire can do with nanoparticles."

"The key issue is industrialization," he adds, "the know-how to go through the detailed approach, to determine what the new technology, in detail, can really do. And that's why we are working together.

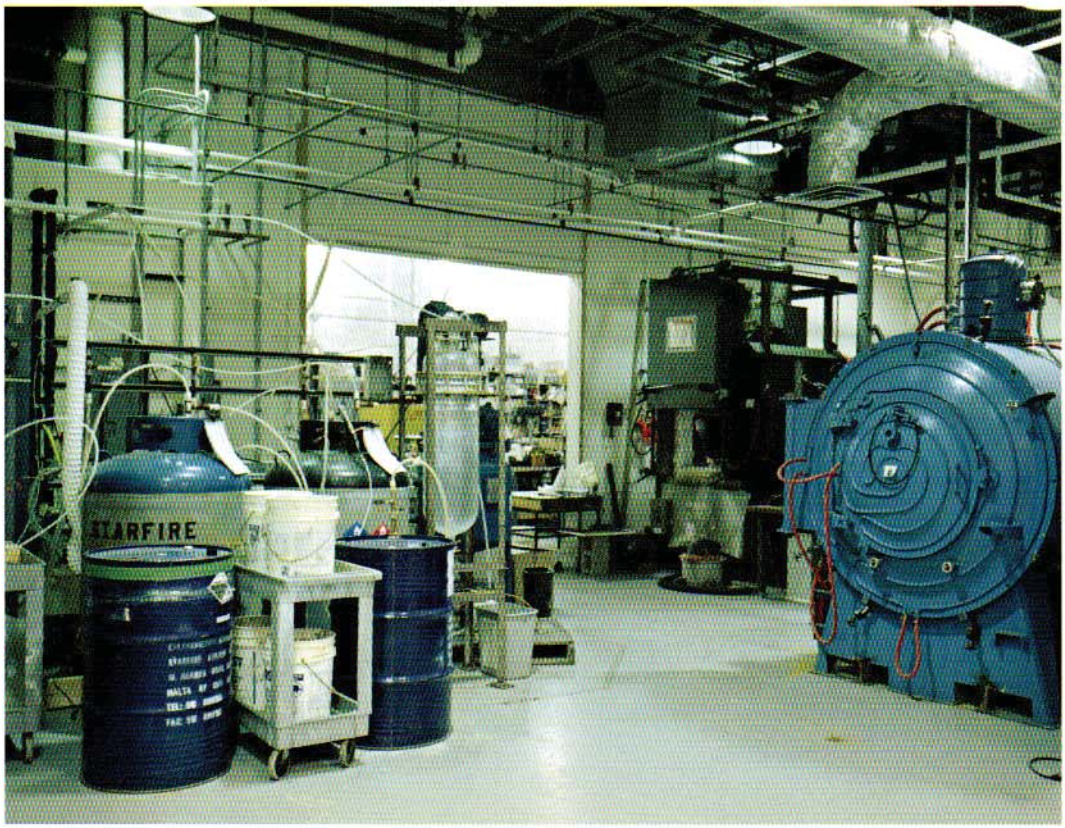
Starfire troopers: Richard Saburro (left) and Herb Armstrong at their factory in Malta, New York.

Once we have established that, then we must go and penetrate a market with that additional know-how that we will have developed."

IN UNION THERE IS MORE STRENGTH

Both sides see the new alliance as a very natural dovetail of disciplines and mutual advantage. "Clariant is key to our strategy for commercializing this technology," says Richard Saburro. "We had been looking for a motivated partner who could provide Starfire with the market access and the resources to facilitate the deploying of our technology as effectively and broadly as possible."

While Starfire looks to Clariant for help in achieving greater industrialization of their material systems, Clariant is pursuing new material technologies that Starfire possesses. Clariant intends to use its extensive resources within the automotive industry to help advance the industrial acceptance of Starfire technologies, and particularly in Clariant's home ground of Europe. Together, the two companies plan to use the alliance to explore and commer-



Hard labor: a look inside Starfire's plant.

cialize new technologies in the nascent, booming area of ceramic materials and coatings. The path ahead, however, is not expected to be simple. While both companies see great commercial potential in nanostructured ceramic systems, Saburro says, industrial inertia remains a significant challenge. "That's where we think Clariant can be a big help – to help with market access, and to help influence these major companies to take the necessary steps to test, evaluate and adopt a new product."

And counterbalancing the problem of inertia, Liebe points out, is the challenge of impatience and resource needs. "New technology often is underestimated in terms of resources and time required to introduce it." By joining forces with Starfire, he says, significantly more of nanotechnology's business potential can be realized within a profitable market time frame.

Both companies view these issues more as challenges than obstacles, however, and believe that the new Clariant-Starfire alliance will help to overcome them – with not just combined technical strengths, but cultural fusion as well. "This is a long-term alliance that we expect to evolve," says Saburro. "When we initiated it, we were not aware of how broad the opportunities could be for both sides. We are discovering new ideas for and new dimensions to our alliance all the time."

And central to that process of discovery, Armstrong suggests, is the fine meshing of minds and personalities that is happening across borders – where "exactly your chemistry" means even more than the virtues of technical competence and market compatibility.

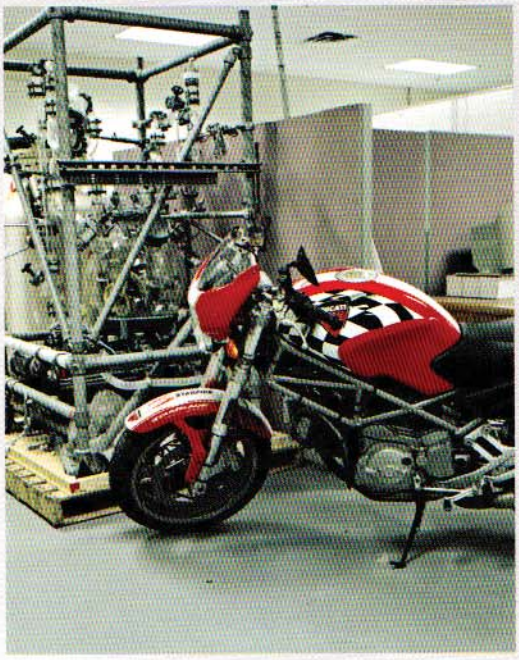
"As you do business across cultural lines," he says, "over time the personal relationships become almost as important as the written documents themselves. We're happy to experience the cultural fit between a small, entrepreneurial company and a large global company – and not only at this level, but at all levels up and down the two organizations, including the working relationships between our technical people and their technical counterparts in Germany. As far as we can see, the relationship that has developed between Starfire and Clariant is reacting with exactly the right chemistry."

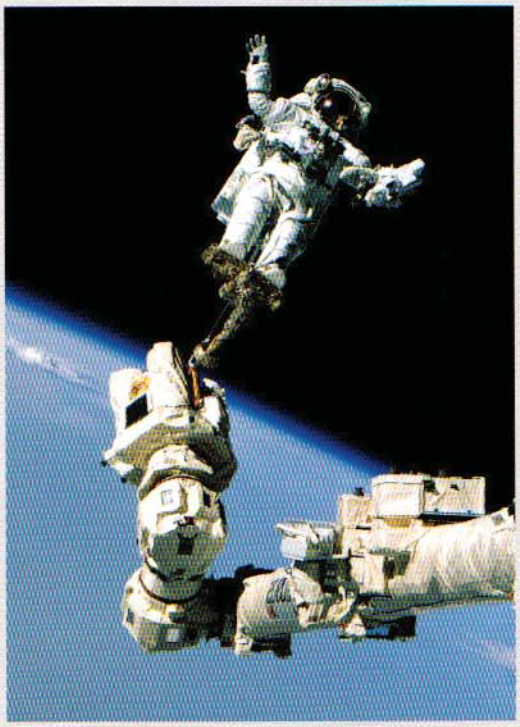
EASY TO BE HARD: THE TRICK OF PRECERAMICS

In high-tech applications, the same property that makes ceramics so useful also makes their use hard – in both senses of the word. While toughness is undoubtedly great in spaceships and circuit boards, with a material so rigid, how does one process it in the first place?

Say hello to preceramic polymers. These fluids are "painted" or "deposited" on to a substrate, usually a mat of ceramic or carbon fibers. This is then cured (similar in principle to firing clay in a kiln) to yield a shell of cross-linked silicon carbide (SiC) or silicon nitride (Si_3N_4).

Not surprisingly, this is easier said than done. As Starfire's Walter Sherwood points out, ceramic mass yield should top 75% at all processing temperatures. Byproducts should be few and environmentally benign. Silicon carbide should be close to stoichiometric (equal numbers of carbon and silicon atoms) to ensure that the ceramic matrix contains minimal impurities such as unreacted carbon, silicon or silicon oxide. Getting all that right is hard – again in both senses – but also Starfire Systems' main stock in trade.





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STARFIRE IN SPACE

Nanostructured ceramics hold great promise for high-performance gains in extremely demanding commercial and military applications – such as STS-114, the July 2005 mission of the space shuttle Discovery.

During that mission, astronauts successfully deployed a heat shield tile repair kit for the first time – a kit based on Starfire Systems' preceramic polymer technology. NASA needed a sealing compound to repair small cracks and coating damage on the shuttle's exterior Thermal Protection System (TPS). A lengthy evaluation had selected Starfire's product as the only commercially available system that could solidify from a caulk-like material to an extremely durable solid ceramic during the 3,000+ degree reentry of the shuttle into the atmosphere – conditions hot enough to melt steel.