Trying Nano On For Size

Nanotechnology developments begin to dwarf apprehension over its viability in the design and development of products.

by Carrie Ellis

One billionth of a meter? What good can come of something so small? The term nanotechnology involves any technology that pertains to small matter—approximately 100 nm or smaller to be more exact, although no standard measurement has been technically delineated as such. The word can also be used to refer to the application of it: the study and building of devices on the nanometer scale, meaning built from single atoms and molecules. (To put a nanometer into a more fathomable context, the diameter of a DNA double helix is 2 nm.) Yet no matter how infinitesimally miniscule a nanoparticle may be, enough of them may add up to making a big impact on the product design and development community.

There are several different types of nanotechnologies currently (and viably) available, in development, or in the research and development phase that may be of present or future use to design engineers. These nanotechnologies may include fibers, powders, particulates, components, crystals, devices, etc. However, under the broad-brimmed hat of nanotechnology, you may also find nanomaterials. Nanomaterials can consist of, but aren't limited to carbon, ceramics, ferrites, metals, minerals, polymers, semiconductors and silicates.

What's difficult about exploring the options of nanomaterials is we don't necessarily have any limitations yet (and likewise for all nanotechnologies), so it may be difficult to decide in which applications nanomaterials make sense. But we do, in fact, have other useful data at our disposal. For example, in the transition from the macro to the micro, the physical properties of a material may be altered—this pertains to mechanical properties, electrical properties, magnetic properties, thermal properties, optical properties and more.

Nanocomp Technologies recently announced that they have manufactured the largest cohesive sheet of nanotube material ever in 3' by 6' sheets.

One of the other obstacles facing the implementation of nanotechnology, however, has been practical manufacturing of nanotechnologic products in enough quantity. To aid in addressing that issue, Nanocomp Technologies has figured out a way to successfully produce 3' by 6' sheets of carbon nanotube material—the largest cohesive sheets of nanotube material ever manufactured. According to the company, short nanotubes can have limited industrial use because they are difficult to incorporate into existing manufacturing processes and do not possess the high-performance properties of long carbon nanotubes.

What Miniature Materials Can Accomplish

According to Nanocomp Technologies Vice President of Business Development John Dorr, "Nanotechnology is the underlying technology utilized by our company to deliver high-performance materials in sheet and yarn formats. In and of itself, nanotechnology means little unless it is applied in the form of a material and/or application that solves challenges in a specific vertical industry. For example, the aerospace industry is looking to leverage Nanocomp's nanotech materials for electromagnetic interference (EMI) shielding, high-frequency conductivity, lightning protection and a variety of other weight-saving applications."

Dr. Kim McGrath, a leading scientist at QuantumSphere, has a similar view: "One of our big value-adds is highly uniform, very small materials with high purity, but it's really about what these nanoscale metal particles enable, and specifically speaking, what we work on is hydrogen generation by water electrolysis. It's simply taking a catalyst, applying energy to it, and splitting water molecules into hydrogen and oxygen molecules. Then we look at the efficiency and the amount of gas that can be produced. The technical way that hydrogen is currently being made is through steam reformation. This process produces hydrogen, but it unfortunately also produces a lot of greenhouse gases. Quantum envisions that we can make electrolysis—the splitting of water—much more energy-efficient through the use of nanomaterials, resulting in a much cleaner way to produce hydrogen.

"In the labs, we've been comparing the efficiency—efficiency being just how much energy I need to put in my electrolyzer for the amount of gas that I get out—of electrodes in commercial electrolysis systems right now (which are usually just plain metal plates) with metal plates with these metal nanoparticles adhered to them. Our team has come up with a way to coat these metal nanoparticles onto surfaces, and what that does is increase the surface area of an electrode—of that metal plate—by orders of magnitude."

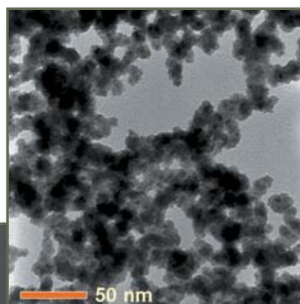
Kevin Maloney, QuantumSphere CEO, adds, "And when you think of surface area, imagine a baseball if you took the leather shell off and laid it flat; the surface area of the baseball would be about the size of the palm of your hand. A sheet of paper is about 100,000-nm thick, yet we're engineering materials anywhere from about 3 to 30 nm in size. If you took roughly a gram or just a small handful of these very fine, black nanomaterials, the surface area of those particles, like the baseball when laid flat, would be about the size of a soccer field. If you took a gram of micron-sized particles in your hand, the weight difference [when compared to the nano-sized particles] would be like 60:1. The surface area of the micron-sized particles when laid flat, in contrast, would be about the size of a sheet of paper. So it's truly amazing when you take it down to the nanoscale how the physical characteristics truly do have some significant value."

"Every particle has an increased surface area or volume ratio," according to McGrath. "This is expressed as an increase in efficiency and in gas output. So now we see these electrolysis-created nanomaterials, when integrated into hydrogen generation applications, enabling increased efficiency, which ultimately will help this electrolysis technology move into the market and be a competitor to steam reforming."

Ample Benefits-Based Appeal

McGrath just mentioned one successful application integrating nanomaterials due to the enhanced surface area of nanoparticles, but what other benefits can nanomaterials impart to designers as a whole? And how can these nanomaterials be leveraged in the design and development of a new product?

"There are numerous benefits that come from the application of nanomaterials and nanocomponents," says Dorr. "In their most basic material form, nano-sheets and yarns can be incorporated into various composite structures to improve strength, conductivity and thermal dissipation. When formatted into products, nanomaterials can serve as conductive wires, thermal and/or electrical straps, EMI shields, antenna structures and more."



QuantumSphere specializes in the manufacture of highly uniform nanomaterials with high purities and specific physical properties, such as magnetic, catalytic, antimicrobial, conductive, etc.

It is up to the design engineer, however, to decide whether nanomaterials would benefit their design and how. In this vein, McGrath suggests, "You have to try it out as far as determining the possible benefits for a specific application. Nanomaterials in general are interesting because their properties aren't as predictable as some other materials. In some ways they're very different."

In regard to how to determine whether the nanomaterials are even worth trying out, McGrath thinks, "Companies will want to stay competitive and continue to offer value-add to their customers. In a lot of the applications that we've been integrating our nanomaterials into, we do see a significant performance enhancement. The question remains, though: Is it cost-effective to add the nanomaterials? We see that in some applications there is a clear benefit, meaning not only can you reduce costs by using less materials, but you can also increase performance."

On the other hand, McGrath notes, "There are other applications out there that may not tolerate the use of nanomaterials—[nanomaterials] cost a little more than regular materials, but for good reason. They're more active, and they have very specific functions. So it's really about looking at the cost-benefit, identifying risks and asking questions, such as: Is my product going to cost more if I integrate nanomaterials? Does it not matter? Do I just need more performance? Or can I actually reduce costs *and* increase performance?"

"And generally what we're finding is that most large companies want to increase performance 30 percent or decrease costs 30 percent. In a battery we've been working to commercialize, we did increase the cost slightly of the catalyst, but the performance of the nanomaterials in the cathode was increased by about 320 percent," according to Maloney.

Dorr feels that any design looking for certain value-add performance characteristics that nanomaterials can provide is an ideal candidate: "For example, we excel at EMI protection, high-frequency AC conductivity (as an alternative to copper) and lightning protection alternatives." However, to determine whether nanomaterials are a good fit for a project- or product-specific design, he warns, "Empirical comparisons to existing materials/solutions is the only way. Never accept a supplier's performance claims. Testing, testing and retesting is key to separating marketing claims from engineering reality."

McGrath feels the same way: "Any design with a specific problem [is an ideal contender for nanotechnology.] We're particularly good with the energy applications, but there are so many others. We have some university research going on studying materials with heat issues, magnetic properties, antimicrobial activity and all these other things, so pragmatic integration is really on a case-by-case basis."

Leveraging The Little Through Integration

Now comes the hard part—weighing the risks and benefits, then eventually, integration. "The greatest exposure [to risk] from the implementation of nanotechnology is assuming its performance is greater than it really is, but there are many applications for nanomaterials that can be fulfilled today," according to Dorr. His advice for implementing nanotechnology into a design is to "take advantage of a supplier's experience, as well as designers who have 'been there—done that.' A credible supplier will share what works and what does not because it is in everyone's best interest to do so.

"Although nanotechnology may appear to be a new field, nano research has been around for a long time. There is a wide range of organizations and Internet-based resources to help. Nanomaterial suppliers are also eager to work with design engineers as they make investments in application-focused talent to facilitate adoption of their products and technology."

Maloney concurs, "The key is not only to get your hands on enough meaningful amounts of the nanomaterials (with considerations of size, purity, volume and safety), but also to take advantage of the experts who know how to integrate these materials into devices. Integration is our whole focus here. We try to build a relationship in which we're just not providing nanomaterials because there's so much expertise you need to overcome these obstacles of working with them. We can help avoid a lot of the challenges of integrating nanomaterials into systems. It's all about understanding the technical side, and communicating back and forth with the customers and partners."

Although design engineers are bound to run into some obstacles, McGrath believes it may be difficult to brace yourself for pitfalls, "I think the obstacles themselves would be very application-specific. But the hardest part is: What do you have to do to that material to get it into your application? You have to disperse it in a solvent properly, you have find a way to get it to bond to a surface in a certain way and there's experimentation that goes along with that. My best advice is to roll up your sleeves and talk to us about it. One thing we are getting better at is learning how to disperse these materials properly in a variety of applications." PDD