

Materials is Nanoscience too

By Pearl Chin, PhD, MBA

Materials science is an area that has evolved from metallurgy into the interdisciplinary discipline it is now, complete with a name change. Materials science traditionally included metals, ceramics, and polymers and also includes composites as it is about combining materials. For a while, the German scientists were saying that nanotechnology is nothing more than materials science. They're right to some extent if their definition includes biological systems. Materials science does not currently include biochemical systems but that can be subject to change if we keep an open mind and can draw on basic biology and chemistry training. Most materials science graduate training focuses more on chemistry and physics, especially solid state physics. At this point, my undergraduate training in chemical engineering, thankfully enough also allows me to understand biochemical systems. I always forget about the mathematicians since most of what they do seems like support staff to the other branches of science which without mathematics would be nothing. This is a common occurrence among scientists so I ask their pardon as I apologize for the memory glitch. It is unclear whether the Germans still think the way they do about nanotechnology but they're not wrong either. Everyone is right to some extent as to what nanotechnology is. They're just not completely right since they only have a piece of the answer. So it is quite natural that scientists themselves can have a very myopic view of what nanotechnology is all about. There is so much to do in their own narrow fields that it is often hard to look outside of the confines of their research boundaries.

Unknown to many, materials science is also a significant portion of nanotechnology. The materials science part of nanotechnology covers a broad range of applications by studying polymers, metals and ceramics systems, which includes nanotubes, buckyballs, nanoscale fibers and particles, catalysts and more. The applications of these materials are diverse and transcend industry boundaries. Buckyballs or buckminsterfullerenes are hollow spheres of sixty carbon atoms (C₆₀) arranged in a soccer ball or geodesic dome configuration. They were named after the father of the geodesic dome, Buckminster Fuller. Buckyballs were discovered in 1985 by Richard Smalley and Robert F. Curl, Jr. of Rice University and Sir Harald Kroto of the University of Sussex and they all shared the Nobel Prize in Chemistry for this discovery in 1996. The latest technology development is carbon nanotubes, which are carbon atoms arranged in a similar hexagonal array as buckyballs and graphite but are in the shape of tubes. Due to their small size and low defect density, they exhibit superior electrical and mechanical properties that can be exploited. Dr. Sumio Iijima, Senior Research Fellow at NEC Corporation and Professor at Meijo University discovered carbon nanotubes using high resolution transmission electron microscope that clarified the atomic structure and character of multi-wall and single-wall carbon nanotubes that were by-products of making buckyballs. Buckyballs and carbon nanotubes as drug delivery vehicles in medicine are sexy but they also are being considered for broader materials applications as well. For instance, carbon nanotubes are being used as transistors that outperform silicon based ones. Carbon nanotubes are being used to attain brighter images in HDTV. They are also being used to make biosensors. There is buckyball research being done for quantum computing applications.

Materials research is also currently being used to design electrodes, membranes, and catalysts for fuel cells using carbon nanotubes and solid oxides. Other examples of materials related nanotechnology are high performance fiber mirrors to be woven into military uniforms as bar codes for identification purposes. IBM designed a quantum computer using five atoms. Manipulation of materials at this level becomes important because quantum computing will replace microprocessors as we know it. They will be smaller and more powerful because quantum computers can parallel process versus the standard serial processing of information by exploiting simultaneous quantum particle spin behavior. The laser teleportation as well as quantum dots research has major implications for enabling quantum computing over the next decade. Quantum computing will become important in cryptography (code breaking) and large database searches. With materials research, there are implications for new data storage technologies and nanocomposites as well. And this is just the tip of the iceberg. All of this comes under the heading of nanotechnology materials research and obviously are at various stages of research development. As important as all this ongoing research is, this may all seem esoteric but it is balanced it with everyday commercial applications of nanotechnology as pointed out earlier.

Now or never. Not better late than never.

Technical innovation has its own timetable. Many of these opportunities are at the R&D stage still and it is admittedly a gamble and may not be recognized when it happens. However, this is not atypical of new innovation. For instance, the patent for the fax machine technology was granted in 1843 to Alexander Bain, 33 years before the patent was given for the telephone. The advent of the fax machine didn't happen until 32 years later via telegraph mode and it wasn't until in 1906 that newspapers started using the idea to transmit photos. Now we have the modern day digital fax machine over 100 years later. All these scenarios are much longer than the acceptable period for a return on venture capital (VC) investment but most government funding has no such expectation. There is much nanotechnology still in the research phase but bringing innovation to commercial application has certainly sped up since the time of Alexander Bain.

When the innovation happens you just have to be ready to jump on the opportunity when it presents itself and you have to be knowledgeable enough to recognize it when it happens. In early July, Sir Timothy Clifford, a visiting museum director from Scotland at the Cooper-Hewitt Museum in New York City, found a work of art by Michelangelo in their box of Italian decorative design drawings by unknown artists. When asked how he recognized the drawings as Michelangelo's, he responded with laughter with "It was just as I recognize a friend in the street or my wife across the breakfast table." The nature of discovery is to be prepared to recognize a discovery so that you'll know it when you see it but you can't plan for it. This approach should be no different for nanotechnology. Sir Harald Kroto said early this past July at a Meeting of Nobel Laureates in Lindau, Germany that "The greatest scientific advances couldn't be and weren't predicted. If I had set out to discover fullerenes, I probably wouldn't have done it...It never crossed my mind to win a Nobel Prize. I was happy doing my science." Such is the mindset and motivation of the typical scientist.

The scientists are always proving me wrong about how clever they can be. There have been so many instances that someone has said it can't be done in a certain time period or can't be done at all and then some genius figures out some unconventional way to do it the following month and wins a Nobel Prize for it. A few weeks ago in late July at the World Technology Network Summit, I was listening to a government research lab scientist who specialized in carbon research. He was complaining that the potential applications of carbon nanotubes were being overhyped because they couldn't find ways to make them interact and combine chemically with any systems. A week later I came across an article in an issue of Chemical & Engineering News from two weeks before about how scientists from University of California, Los Angeles, University of Oklahoma, and University of Negev in Israel had discovered ways to coat carbon nanotubes in starch-based molecules to make them dissolve in aqueous (water) solutions that were stable for weeks. This has major implications in inexpensive purification processes, drug biocompatibility, storage and delivery modes. Go figure. Science is unpredictable. Expect the unexpected.

Dr. Pearl Chin has an MBA from Cornell, a Ph.D. in Materials Science and Engineering from University of Delaware's Center for Composite Materials and B.E. in Chemical Engineering from The Cooper Union. Dr. Chin specializes in advising on nanotechnology investment opportunities. She is also Managing General Partner of Seraphima Ventures and CEO of Red Seraphim Consulting where she advises investment firms and startup firms on the business strategy of nanotechnology investments. She was Managing Director of the US offices and co-Managing Director of the London offices of Cientifica. Prior to that, she was a Management Consultant with Pittiglio Rabin Todd & McGrath (PRTM)'s Chemicals, Engineered Materials and Packaged Goods group. Dr. Chin will be advising the Cornell University JGSM's student run VC fund, Big Red Venture Fund (BRVF), on investing in nanotechnology. She is a Senior Associate of The Foresight Institute in the US and was the US Representative of the Institute of Nanotechnology in the UK. She was an alternate finalist for a Congressional Fellowship with the Materials Research Society. She was also a Guest Scientist collaborating with the National Institute of Standards & Technology (NIST) Polymer Division's Electronic Materials Group under the US Department of Commerce. Dr. Chin is a US Citizen born and raised in New York City.

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