TOP NANOTECHNOLOGY PATENTS: A BAKER'S DOZEN

People ask Foley from time to time about which are the **top nanotechnology patents**. Good question. Does that mean the most valuable patents now or the potentially most valuable patents in ten years? Does it mean the most technologically interesting patents? Sadly, some really nifty patents are not very commercially important, and some very pedestrian patents are commercial gold mines. Here, we provide one brief, highly subjective, and speculative commentary about a dozen or so nanotechnology patents which struck us as either important, interesting, or in some cases, BOTH.

We can begin with **IBM** and Gerd Binnig and Heinrich Rohrer, inventors of the scanning tunneling microscope (STM) and winners of the 1986 Nobel Prize in Physics. The original IBM patent on STM (4,343,993) clearly opened up new vistas about imaging the atomic, molecular, and nanoscale world. This was almost too good to be true, and indeed, they were apparently told that STM "should not have worked in principle." (see Nobel address, December 8, 1986). However, this was followed by the flash of insight that similar technology could be used to build new things and become a "Feynman machine" (4,550,257). Modern nanotechnology was born, although it took a decade to gather steam. Scanning probe methods remain at the center of nanotechnology.

Concepts of nanofabrication blossomed in the 1990's. For example, nanoimprint lithography (NIL) was invented by Professor Stephen Chou (5,772,905), and many companies rushed to develop the method including NanoOpto, Nanonex, and Molecular Imprints, among others. Also, in Professor Chad Mirkin's group at Northwestern University, DIP PEN NANOLITHOGRAPHIC printing was invented (6,827,979), and a startup company, **NanoInk**, was born. Mirkin already had patented impressive gold nanoparticle biodiagnostics (6,361,944), now commercially valued by Nanosphere.

Supplementing nanolithography, nanomaterials came of age as well, and material science blossomed with the invention of carbon nanotubes at NEC by Sumio **Iijima** (5,747,161, filed September 8, 1992), and also by a team from IBM (Bethune et al., 5,424,054, filed May 21, 1993). The carbon nanotube race to the patent office continues to this day!

Moreover, strange optical effects at the nanoscale were observed and commercialization ideas advanced for nanoparticles. For example, **quantum dot** technology was advanced by leaders at Berkeley, Paul Alivisatos, (5,505,928) and MIT, Moungi Bawendi (6,322,901). Quantum dots were made dispersible, monodisperse, and even useful, all of interest to licensee Nanosys and Quantum Dot (now Invitrogen).

Connecting nanotechnology with molecular electronics, another seminal patent emerged (5,247,190) when thin films of **conjugated polymers** were found to glow, opening up a new product for organic LEDs, thanks to Cambridge's Richard Friend and co-workers (now licensed to Cambridge Display Technologies, CDT). This discovery helped fuel award of the 2000 Nobel Prize in Chemistry for inventors of electrically conductive, conjugated polymers. CDT went public in 2004 and is actively watched by nanotechnology companies. In the U.S., **Plextronics** (Pittsburgh, PA) is also actively commercializing these polymers including regioregular polythiophenes and nanostructures thereof.

Adding life to nanotechnology, **biomimicry** also became an important ingredient of nanotechnology, also helping to connect nanotech with biotech. The gecko lizards magically walk upside down on ceilings, enabled by a structural micro- and nano-mechanism now patented by Berkeley (6,737,160) to capture the public imagination. The patent tells a story:

> *Adhesive mechanisms in nature have been studied, but have not been fully understood or exploited. For example, Geckos are exceptional in their ability to rapidly climb up smooth vertical surfaces. The mechanism of adhesion used in Geckos, Anolis lizards, some skinks, and some insects, has been debated for nearly a century. While some prior work has identified the morphology of seta used by Geckos and other insects, this prior work does not identify how the seta operates. In addition, this prior work fails to identify how to use a seta to perform useful work. It would be highly desirable to identify and exploit the adhesive force mechanism utilized by Geckos and other insects. Such information could result in the utilization of new adhesive microstructures and the fabrication of such structures.*

Indeed. Patent prose at its finest!

Finally, nanotechnology was influenced by early science fiction-like concepts of non-biological **self-replicators**, and Zyvex found a way to patent one type (6,510,359 to Merkle et al.)! Figure that one out - patent applications, ironically, do not require so-called working examples. More recently, cries have been made to use nanotechnology in a big project, e.g., to create the space elevator. However, has the **space elevator** now been patented by James Dempsey from Oshkosh (6,981,674)?

In conclusion, this selection is necessarily speculative and subjective, and no one should be too earnest about it. But it was fun selecting. Closer inspection reveals this selection comprises a "baker's dozen" of 13 patents. In older, simpler times, when a customer was to receive a dozen of something, the seller would toss in an extra for good will (and to encourage the customer to come back). Perhaps more of that is needed today in business.

We both thank the inventors of the above patents and apologize to the many inventors and co-workers we could not include in a brief piece but deserve recognition. To reward their efforts, many in the legal community keep working to keep the patent system working effectively to enable additional nanotechnology innovations which can turn the world over.

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