

Atomically Precise Manufacturing (APM) is an emerging and potentially transformational manufacturing capability in which devices are fabricated by direct manipulation of atoms and molecules in two or three dimensions.

Because of its atomic scale accuracy and precision, APM may enable the fabrication of next-generation, ultra-miniature electronic devices, especially those based on quantum circuits. But APM will become mainstream only if certain technological hurdles can be overcome, one of which is to develop reliable methods to produce the atomically sharp nanoprobes that are necessary to manipulate individual atoms and molecules.

Using DOE SBIR funding (DE-SC0018530) from the Office of Basic Energy Sciences (BES) and the Advanced Materials and Manufacturing Technologies Office (AMMTO), Tiptek LLC (Tiptek) developed a greatly improved method to create ultra-sharp nanoprobes. Because APM

is still in its infancy, Tiptek has used this new method to address the needs in two closely related markets: **Semiconductor Nanoprobng and Failure Analysis (SNFA)** and **Scanning Tunneling Microscopy (STM)**. Nanoprobes that are needed for APM, SNFA and STM all share the attributes of conductive nanometer-scale apex diameters of curvature (DOC) and controlled tip geometries. In fact, probes for STM and APM are identical whereas probes for SNFA differ only in that they are bent and inserted into a capillary (see


	
Founded	2011, Savoy, IL
Lineage	University of Illinois at Urbana-Champaign Spin Out
Technology	High-yield manufacturing process for nanoprobes
SBIR Use Case	Nanoprobes are used by computer chip manufacturers for QC to locate faults and defects during chip design and manufacturing and by researchers working to advance atomically precise manipulation.
DOE SBIR Funding	Phase I, Phase II and Phase IIB \$2.4M
Success Metric	FY22 SBIR/STTR Company of the Year Sole U.S. manufacturer of nanoprobes (15% of the global nanoprobes market)
Employees	5
Website	https://www.tiptek.com/

figure above). Tiptek's novel nanoprobes are extremely sharp (near atom-sized point), exhibit low contact resistance, and have the ability to survive many contacts with the surface without deformation making them ideal for both the most advanced SNFA and STM applications. ***As the sole U.S. manufacturer of nanoprobes, Tiptek and its work play an important role in securing the domestic supply chain for semiconductor manufacturing as outlined in the 2022 CHIPS and Science Act.*** Tiptek's success in building a sustainable business based on sales to the SNFA and STM probe markets has positioned the company long-term to play a key role in APM as that market emerges.

In 2020, Tiptek received a Phase IIB grant that enabled them to develop a new nanoprobe manufacturing process able to etch multiple tungsten wires simultaneously. Tiptek's new process led to an unprecedented 150-fold increase in production rate and resulted in the discovery of a fundamentally new probe shaping process for which a patent is being prepared. In addition to improvements in the manufacturing process, the Phase IIB grant also funded Technical and Business Assistance (TABAs) resources that Tiptek used effectively for market launch.

During their Phase IIB grant period, Tiptek applied successfully for a DOE diversity supplement, which supports one of the goals of the SBIR program: to encourage diversity and minority participation within the entrepreneurial community. Scott Lockledge, CEO and co-founder of Tiptek, commented, *"Yes, we had a wonderful, wonderful intern, Sarah Hashim. Sarah is working on an undergraduate chemical engineering degree with an interest in biomedical engineering (even though we don't do biomedical research) she worked with us for the summer, and she just did a great job!"* She was one of three finalists in the University of Illinois' Best Entrepreneurial Leadership in a Startup award from over 800 interns to honor her outstanding work in Summer 2022. She developed a process engineering improvement which was implemented into Tiptek's production process.

Tiptek had success despite challenges raised by COVID. Lockledge reports, *"there is one convention that is critical in the SNFA marketplace, the International Symposium for Testing and Failure Analysis (ISTFA) but it was canceled for multiple years. In the interim, we prepared for market launch by developing a marketing communication strategy, product literature, website and designed a tradeshow booth using TABA funds. In October 2022, we finally debuted our novel nanoprobes at ISTFA."*

Customer Discovery and Partnerships have always been at the center of Tiptek's product development strategy. Tiptek attributes much of its success to the multiple partners that helped them transition their Minimal Viable Product (MVP) into the final product that had the critical features desired by end-users. Throughout development Tiptek collaborated with and supplied nanoprobes to Sandia National Laboratories (SNL) to support their work in atomically precise fabrication, Oak Ridge National Laboratory (ORNL) to support work in low dimensional and quantum materials, the University of Illinois at Urbana-Champaign for their development of nano-electronics and nanoscale devices, and [Zyvex Labs](#) (another DOE-supported SBIR awardee) in their quest to develop quantum devices. Lockledge stresses, *"their feedback has been critical. As a small company you can't do everything especially on a complicated or complex process. Reaching out and building those relationships are critical, you just have to do it if you're going to produce products that have the features required by actual customers"*.

Tiptek's relationship with Thermo Fisher Scientific (TFS) and by default their end-users across the globe is another crucial partnership. Tiptek supplies nanoprobes to TFS for use in their nanoprobe instruments in North America, Europe, and Asia. Given TFS' command of the global nanoprobe market, this relationship

keeps Tiptek at the forefront of emerging trends, instrumentation advances, and positions them well in the global supply chain.

Company Background

In 2011, Tiptek was spun out of the University of Illinois at Urbana-Champaign to commercialize Field Directed Sputter Sharpening (FDSS) technology developed in the labs of Gregory Girolami and Joseph Lyding. FDSS enabled Tiptek to manufacture hard, conductive, and ultra-sharp probes in its manufacturing facilities located near the University in Savoy, Illinois. Today, Tiptek employs five (5) full-time employees offering a product line of probes and needles that are purchased and used by industry leaders for scanning probe microscopy, transfer of lamella formed by focused ion beams (FIB), and SNFA used in semiconductor failure analysis. Tiptek has captured 15% of the world market for nanoprobes over the last six years.

Advice and Lessons Learned

Tiptek has received three (3) DOE funded SBIRs (Phase I, Phase II and Phase IIB) totaling \$2.4M to optimize the nanoprobe manufacturing process and commercialize their nanoprobes. When asked what the SBIR program meant to the company, Lockledge stated, *“it's everything, we wouldn't have been able to do it without the SBIR funding. We put our own money into it, but that would not have been sufficient to take us to commercialization, not even close. So, the SBIR funding allowed us to take what was essentially an idea and some academic research and turn it into a commercial product”*. Lockledge commented further, *“we have certainly applied for SBIR awards we did not get. They are very competitive. We feel very fortunate to have gotten this one [Phase IIB] as it's been critical in enabling use to bring the technology to the commercial market”*.

Lockledge continues, *“with respect to lessons learned, I'm not even sure where to start there have been so many. One of the keys to our success that I want to emphasize is **don't let perfection be the enemy of success**. Coming out of the university you're thinking that you need to have all the answers nailed down 100%. Often you don't have the luxury of being able to know everything you would like to know about a process or product before you go to market. There is enormous value in getting your MVP in front of actual customers to get feedback. This is critical - **don't let perfection be the enemy of success**. As scientists and engineers, we want to keep going back to understand and perfect it, but sometimes you need to just get it out there”*.

Final word of advice - build a relationship with your DOE Program Manager. Lockledge wants to make sure to recognize Tina Kaarsberg (Kaarsberg). *“She has been a great program manager. Beyond giving us technical guidance, she provided mentorship and helped us make key technical connections. She has been instrumental in our success.”* Kaarsberg responds by stating, *“I'm thrilled that BES gave EERE the opportunity to manage this groundbreaking project and that DOE recognized them as the FY22 SBIR/STTR Small Business of the Year. However, our relationship with Tiptek will continue since they signed [AMMTO's EES2 Pledge](#) at our AMMTO peer review meeting in Spring 2023 guaranteeing them a continuing place in our microelectronics innovation ecosystem. Stay tuned!”*.