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Nanotechnology, Made in Germany

Engineering expertise and forward-thinking government support have helped to create a vibrant nanotechnology network that is enabling the development of next-generation medical technology.

By: Yvonne Klöpping, Associate Editor

While the use of nanotechnology in medical applications is still, relatively speaking, in its infancy, it has already achieved a great deal. Nanotechnology research has contributed to advances in cancer therapy, bone replacement materials, and stent coatings; in the years ahead it will play an increasingly ubiquitous role in the development of leading edge treatments and devices. In fact, working on this tiny scale opens a vast range of opportunities in the medical field, which German entrepreneurs and engineers are uniquely positioned to exploit.

Government support

In Germany, federal funds for research and development of nanotechnologies amounted to approximately €400 million in 2010. That puts Germany right behind the United States and Japan when it comes to absolute investment funds. According to Marc Böhme, PhD, Managing Director Sales and Marketing at amedo Smart Tracking Solutions GmbH, nanotechnology with the made in Germany label is currently holding one of the leading positions internationally. “Numerous young companies are developing innovative products in various areas,” Böhme says. “But for further market establishment and commercialisation, the medical device industry in Germany needs to network more intensely with established industry. To maintain a leading position in this innovative market segment globally, there is a need for extensive R&D efforts, both at the university and industry levels,” says Böhme.

To stimulate growth and networking in the nanotechnology field, the federal government enacted the Nanotechnologie 2015 programme at the end of last year. “If this mobilisation . . . does not succeed, other countries—first and foremost China and other Asian countries—are going to move right past us,” explains Böhme. Martin Weinzierl, Project Manager, IVAM Research, adds that, because it is a skill-intensive undertaking, nanotechnology is in good hands in Germany. “Various universities and research institutes are involved, and centres of competence and clusters have emerged. The made in Germany [label] is highly respected internationally—the German research community has become a role model,” Weinzierl says. “Hence, nanotechnology has a pretty good chance to make a mark. And this holds particularly true for regulation-intensive industries such as the medical device sector.”

Nanotech advances

In the aftermath of the financial crisis, increasingly young, research-focused companies have entered the market, says Böhme. “Advances are not only

anywhere these days, including in jackets, glasses and ceramic coatings," particularly in the medical arena. I can see obvious developments in applications such as the transport of active ingredients or surface structuring. We already have accredited tumour therapies based on nanoparticles, and tissue engineering and drug targeting are gaining in importance," says Böhme. He also cites visionary work that is being done in nanorobotics and nanomotors. "Targeted molecular therapies that overcome the blood-brain barrier are possible, as is the repair of DNA."

One of the largest nanotech areas in Germany is North Rhine-Westphalia (NRW). The largest of the German states by population, it has received €74.2 million to invest in nanoscience, new materials and production technologies through the European Framework Programme for Research and Technological Development (FRP), a funding programme created by the European Union to support and encourage research in the European Research Area (ERA). NRW is said to be the land of future technologies. About 400 stakeholders are engaged in research, development and application of nanotechnologies in NRW. More than 22 universities and nonacademic research institutes, among them approximately 120 specialised material research chairs and more than 500 material producing companies, have turned NRW into Germany's most important hub for new materials.

In two of NRW's biggest cities, Dortmund and Bochum, healthcare-related micro- and nanotechnology research and development is burgeoning. Renowned research institutes and a tight network of life science companies form a hotbed of innovation for medical applications, products and services. In July 2011, local companies presented current micro- and nanotechnology developments for medical applications during an event organised by Germany's IVAM Micro- and Nanotechnology Network in Dortmund.

RFID and piezo technology

Medical device company amedo Smart Tracking Solutions GmbH was among the companies attending the event in Dortmund. In his presentation, Böhme talked about novel RFID-based navigation for precise positioning of medical instrumentation. Amedo applies the latest tracking- and navigation technology to small-scale medical devices, particularly instruments used in surgical and minimally invasive procedures. "Submillimetre-size RFID chips serve as a vehicle for the precise localisation and navigation of surgical instruments or medical products," says Böhme. "With that, both extracorporeal medical products and invasive catheters or such can be navigated to millimetric accuracy in three-dimensional space." According to Böhme, the trend in industrial RFID technology is towards further miniaturisation and interconnection with miniaturised sensor systems to enable measurement tasks to be performed at specified areas in a patient's body.

Elliptec Resonant Actuator AG, a developer and manufacturer of precision motors and actuators, also presented its innovations at the event. The firm produces prefabricated piezo parts that generate nanoscale movements. "These tiny movements are generally run one after the other to create a larger and very precise actuation," says Dirk van Vinckenroye, who is on the Elliptec AG board of directors. "Our customers' demands in the micro and nano areas are high." He goes on to explain that the conversation with customers generally revolves around the precise positioning of prefabricated parts or very precise measurement, miniaturisation or cost reduction potential compared with conventional technologies. As an example, he cites the use of piezo technology in aesthetic surgery to minimise wrinkles. In collaboration with a US medtech company, Elliptec has developed the XY Scanner, a 2-axis positioning unit that allows a laser-lead optical fibre to move rapidly and precisely across the skin in a matrix of approximately 100 points on an area of 1 cm2. The fibre stops at every single point to treat the skin via direct laser irradiation.

Nanotech trends

More and more medical and pharmaceutical products that incorporate nanotechnology are reaching marketability. Nanoscale transport systems that carry active ingredients or diagnostic devices to damaged cells is one of the

surface coatings probably will be increasingly established in medical device [illegible]," he adds, "especially implants with nanostructured surfaces which often have better biocompatibility and reliability. Increasingly popular are nanostructured surface coatings, such as those containing silver particles. In addition, the diagnostics market with its molecular imaging and personalised products is going to play an important role in the future. Nevertheless, all of these new products and processes will have to prove themselves in terms of customer value and cost effectiveness," says Böhme.

IVAM's Martin Weinzierl notes that advances in nanotechnology basically come from two different directions: the bottom-up approach, which starts at the molecular level to develop highly productive materials, and the top-down approach, which is epitomised by miniaturisation and has a profound impact on implant technologies. "This interaction is particularly important in medical device technology," explains Weinzierl. "Technology that remains in the body permanently has to be not only biocompatible but also bioresistent, so that it won't be rejected by the body. This can be attained through the materials or the micro and nano structures."

Risky business?

While the enormous potential of nanotechnology in medical and countless other applications is well documented, there are potentially tremendous risks that are simply unknown at this stage. The possible risks of nanotechnology and its effects on humans and the environment have been and continue to be a widely discussed subject. "In addition to all of the advantages of nanotechnology, these new structures are also showing new, negative characteristics—the activation of inflammatory processes inside the body, for instance," Böhme notes. "Basically, not all questions have been answered concerning the risk potential of nanoparticles. In particular the determination of toxicity in relation to individual applications should be paramount to protect the user or patient."

For better assessment of the risks associated with nanotechnology, the German Öko-Institut (Institute for Applied Technology) recently introduced the Nano-NachhaltigkeitsCheck (Nano Sustainability Check), which uses a systematic concept for the consistent evaluation of the sustainability potential of nanotechnology products. For the first time, a consistent pattern has been created to identify the ecological burden or relief and the risks and challenges involved with the market introduction of nano products. Together with project partners BASF and Nanogate, the Öko-Institut introduced the Nano-NachhaltigkeitsCheck on 20 May 2011. The project is funded by Germany's Federal Environmental Agency and the Federal Environment Ministry.

"The Nano-NachhaltigkeitsCheck is an instrument for internal evaluation with which companies can conduct sustainability analyses during the development or market introduction of their nano products," explains Martin Möller, Senior Researcher and expert for sustainability evaluation at the Öko-Institut. "By means of precisely defined key indicators, one can evaluate at an early stage how a nano product is positioned compared with a [product that was not developed using nanotechnology] and whether the product can be optimised or if deployment would bear advantages. That makes this instrument interesting for medical device manufacturers who want to systematically deal with aspects of sustainability," adds Möller.

Key analytical factors, according to Möller, include the product's CO2 footprint, energy efficiency and recyclability; the possible incidental aspects of using nanomaterials; employment and health protection; beneficial aspects; and socio-economic effects. "The Nano Nachhaltigkeits Check is a useful system for suppliers to the medical device industry, as they can detect possible risks and weaknesses of new developments or products that are already on the market and come up with suitable solutions, if necessary," Möller explains. "The system can be used as an early warning method and can therefore make an important contribution to the innovation process of nano products in the medical device sector."

new technologies." But complacency on the part of industry would be a huge mistake. "Education and communication is necessary to confront preconceptions," says Weinzierl.

Yvonne Klöpping is Associate Editor of EMDT.

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