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Supplement to the Treatise

WOLFGANG RUNGE: TECHNOLOGY ENTREPRENEURSHIP

How to access the treatise is given at the end of this document.

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The current case relates to a group of German university spin-outs or research-based startups (RBSUs), respectively, based on scientific optical instruments and specifically nanotools, WITec GmbH, JPK Instruments AG, and Attocube Systems AG, for which individual case documents are generated. All university startups are a more or less competitors, but exhibit different paths of development which represents a “science2business” approach.

This cluster of startups deals with an enabling technology for nanotechnology, very highly resolved microscopy, which was honored with the Nobel Prize in Chemistry 2014 awarded jointly to William E. Moerner, Eric Betzig, both from the US and Stefan W. Hell (Germany) “*for the development of super-resolved fluorescence microscopy*."

Technology and market as well as competitive situations for these startups are described more detailed in the WITec case [Runge 2014a].

Wolfgang Runge

JPK Instruments AG

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JPK Instruments AG was launched in 1999 by an entrepreneurial triple [Runge:191,306,328] while they still were studying, in particular, while they were performing their diploma theses. The three co-founders which are friends and know each other from childhood was complemented by a fourth friend only one year later.

The friends did not want to become employees and there was consensus among them to found a firm. Actually, they were actively searching for an appropriate opportunity and technical business idea to be pursued. Their fundamental business orientation was nanotechnology and specifically *nanotools* focusing on work on the molecular level – analyzing, handling, manipulating, measuring and visualizing.

JPK Instruments is a manufacturer of nanoanalytical instruments particularly based on atomic force microscopy (AFM) and generally scanning probe microscopy (SPM) essentially for academic and industrial R&D in life sciences, biosciences and soft matter applications, even living cells.

With product lines based on AFM and Force Sensing Optical Tweezers JPK provide solutions for super-resolution imaging and the analysis of nanoscale interaction forces of atoms and molecules – focusing on BioSPM.

The Technology and the Market

The atomic-force microscope (AFM) was developed 20 years ago, but only at the end of the 1990s it became a significant tool for biologists said Irene Revenko, applications scientist at AFM manufacturer Asylum Research. Most of the experiments were essentially just replicating earlier findings that had been done on other instruments. "In the last five years people began to get new data with AFMs that they weren't getting with other microscopy techniques." [Heyman 2005]

With their "scanning probe" design, AFMs as well as in force spectroscopy studies can be used in experiments that map a sample's mechanical compliance (hardness), charge, or magnetic field. The tools' primary biological application, however, remain imaging, where its high resolution and ability to image live samples made it a device worth considering for researchers seeking to combine electron microscope-level resolution with the sample variety afforded by optical microscopes [Heyman 2005].

In 2005 research-grade AFMs could cost from $100,000 to $300,000, depending on the configuration, and an integrated AFM-confocal microscope could run much higher.

Increasing government and corporate funding in life sciences and nanotechnology is predominantly driving the microscopy market. Furthermore, technological advances that enhance ease of usage, automation, better quality imaging, faster/better analysis have also had a huge positive impact on the market [PR Newswire 2011].

With particular interest in applications in biosciences, life sciences and bionanotechnology the following recent market aspects shall be emphasized.

The optical microcopy segment dominated the microscopy market. However, it was expected to lose market share to advanced microscopies such as electron and scanning probe [PR Newswire 2011].

Currently the fastest-growing segment of the global microscopes market is reported to be scanning probe microscopes (SPMs), with a CAGR [Runge 2013:239] of 10 percent between 2013 and 2018. Charged particle (electron, ion) microscopes have a projected CAGR of 6.8 percent, and optical microscopes 4.7 percent. As a result, charged particle microscopes are projected to increase their market share from 41.7 percent in 2012 to 43.4 percent in 2018. Optical microscopes are projected to lose market share, from 39.1 percent in 2012 to 36.6 percent in 2018 [BCC Research 2013].

- The world microscopy market was expected to grow from $2.7 billion in 2010 to $4.5 billion in 2015, at an estimated CAGR of 10.8 percent from 2010 to 2015 [PR Newswire 2011].
  It was suggested that the global market (microscopes market and related accessories) had reached ca. $3.8 billion at the end of 2012 and was estimated to reach a total of over $4 billion during 2013. By 2018, the industry is forecast to hit a value of $5.4 billion (CAGR growth rate of around 6 percent between 2013 and 2018) [BCC Research 2013].
- The *US* accounted for the largest share of the overall global microscope market in 2012 with nearly one-third of the market for all types of microscopes. *Japan* had the second-largest market share, with 20 percent of the global market, followed by *other Asian countries* with 19 percent and the *EU* with 18 percent [BCC Research 2013].
  Japan and other Asian markets are expected to experience the most rapid growth over the next five years, with CAGRs of 7.0 percent and 7.4 percent, respectively, between 2013 and 2018. The US and the EU are expected to lag behind [BCC Research 2013].

The semiconductor industry was the largest application area of microscopy accounting for 31 percent of the applications' market. *Life sciences and material sciences* accounted for ca. 27 percent and 24 percent of the total market. Nanotechnology accounts for a meager 10 percent of the market [PR Newswire (2011].

But in 2012, the *life sciences* were reported to be the dominant end-user market for microscopes, with 31 percent of the total market, followed by materials science (26 percent), semiconductor manufacturing (24 percent), education (12 percent) and nanotechnology (7 percent). Between 2012 and 2018, semiconductor manufacturing's share of the market was projected to slip to 19 percent. Meanwhile, materials science, education and nanotechnology should gain market share, while life sciences' share remains constant [BCC Research 2013].

Generally, it was assumed that the world's total revenues in pharmaceuticals, medical devices and diagnostics, which are gained by nanotechnology, will increase from $15 billion in 2007 to $310 billion in 2015 [Pelzer 2009].

Generally "About 40 % of current atomic force microscopy (AFM) research is performed in liquids, making liquid-based AFM a rapidly growing and important tool for the study of biological materials." [Baro and Reifenberger 2012]

Awards and Publicity

So far JPK received several innovation or founder awards.

In 2011 JPK received an award from the German state-owned KfW Bank Group in cooperation with the German journal SUPERillu in the area of *future technologies* and got the award directly from Germany's Minister of Economics. It was a competition with 392 candidates promoted by KfW and SUPERillu [JPK 2011c].

In January 2009 the Prism Award for Photonics Innovation acknowledged a JPK product. JPK's NanoTracker™ was voted the world's most innovative product in "Life Sciences", one of nine categories of the competition. CEO Frank Pelzer commented: "We are pleased that our many years of research are not only appreciated by our customers but have now also found favor with a panel of international experts." "Our NanoTracker™ is a milestone in cell research. No other instrument enables three-dimensional and non-destructive real-time observations at such a resolution. The NanoTracker™ affords researchers completely new insights and possibilities." [JPK 2009a]

The NanoTracker™ operates with laser tweezers and can trap, track and detect nanoparticles solely with light. This allows researchers, for example, to examine at the nanoscale level how viruses and bacteria enter a cell. On this basis, researchers can develop drugs that prevent harmful elements from entering cells or promote drug delivery into cells [JPK 2009a].

In 2007 JPK was the No. 1 and, hence, the fastest growing German company of the nanotech sector on the *Deloitte Technology Fast 50* ranking. The leading companies in Germany were determined on the basis of their compounded percentage sales growth rates of the past five years. JPK achieved a growth rate of over 970 percent. Apart from the No. 1 position in nano-technology, JPK made the second place in the life sciences industry, its core business, and third place in the New Technologies segment [FPK 2007b].

In 2008 JPK was again the No. 1 in the *Deloitte Technology Fast 50* ranking and achieved a growth rate of over 930 percent. This renewed recognition as the fastest growing company in the nanotechnology sector was assumed to increase JPK's visibility to investors [JPK 2008b].

The Entrepreneurs

Physicist Torsten Jähnke (born 1973), Frank Pelzer (born 1972), MBA, and Jörn Kamps (born 1972), physicist, were born and raised in the Uckermark region, 80 kilometers north of Berlin, in Templin and Lychen. There they also went to the same "Gymnasium" (similar to the British grammar school or US preparatory high school) and later studied at the Humboldt University in Berlin sharing a student apartment [Ernestine 2013; JPK].

Foundation was preceded by research, which the founders were following up during their study time. "We all have passed at the same time the Abi (short for Abitur, the final examination of a German Gymnasium), studied physics or economics and lived in one apartment (in Germany called WG – Wohngemeinschaft; commune). Even before our thesis we have developed measurement instruments for nanotechnology." [Reckermann 2014]

After school the trio parted ways for a while. "In Berlin we met again and then studied at the Humboldt University. My two partners in the Physics Department and me at the Faculty of Economics. Mid-1990s, we had the idea to start a business. Where the journey would go to was not clear to us at that time." [Ernestine 2013].

In 1997, they decided they wanted to have their own company rather than being employees of a large corporation [JPK]. Later the first letter of their last names served as part of their company's name.

It must be considered, however, that the Trio (that later became a quartet) grew up in the former socialistic German Democratic Republic (GDR) and was exposed to the GDR's educational system until the Reunification of Germany in 1990 [1] – which, after the fall of the Berlin Wall, was simultaneously a reunification of the city of Berlin. In this context it is also to be noted that

Humboldt University, the first (of three) universities of Berlin, was located in the GDR-part of Berlin.

Therefore, it is not surprising that people like the present trio of friends striving for personal independence, actions and responsibilities followed an entrepreneurial track for their further lives [Runge:301,308,318,983-984].

After success with JPK in 2008 Pelzer, the fifth of six brothers, considered his youth in the GDR, the fall of the Berlin Wall and then the challenge and freedom of the West as a great luck. After graduation at the Gymnasium and hitchhiking "around all of North America" he returned to Berlin "with a high level of satisfaction" and he was happy and felt "I can achieve anything." For him it was the entry into studying business administration. And with the other three friends sharing a WG in Berlin they generated a drive for a sophisticated own venture [Afheldt 2008].

Concerning German policy on the federal and state level (and also the EU level) after the Reunification there were a lot of political support programs and initiatives to transfer the socialistic economy of the GDR into that of a capitalistic economy, to rebuild the country and the educational and scientific systems to catch up with Western standards. In particular, there was much (financial) support for Berlin – the “new” old capital of Germany.

For studying at the Humboldt University the three friends lived on a special German scholarship of the Federal Government (called “Bafög” – Bundesausbildungsförderungsgesetz) [Humboldt University 2003] or worked as “student served assistants” (in German studentische Hilfskraft) [Humboldt University 2003].

Furthermore, concerning the science and research environment the Berlin-Potsdam area (Potsdam is the capital of the State of Brandenburg surrounding Berlin) is a German “Science and Technology Center”: Within a diameter of ca. 50 km there are four universities, several universities of applied sciences, research institutes of the Max Planck Society (MPG), Fraunhofer Society (FhG) and WGL (Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz – WGL – Leibniz Society) [Runge:165-169] and Germany’s largest technology park.

Specifically, the Charité (Universitätsmedizin Berlin) [2] is the most prominent hospital and medical school in Berlin. Acting today as the medical school for both the Humboldt University and Freie Universität (Free University) Berlin, Charité is one of the largest university hospitals in Europe. With numerous Collaborative Research Centers (CRC) of the Deutsche Forschungsgemeinschaft (DFG; national German Research Foundation similar to the NSF in the US), Charité is one of Germany's most research-intensive medical institutions.

The founders were risk-aware, but not risk-averse when focusing on nanotechnology. After having entered production of nanotools, what comes next? Speculation! Pelzer could imagine that JPK ends up back at zero. In 2003 the business prospered; JPK had just received a major order from Taiwan. But, on the other hand, the domestic sales shrank because the public sector had no money [Osterloh 2003] – after the Dot-Com Recession.

This is a normal situation for firms with customers from public organizations: Results of an economic recession show up for non-public, for-profit customers immediately who will reduce cost and orders straightly. But for the public sector the budget for the current year is (usually) still valid. A recession is felt by firms selling to public customers with retardation; related reduced tax income of the state results in the following year in reduced budgets for public organizations and, hence, reduced finances for acquisitions.

In retrospect, as JPK’s recipe for success the founders concluded: "You have to look for a growing industry with a niche in which, however, you should not act too broadband."

[Reckermann 2014]. The related opportunity for JPK actually was the interfaces between nanotechnology and soft matter and life sciences, BioSPM.

Remarks Concerning Corporate Culture

JPK works almost exclusively with scientists: physicists, chemists, biologists and biochemists or multidisciplinary scientists like biophysicists or biochemists. Also computer scientists are employed as well as mathematicians. In production there are electrical engineers, mechanical engineers and precision engineers. And there are also a few MBAs. (By 2013) 80 percent of JPK's employees had a diploma, 40 percent had a PhD or Dr. degree [Ernerstine 2013].

Correspondingly, JPK has largely a "research culture" [Runge:388; Runge 2006:242,627-629].

"As an enterprise we have a long-term orientation. We knew from the beginning that we need to market our products worldwide. We mainly use our offices in other cities to expand sales." [Ernestine 2013]

JPK's leadership (founder) team exhibits a heterogeneity usually assumed to be very favorable for NTBFs. But, generally, there are issues for the *leadership team* with strong social ties over more than two decades to cooperate efficiently for such a long time. There are pro's and con's.

The combination of technical and commercial competencies is definitely an advantage. Another advantage of the situation is that they already knew each other from childhood – and thus also know the quirks of the others. Hence, one can understand more, accept and cope with friction. "Confidence in our course also played a major role. The disadvantage of such a tight constellation is that it often lacks the professional distance between friends. One tends to ignore things instead of addressing problems directly." [Ernestine 2013]

Needed and expected qualifications to work with JPK are enthusiasm and persistence. The development of a product can sometimes take longer than two years. The frustration level of the individual must therefore be very high. It is also important to be able to integrate into a team. And they should be able to think long term and thinking internationally [Ernerstine 2013].

The advice for young entrepreneurs according to Pelzer's experience reflects to a certain degree attitudes and approaches of the leadership team which also influences corporate culture [Ernerstine 2013].

- "Have great resilience. You will not start a business at the age of 20 years with all the problems and challenges in your head that you will encounter later. And that's a good thing. It is much better then to solve the problems as they arise, which let you emerge stronger."
- "With the knowledge and experience of today we would certainly not have started our company. There are always incredibly strenuous and risky phases."

JPK employs people from many nations: from the US, Ukraine, Japan, China, Singapore, UK, Bulgaria, the Netherlands, France and India – and of course also from Berlin (and Germany). This requires to have or have developed *intercultural competencies* of the leaders and the below level of people filling roles of line management charged with meeting corporate objectives in a specific functional area or line of business. The corporate language is English.

Teamwork or project work in an *international environment* means bridging different cultural and educational mindsets and utilizing the knowledge and creativity resulting from *diversity* of scientists in universities and industrial research customers from around the world to develop nanotechnology instrumentation for life science applications.

If JPK has free positions and does not find appropriate employees in Germany to fill the gaps due to a shortage of relevant specialists in Germany, Pelzer said “We need to look for our employees around the world.” [Hansen 2010]

Focusing on customers from university research or research in public research organization *customer orientation* means understanding the customers’ needs in the scientific community and keeping their pace of progress to generate growth for JPK in a sustainable way.

Hence, JPK’s corporate culture is influenced by an orientation towards “*fast development*.”

Business Idea, Opportunity, Foundation and Product Developments

1998, when Pelzer had just returned from a lengthy trip to Alaska, the other two physicists confronted him with the idea to enter the nanotechnology field. “We have built our company already during the time when we worked on our diploma theses and simultaneously looked also for financial backers. That was not so easy, because it was the heyday of the Internet. But we did want to stretch molecules and push atoms.” [Ernestine 2013].

Torsten Jähnke, fascinated by all forms of nanotechnology through student jobs, initiated the idea to develop optical scanning probe microscopes (SPMs) into a business. In October 1999, the three friends, while still students, founded JPK Instruments AG using their own funds [JPK].

The related basic nanotools in this endeavor were Atomic Force Microscopes (AFMs) and SPMs. And they, as other competitors did, transferred the technology into standardized products, but focusing on *applications in the life sciences*. With these microscopes one can perform measurements without preparation of living cells on the nanoscale. You can work on the molecular level, analyze, manipulate and measure [Ernestine 2013].

During the day the three friends from the Brandenburg town Templin wrote their theses and at night they dealt with nanotechnology and already developed measurement instruments for this high-tech science. "Little did we know that there is much to discover in this still largely unknown world," said Frank Pelzer [GRUENDER-MV.DE 2011].

Microscopy has always played a key role in life science research. Microscopy-related and high-end optical techniques bear the potential to visualize, better elucidate and finally control biological processes on the level of single molecules, individual living cells and living cell assemblies. Successfully addressing these issues would enable the convergence of life science and nanotechnology in research and for industrial applications.

JPK followed a meticulously planned approach to founding a firm. According to Pelzer’s conviction and the related situation “to start one’s own business, it is essential to write a business plan.” The related test field for assessing one’s business plan was the business plan competition Berlin-Brandenburg. This is announced by the publicly controlled investment banks Investitionsbank Berlin (IBB), Investitionsbank Brandenburg and business organizations in Berlin and Brandenburg. It will be awarded annually forcing the participants to the systematic analysis of the project and will reveal gaps in knowledge [Humboldt University 2003].

By participating in such contests, one may benefit from a wide range of seminars, coaching by experts in the field and contacts with potential financial backers. Concerning assessments of JPK’s business plan “we were convincing as a team and additionally had support by well-known scientists in Berlin.” [Humboldt University 2003]

They all successfully completed their university educations with related diploma degrees in 2000/2002.

Founding JPK occurred with a sense of *urgency*. When Pelzer completed his studies in 2002 some 20 scientists worked already for his company. "We had to get going so fast; in nanotechnology every day counts." [Hansen 2010]

They started the private stock firm JPK Instruments AG with the following Board of Directors:

- Torsten Jähnke (CTO), physicist, responsibility for technology, sales and marketing (note: combination of R&D/technology and marketing and sales)
- Frank Pelzer (CEO), MBA, with responsibility for business development and finance
- Jörn Kamps (COO), physicist, with responsibility for production and intellectual property – at the university he worked already on optical image processing. (http://proceedings.spiedigitallibrary.org/proceeding.aspx?articleid=919284).

In 2000, they persuaded another good friend, René Grünberg (born 1973), to join the board of managing directors [JPK] as Controller including responsibility for shareholdings. Due to the rather complex finances' structure and financing JPK required a manager being responsible for Accounting, Controlling, and Equity Investments.

During the development of the firm Frank Pelzer and Torsten Jähnke emerged as the commercial and technical leaders, respectively, of JPK.

As a (private) stock company JPK established a Supervisory Board with qualified members, an MBA, a venture capitalist and Prof. Dr. Klaus Ploog, the leader of the Paul-Drude-Institute for Solid State Electronics (Berlin) engaged in research interfacing materials science and solid state physics with emphasis on low-dimensional structures in semiconductors [JPK 2002].

In 2004 members of JPK's Supervisory Board were changed. For instance, JPK got Roger Bendisch as a member of the Supervisory Board. Bendisch was (is) Managing Director of IBB Berlin mbH. Dr. Andreas Eckert was appointed as the new Chairman of the Board. He was Chairman of the Board of Eckert & Ziegler Radiation and Medical AG, Berlin, founded in 1997. Eckert also participated in the founding of numerous technology companies at home and abroad [Berlin News 2004].

JPK was formed to seize the opportunity in the blossoming nanotechnology tools market and further developed the AFM technology so that living materials, such as cells, can be studied with it. "That's our niche," said Pelzer. "With this BioAFM technology we are world leader." [Ronzheimer 2007]

In May 2000, JPK began building what would become its first product, the NanoWizard AFM. The NanoWizard combines an ordinary optical microscope (for determining what mechanical, chemical, and optical properties a sample has) with an AFM (for imaging and manipulation). That this *functionality was exactly what people were asking for* was confirmed by JPK by its August 2002 Tools Survey (mentioned in "Nanotech Tool Time," August 2002) [Forbes/Wolfe 2003].

And just one year later at the 2001 NanoBioTec conference in Münster (Germany), they launched the NanoWizard®, the world's first dedicated BioAFM [JPK].

So far, research work with the available equipment was very expensive. To examine a sample, a biologist needed up to a week. Another problem was that researchers often achieved different results with identical samples. Therefore, it was urgently necessary to significantly *accelerate the investigation method* and *standardize it* [Schäfer 2006].

Furthermore, JPK could offer its new microscopes at *a cost much less than the usual scanning microscopes* on the market and providing additionally a much deeper insight into matter and especially into the human cell [Osterloh 2003].

According to Pelzer “We will be #1 in cell research.” “All pharmacologists want to know how drugs influence cells. We can see how viruses go into the cell. We can measure how fast this happens and if the drugs can make it happen faster. We're not fishing in the dark anymore.” [Forbes/Wolfe 2003]

At the time of foundation JPK “saw Veeco as a big player in the instrumentation sector,” said CEO Frank Pelzer. “But they were in the semiconductor and materials science market. Hardly anyone was in life sciences.” At that time Digital Instruments (DI), then acquired by Veeco, had a “BioScope” which was starting to look at soft metals. “The customers only had one supplier in the space, DI, so they had to play by their rules. The customers wanted competition, they wanted more innovation which would come about with market pressure,” said Pelzer [Forbes/Wolfe 2003].

Eighty-five percent of JPK’s 2003 customers were German research institutes, but with UK and French distribution contracts already in the works, JPK expected to see the $130,000 NanoWizard Systems spreading the European research community. And Pelzer said JPK will enter the North American market in 2005 after establishing a solid base in Europe and Asia, but keeping a very close eye on the US competitor Asylum Research [Forbes/Wolfe 2003].

Only six months after the introduction of its first product JPK completed the fourth quarter of 2002 with a profit and, due to the large demand for the full year 2003, could expect also ending in the black.

NanoWizard whose development began by the end of 2000, was conceptualized for applications in the fields of soft matter, biosciences and life sciences. At that time it was the only device that combined an optical and atom force microscope such that it can visualize, for instance, the surface of living objects (tissues and single cells) continuously down to the nanometer range [JPK 2002].

And it was planned for 2003 to extend its product range by the LightWizard™ SNOM, a scanning near-field optical microscope, which unlike the NanoWizard AFM can acquire in addition to the topography also optical properties, such as fluorescence or wavelength-dependent absorption, of the living specimen or individual molecules [JPK 2002].

Between 2002 and 2006 the roadmap for a powerful product line was developed and executed [JPK], but also strategies for firm’s growth. The upgraded NanoWizard® II product line was launched in 2006.

Further developments of JPK required *internationalization*. According to Frank Pelzer "the development of a product ready for market launch can cost five to ten million euros. In Germany I can achieve maybe only €3 million in sales. We therefore had to go abroad to refinance our investments and make a profit.” [Commerzbank 2013]

The export rate became 60 percent. And by 2007 at the former AEG-site in the Bouchéstraße, JPK’s headquarters in Berlin, there were produced annually between 50 and 60 nanomicroscopes, which were mainly sold to research laboratories abroad [Ronzheimer 2007].

The site of the former giant electricity firm AEG in Berlin provided facilities for the JPK headquarters with overall 24 employees and the operational functions of research, development, manufacturing and sales. Production occurred on a factory floor [Osterloh 2003; Reckermann 2014].

Non-Organic Growth and Distribution

After first installments of NanoWizard® (2002) and JPK reached profitability (2004) JPK focused on *non-organic growth* [Runge:681-682, Figure I.127]. In 2004 it founded nAmbition

GmbH in Dresden (State of Saxony). And in 2006, after foundation of nAmbition GmbH, JPK announced the 100 percent acquisition of lpi light power instruments GmbH (Berlin, Germany). This was, according to its CTO Torsten Jähnke, “the next strategic step for the JPK Instruments group on its way to becoming the leading NanoBio instrumentation company.” [JPK 2006a].

lpi light power instruments became JPK´s business unit for advanced optical technologies; it strengthened and diversified JPK’s R&D capabilities in this field and filled furthermore its product portfolio with exceptional new instruments [JPK 2006a].

The company held pertinent intellectual properties and had built up a development team that was highly skilled and experienced. The CEO of lpi, Dr. Sven-Peter Heyn, before becoming CEO of lpi in June 2005, served for more than 15 years in different management and executive positions within the medical technology and life sciences sector. In this way the emerging JPK Group with lpi as a subsidiary could profit from Heyn’s experience [JPK 2006a].

In 2006 JPK’s announcement of the 100 percent acquisition of lpi GmbH occurred after closing an nAmbition-related substantial financing round. Regarding nAmbition JPK appeared formally as a “corporate investor” which later took over the firm it had invested in.

nAmbition GmbH (an LLC; Nano & Ambition = nAmbition) was founded in Dresden/Germany in July 2004 and successfully completed its first financing round in 2005. The initial investors were JPK Instruments AG, Dresden Fonds GmbH and the Technology Holding Company tbg (Technologiebeteiligungsgesellschaft mbH, a public investment company) [nAmbition]. It is focused on the development of nano-instruments for bioscience applications, in particular, in medicine and pharmaceutical research. nAmbition is located in the Biotechnological Centre (BIOTEC) in Dresden and in the initial phase employed more than 12 scientists and engineers [JPK 2005a].

nAmbition and TU Dresden acquired one of the biggest technology grants in the history of funding NanoBiotechnology in Germany, with more than €3 million from the InnoRegio and BioMeT initiative of the German BMBF ministry. JPK Instruments AG together with partners from Dresden Fonds GmbH, Kajak GmbH (Managing Director Karl Schlagenhauf) and tbg was guiding nAmbition to become a major player in the nanobio-sector [nAmbition].

InnoRegio relates to the European Regional Development Fund (ERDF, in German EFRE) of the EU. [5] By the end of 2004 Karl Schlagenhauf became a member of JPK’s Supervisory Board and simultaneously the Chairman of the Board and he ended his term at the end of 2007 [EB].

Around 2000 the TU Dresden supported their scientists heavily to found firms (cf. the case of Novaled AG, founded in 2001 [Runge 2014c]). At that time Prof. Müller had good reasons to develop his idea to build a robot for single molecule experiments. And therefore he looked for co-workers and financial backers. And he founded nAmbition with the goal to build a robot which can measure interactions between single molecules totally automatically [Universität Basel].

Daniel Müller, a biophysicist, was Professor of Cellular Machines at the Biotechnology Center at the TU-Dresden from 2003 to 2010 [Daniel Müller], then Professor of Biophysics at the Department for Systembiology of the ETH Zurich at Basel [Universität Basel].

The Imaging Facility at the Biozentrum of the Basel University and Imaging Facility at BIOZ of the TU Dresden were formally opened in 2005.

What actually followed, the “short story” of nAmbition, is a technology entrepreneurship case in a superordinate case.

Karberg [2006] describes how a serendipitously found technique by later Prof. Daniel Müller in 1999 to investigate single protein molecules was turned ultimately into a commercial product.

Daniel Müller was engaged in postdoctoral work at the Biozentrum Basel (Biocenter Basel) [Daniel Müller]. His finding referred to an observation when working with AFM and proteins; he accidentally let the cantilever too close to the proteins. "While scanning a protein at the tip got suddenly stuck," he remembered. This was the start of developing a technology allowing to measure interaction forces between molecules. Using the original technique, however, required weeks of manual work. Hence, there was a need and wish to further develop and automate the technique.

In 2003 Müller met serial entrepreneur Karl Schlagenhauf who immediately was excited about the related opportunity. Together with JPK as the “parent company” they founded nAmbition, and its managing directors were Schlagenhauf’s daughter Jelka, Frank Pelzer of JPK and Jens Struckmeier, who has been “captured” by Müller from AFM market leader Veeco Instruments from the US [Karberg 2006]. Dr. Jens Struckmeier became chief technology officer for nAmbition [JPK 2005a].

“We have a technology with which one can answer so far unresolved questions," said Dr. Struckmeier and continued "if we can harness the atomic force microscopy as easy and as known as optical microscopy, then the market will be very large.” [Karberg 2006]

JPK’s CTO Torsten Jähnke added “We are very happy that we could win Dr. Jens Struckmeier as chief technology officer for nAmbition. He has outstanding expertise in SPM technology – especially for biological applications – and will guide nAmbition to be the technology leader in this field.” [JPK 2005a]

In 2006 nAmbition had 16 employees [Karberg 2006] and it had ten patents or patent applications, respectively, listed in the European Patent Office (EPO) database (Table 2).

The financing of nAmbition for a very costly development phase of the technology was made possible by commitment of €3 million by JPK Instruments, Dresden Fonds (covering Ostsächsische Savings Bank, Saxon Investment Company, Sachsen LB), tbg and €1.7 million by the BMBF (Federal Ministry for Education and Research) [Karberg 2006; Schäfer 2006; BioMet 2006].

nAmbition completed one of the largest German nanobiotechnology research and development projects in conjunction with the BMBF and the Workgroup Cellular Machines of the Technical University Dresden on December 31, 2006 [nAmbition].

Some relevant projects of nAmbition at that time listed by Prof. Müller comprise [Daniel Müller]:

BMBF	CellHesion – Technologische Entwicklung der kraftspektroskopischen und mikroskopischen Analyse der Zelladhesion (Technological development of force spectroscopic and microscopic analysis of adhesion of cells)
BMBF	ForceRobot – Entwicklung der automatisierten Kraftspektroskopie zur Hochdurchsatzanalyse biomolekularer Wechselwirkungen (ForceRobot – Development of automated force spectroscopy for high-throughput analysis of biomolecular interactions) InnoRegio BioMetT – Verbundvorhaben (Joint Project); Jan. 1, 2005 – Dec. 31, 2006, Project Leader Dr. Jens Struckmeier, €1,629,087 [ConsulTech 2008]; partnering of nAmbition and the Workgroup Cellular Machines of the Technical University Dresden

EFRE	Entwickung eines schnellen Rasterkraftmiskroskops (CellWizard) für zellbiologische und medizinische Anwendungen UT27 (Development of an automated atom force microscope (CellWizard) for cell-biological and medical applications).

The ForceRobot project became a success. JPK developed the device further to become its ForceRobot® commercial product [Universität Basel]. Similarly there appeared CellHesion® Development Kit for studying cell adhesion and cell mechanics phenomena.

In 2007 JPK increased its share of nAmbition GmbH in Dresden to 100 percent (acquisition of shares from investment company Dresden Fonds GmbH) thus extending its product portfolio and boosting significantly its Molecular Analytics Division. Apart from growth in sales and long-term improvement of earnings, JPK also expected the acquisition to be helpful in winning new customer groups [JPK 2008a].

nAmbition is staffed by a multi-disciplined team of scientists who are encouraged to exploit novel ideas to answer the market-led needs of the life sciences community. It is dedicated to develop new applied methods in the field of molecular analytics to deliver results in a more reproducible automated manner pushing the boundaries of how processes may be visualized and quantified [nAmbition].

ForceRobot®, launched in 2007, was the first product of its kind that enables automated measurements on individual molecules, thus producing a protein fingerprint. Among other applications, this feature can be used to identify where active ingredients in drugs bind to the target molecule, as well as the strength of the resultant binding. For the first time it was possible to gain targeted *insights into the complex interactions of individual biomolecules with active ingredients*, thus opening up new paths in the field of pharmaceutical research [JPK 2008a].

The measurement of cell adhesion and cell elasticity is a primary focus of research activity in the life sciences. Many different disciplines are interested in the interaction of cells with other cells or substrates.

So far all methods to study these phenomena had their limitations. With launching the product CellHesion®200 in 2008, JPK had created an integrated system for *measuring cell-cell and cell-substrate interactions*. CellHesion® technology provides quantitative and reproducible measurements of the adhesive and stiffness characteristics of living cells. The system delivers precise *information about single molecule behavior* and can also be used to determine mechanical characteristics, such as cell elasticity or stiffness (see CellHesion BMBF project) [Nanowerk 2008].

The acquisitions of nAmbition and lpi meant a notable increase in manpower and intellectual capital (patents).

At the end of 2007 JPK expanded considerably – production capacity extended to meet increasing sales volume. According to Jörn Kamps “We have significantly increased the workforce this year in response to the *high number of orders*. This strong growth is expected to continue over the coming years, and we have *now created the optimal structures* to meet this demand." Alongside new office space, the production, storage and logistics capacities have been particularly increased, and new machines have been acquired. The production capacity became many times larger as a result of the expansion. The measurement, test and service laboratories had also been expanded and equipped with additional instrumentation. *New personnel* have been added in the areas of applications and customer services [JPK 2007a].

By 2008, on the basis of powerful state-of-the-art technology, the JPK Group implemented solutions for high-resolution imaging, force measurement, nanomanipulation and lithography for life science applications. The BioAFM NanoWizard® and the modules CellHesion® (for the study of cell adhesion and cell mechanics phenomena) and TAO™ (Tip-Assisted Optics module for the combination of optical spectroscopy and AFM) and LightWizard® SNOM were at the center of the product and accessories portfolio.

Already in 2003 it was speculated that JPK “steams ahead closer to an acquisition by a major tool provider.” [Forbes/Wolfe 2003]

And discussing investment options in nanotechnology concerning JPK Uldrich [2006] noted:

What to watch for:	If it can address presence in the US or if major pharmaceutical firms were to purchase JPK’s equipment, it would be a bullish signal.
Conclusion:	“The life science sector needs equipment like NanWizard and the market for such equipment is likely to grow considerably in the years ahead as a result of increased investment in cellular research and drug discovery. The fact that JPK now has a growing distribution network in place in Great Britain, China, Taiwan, South Korea, Japan and Canada suggests that it is finding growing markets for its products.”

JPK's success hitherto was its high level of *application expertise* and the close *collaboration with leading scientists and research institutes* in the field of nanobiotechnology.

In 2007 JPK was the No. 1, the fastest growing German company, of the nanotech sector on the *Deloitte Technology Fast 50* ranking. Apart from the No. 1 position in nanotechnology, JPK made a second place in the life sciences industry, its core business, and third place in the New Technologies segment [FPK 2007b].

In 2008 JPK was again the No. 1 in the *Deloitte Technology Fast 50* ranking in the nanotechnology sector which was assumed to increase JPK's visibility to investors [JPK 2008b].

With its first customer being from Taiwan JPK focused at first essentially on customers in Asia and Germany and specifically Berlin and Brandenburg with a very high density of universities and public research organizations. By 2003 85 percent of JPK’s customers were German research institutes. Pelzer said JPK will enter the North American market in 2005 after establishing a solid base in Europe and Asia [Forbes/Wolfe 2003].

And the actual proceedings of organizing distribution, mainly by distributors or sales representatives or local companies and some few selected branch offices, took a corresponding path focused on Europe and Asia.

The development of JPK’s global network of distributors and support centers following a Europe, Asia-Pacific route was as follows:

2004	UK, France, Italy, Switzerland, Spain Portugal; China, Japan, Korea, Taiwan and Singapore
2005	Belgium, Netherlands, Luxembourg
2006	Canada and Israel (Ragona Scientific as distributor in Canada [JPK 2006c])
2007	Sweden, Norway, Finland, Poland
2007	Brazil, Australia, India, (Taiwan, China, Korea, Japan, Singapore re-focused) and Thailand.

Direct sales operations by branch offices developed as follows:

2008	UK (Cambridge; JPK Instruments Ltd.)
2008	Singapore
2009	Japan (Tokyo)
2010	France (Paris)

2014 China (new office in Shanghai, fully equipped with a demonstration facility to run samples from customers and to demonstrate JPK's products) [Biospace 2014].

For the US JPK established sales representatives in the US only in 2014. In April 2014 its representative in Canada, Ragona Scientific, took over the "East USA" region [Biospace 2014]. In August 2014 the mid-west company DMS, Inc. led by experienced microscopy specialist Doug D'Arcy was "appointed as the JPK Central US Representative, promoting their world class systems to the research community." [JPK 2014].

Specifically, Torsten Jähnke, CTO and head of sales and marketing, said: "We see China and USA as excellent markets for us. Part of our philosophy is to serve customers as directly as possible because we think that the close contact is important to drive the process of scientific progress together as a team."

If one looks at news of JPK reporting on applications of JPK's products (or UserStories on its Web) and scans the news/stories about using its products from 2011 to (almost the end of 2014) one observes that of ca. twenty reports almost all of them were from Europe/Germany and Asia; only two were from North America (Calgary (Canada) and Nebraska from the US). This indicates that for JPK much effort and a lot of marketing will be necessary to enter the US market as a very late entrant.

Financing, Networking, and Organization

As mentioned above JPK planned in 2003 to extend its product range by the LightWizard™ SNOM, scanning near-field optical microscope. This was realized showing JPK's typical R&D approach by networking/cooperation with an external partner as an important resource.

Together with the Fraunhofer Institute for Physical Measurement Techniques (IPM) in Freiburg/Germany JPK worked on a project (KF: 01/2003 - 08/2004) funded by the Federal Ministry of Economics and Technology (BMWi – Bundesministerium für Wirtschaft und Technologie) in the context of its "Program to enhance innovation competence of mid-sized enterprises" (PRO INNO – PROgramm INNOvationskompetenz mittelständischer Unternehmen) [AiF 2006].

The type of cooperation was "KF": Cooperation R&D project between at least one company and at least one non-profit research and technology organization (RTO). The project aimed to develop a complete near-field microscope taking into account the particular conditions of use in biotechnology based on an existing functional model of a scanning unit. The main components of this system were the near-field probe and the actual microscope. Both components must be perfectly coordinated to ensure the functionality.

The result of R&D would be the prototype of a scanning near-field optical microscope (SNOM) for use in the life science sector, especially also for fluorescence analysis of biomolecules. The marketing of the first commercially available devices worldwide was started one year after project completion.

In relation to the related startups WITec and Attocube Systems [Runge 2014a; 2014b] entrepreneurship for JPK was not only special with regard to the involved people, but also concerning the way of initial financing and its amount.

At the beginning there was participation in the Business Plan Competition Berlin-Brandenburg (BPW) by the (potential) co-founders, then there was use of several political programs of the Investitionsbank Berlin (IBB), the program "Gemeinschaftsaufgabe zur Verbesserung der regionalen Wirtschaftsstruktur" (GA; Joint Tasks to Improve the Regional Economic Structure) and support of technology via the IBB program ProFIT" [VÖB 2009].

The thorough business plan and efforts to catch €2.5 million seed capital took two years. [Afheldt 2008]. The participation in the BPW competition with IBB as one of the initiators and sponsor organizations may have helped with acquiring capital.

JPK became *one of the first investor-backed companies in the nano-biotech sector* (involving IBB Beteiligungsgesellschaft mbH, tbg (a VC division of the business development arm of the German government at that time) and the Innovation Fund of the State of Berlin. Furthermore, the co-founders also secured a grant by participation in the program Futour [3] specifically set up for new ventures in the former GDR by the Federal Ministry of Economics and Technology) [JPK 2002; Forbes/Wolfe 2003].

In 1999, the corporation was launched with the participation of the investment bank (Investitionsbank) and loans for the founders by the “Ausgleichsbank” (Deutsche Ausgleichsbank – DtA). [4] Around €3 million had been invested in the company JPK. In 2003 the founders held about 85 percent of the shares [Osterloh 2003]. But, "In 2002 our start capital was depleted and the product was ready for launch,” said Pelzer [Frey and Kramer 2010].

Financial contributions of the IBB Beteiligungsgesellschaft mbH (Berlin) were typically set up as a silent participation. Financial assets of two silent participations totaling €1,147,000 were reported.

The silent participation of the Innovation Fund of the State of Berlin in the amount of €511,000 ended at June 30, 2005. A partial amount of the investment, €400,000, had been converted into an amortization loan (by October 2005).

The financing of the relatively early acquisition of nAmbition including the very costly development of its technology (ca. €1.7 million) is described above as a process of JPK’s *non-organic growth*.

As given in the “elektronischer Bundesanzeiger” (Electronic Federal Announcements) [EB] at the end of 2006 liabilities with subordination to shareholders were:

tbg Technologie-Beteiligungs-Gesellschaft mbH	€199,700
Dresden Fonds GmbH	€796,600
JPK Instruments AG	€796,600
TOTAL	€1,792,900

From 2004 till 2006 JPK increased its profit from €517,000 in 2004, a profit of €572,000 in 2005 and to a profit of €618,000 in 2006 [EB] and *JPK’s plans in 2008* were: In five years it will have quintupled its sales (cf. Table 1), built new sales channels, for instance, in Singapore and had expanded their product range to include new products for industrial customers [Afheldt 2008].

As described above in 2007 JPK significantly expanded its Berlin headquarters with regard to facilities and personnel in response to the high number of orders and to meet the demand on the basis of relatedly optimal structures.

From the beginning JPK utilized networking and cooperation with customers, particularly customization of their offerings, as the foundation for its technical development – the “customer as the innovator.”

And still currently JPK reports (Electronic Federal Announcements 2011, 2012) that [EB]

> Financing the company is ensured increasingly by continuing operations. In addition, the company has benefited *since its inception by various government-sponsored research grants and silent partnerships*. These government grants have been instrumental in securing the financing of the initial basic products.

To what extent the company will continue to be able to attract research funds depends not only on the quality of their products but also on the general spending policy of the public organizations and agencies.

For broad networking in Germany JPK was a member of competence networks [Runge:178-179, Figure I.39] covering nanobiotechnology, NanoBioNet e.V. and cc-NanoChem e.V. [7]

For illustrating networking/cooperation several examples shall be cited. In 2005 (till 2008) there was a grant for development *of a near-field microscope to investigate membrane proteins in living cells* [Kamps 2008].

There was a joint project (in German Verbundprojekt [Runge:180, Table I.92]) “NanoZell – Nanotomographie von Zelloberflächen (NanoCell – Nanotomographics of Cell Surfaces)” with project duration from Sep. 1, 2004 to Aug. 31, 2007 and support of €514,000 with the following partners [BMBF 2006]:

- Carl Zeiss, Göttingen
- JPK Instruments AG, Berlin
- ZEUTEC Opto-Elektronik GmbH, Rendsburg
- Roche Diagnostics GmbH, Mannheim
- Institute of Laser Technologies in Medicine and Metrology of the University of Ulm (ILM – which cooperated also with WITec [Runge 2014a])
- Institute of Physical Chemistry of the University of Tübingen.

The involved companies contributed aspects of products and applications. JPK involved here also its acquisition lpi GmbH.

Apart from financing aspects the German joint projects provide for startups and young technology ventures opportunities for building networks with universities and public research organizations and established companies which may lead to further common R&D activities and may express established firms as potential customers. These external partners provide an important *resource* for startups as do public money in terms of R&D grants.

“We have some customers in Berlin, including hospitals and universities. Work on projects is always a kind of cooperation. We work also with foreign universities. The spatial proximity for us is of course very interesting,” said Pelzer [Ernestine 2013]

In 2011 JPK had contacts with the Chemical Physics Group of the Chemnitz Technical University whose main research topic is the study of the structure and properties of polymeric materials on the nanometer scale – synthetic polymeric and biological materials (bone and other collagen-based materials). The Group had turned to JPK’s NanoWizard® and JPK provided a *custom-built* base-plate for its device with an extra cut-out in the center so that the Group could mount its specially constructed microtensile testing setup [JPK 2011a].

In particular, collaboration with users is more than simply customization or technical service and very important to JPK for its further development. As JPK's CTO Torsten Jähnke said, "Working closely with our users enables us to see what new developments might be incorporated in the design of future instruments. *Right from day one when we started* the company twelve years ago, we have made it the *company's policy to closely work with our users* and to *listen to their feedback* as to what they thought of both the hardware and software aspects of our instruments." (Emphases added) [JPK 2011a].

Another illustrative cooperation was JPK to address research and technique development activities of the Institute of Photonic Technology (IPHT) in Jena (led by Dr. Volker Deckert). Photonics is seen as the most important key technology of the 21st century. It will play a leading role in the fields of information and communications technology and security, material science, life science and health.

Dr. Deckert is the head of the Nanoscopy Department which utilizes instrumental methods in the development of molecular spectroscopic methods with the highest spatial resolution. Central to this program has been the use of tip-enhanced Raman scattering, TERS. JPK's NanoWizard® AFM systems and Tip-Assisted Optics module (TAO™) provided a platform for the development of these experimental methods. Commenting on his interactions (called Zusammenarbeit/cooperation in the corresponding German version of news) with JPK over the years, Dr. Deckert said "Since 2002, all our TERS experiments relied on instruments based on JPK AFMs.” [JPK 2011b]

Working with Dr Deckert has been of great help for JPK. And CTO Torsten Jähnke explained: "The development of TERS required a tip-scanning system with ready-access to the optics and the multiple electronic signal possibilities. Understanding Dr. Deckert's needs have helped us build in the required versatility and flexibility in the development of our latest systems culminating in the announcement of our new NanoWizard® 3 NanoOptics system." [JPK 2011b]

Addressing again initial financing and its early phase the first years were not easy for JPK. "We entered the market during a time, when there was practically no money for startups," Frank Pelzer recalled. "We then went immediately to Asia and have sold our first unit in Taiwan." By the end of 2003 JPK was extending its activities in the Asian market [Humboldt University 2003]. Since then, JPK has financed itself (largely) via the operational business. Only the Investment Bank Berlin (IBB) was involved with 10 percent. The company still belongs to the four founders by 88 percent [Ronzheimer 2007].

"We have no reason to change that," Pelzer said when asked about a possible IPO. After all, around €30 million were invested in recent years. They were used to expand the company headquarters and two subsidiaries in Berlin and Dresden. "They can be used there, for instance, for quality testing," explained the JPK-CEO [Ronzheimer 2007].

For financing already in 2006 JPK CEO Frank Pelzer did not rule out an IPO: "We can do that,” but so far there are no concrete plans [Ad Hoc News 2006]. However, in the next two to three years JPK wanted to bring nine more product families to the global market and also grow by acquisition. "It costs a lot of money," said CEO Pelzer and estimated the capital needs to be at least €20 to €30 million [Uptech-Network 2006].

According to CEO Frank Pelzer in 2009 JPK looked for finances of €2-€3 million either as a loan or as mezzanine capital [PwC 2009]. In 2010 JPK had an eye on becoming a publicly traded company. In Germany, the company claimed to have a market share of around 70 percent, but it delivered also to Europe, Asia and Canada. For *market development* JPK needed additional capital. “The financial means from operations do not suffice,” explained Pelzer. In particular, Pelzer viewed the US as having a great potential. But JPK was not present in the US market at that time [Frey and Kramer 2010].

Explaining that “investment companies always want to have a say,” using venture capital from investment firms was no option for Pelzer; the founders wanted to keep their independence. “We want to keep the reins in hand.” This meant that only two options were envisioned: a strategic investor or an IPO. But as an important prerequisite Pelzer knew: “The Window of Opportunity for an IPO must be open.” [Frey and Kramer 2010]

By the end of 2012 JPK with ca. 70 employees still kept its three/four co-founders as its leadership/management team with control over the firm.

- Dipl. Phys. Torsten Jähnke, responsible for Technology, Marketing, Sales
- Dipl. Kfm.(MBA) Frank Pelzer, responsible for Business Development, Finance
- Dipl. Phys. Jörn Kamps, responsible for Technology, Production
- René Grünberg, a trained business manager who joined JPK in 2000, responsible for Accounting, Controlling, Equity Investments.

The organization of the firm as a group is shown in Figure 1 (the China branch was added only in 2014).

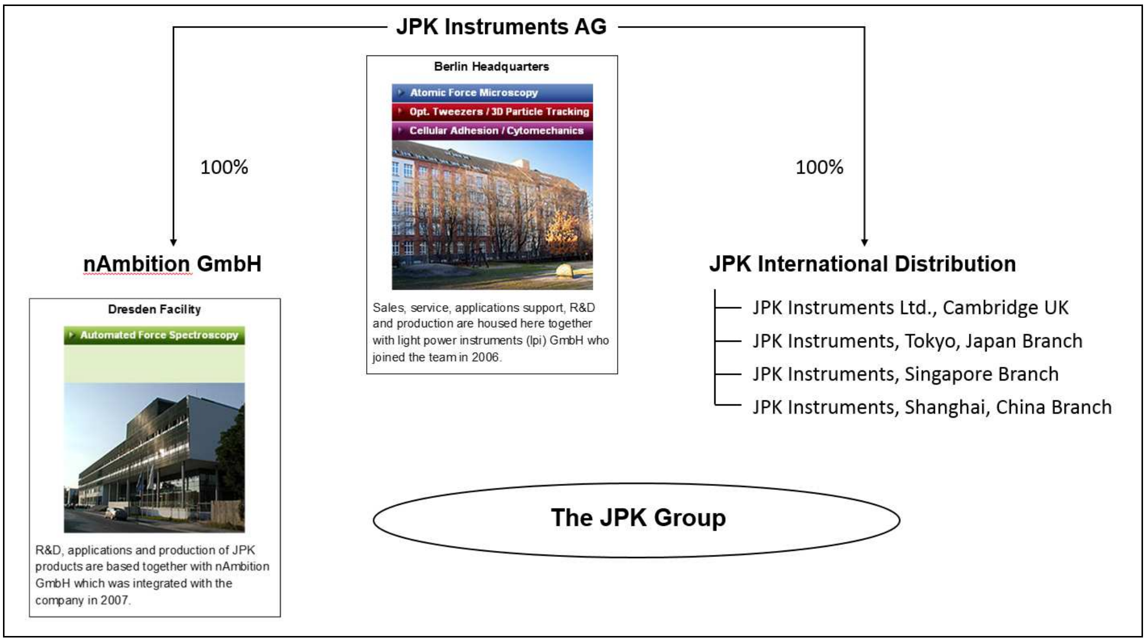


Figure 1: Organization of the JPK Group (Pictures from the JPK Web).

For the first 8-9 years JPK's orientation can be expressed by a motto found early on its Web site: "**J**ointly **P**roducing **K**nowledge" – and innovation together with external cooperation partners and customers.

In and after 2011/2012 the focus was put on JPK's technical division and further developments within the existing product portfolio – continuous improvement, extensions and incremental innovation.

Innovation Persistence, Expansion and Diversification

Modularity is one of the most important parameters when selecting instrumentation for laboratory use today. Having the ability to add new tools and techniques for relatively low capital outlay while obtaining significant technical improvements is key in the world of SPM as most systems have multiple users, each with his/her own requirements – be it in advanced research or in routine analysis.

JPK kept innovation persistence [Runge:628, Figure I.115, Figure I.127] in terms of incrementally improving their product lines, peripherals and accessories and also starting to develop new related offerings.

After successful market introduction of its first product NanoWizard® BioAFM in 2002, a path of *diversification of the product portfolio had been chosen and persecuted*. In addition to its successor NanoWizard® III BioAFM it includes among others CellHesion, TAO™ modules, BioCell™ and also various peripherals for the SPM product range.

Further results of the systematic and selective expansion of the product portfolio added the NanoTracker™ Force Sensing Optical Tweezer and ForceRobot™. With these products JPK's portfolio was significantly expanded and an additional important application/market segment was addressed – using force optical or using force spectroscopic nanoanalytical methods.

Optical Tweezers are scientific instruments that can be used to trap and manipulate single cells in a beam of light. Optical tweezers use a highly-focused laser beam to provide an attractive or repulsive force (typically of the order of piconewtons) depending on the refractive index mismatch to physically hold and move microscopic dielectric objects. They have been particularly successful in studying a variety of biological systems in recent years. [8]

Based on its international customer network and through direct contacts with relevant research institutions *JPK built a valuable "Monitoring System" for market trends* ("technology intelligence"). Correspondingly, JPK is able in the future to adapt quickly to new market conditions and respond fast and flexibly to new requirements. In this way existing products and services can be continuously improved and long term new market-oriented products can be developed and launched In the market worldwide [EB].

But it is to be remembered that so far JPK lacks, or has very little, presence in the US making its monitoring system incomplete if there are specific needs in the US.

The below list of most offerings of JPK includes its lines of further development, a short characterization (given by JPK) and sometimes even short explanations.

- NanoWizard® BioAFM, the world's first dedicated BioAFM
- NanoWizard® II
- NanoWizard 3 BioScience AFM
- NanoWizard® 3 NanoScience AFM, with maximum application versatility
- NanoWizard® 3 NanoOptics for advanced experiments combining AFM and optical spectroscopy
- NanoWizard® 3, with HyperDrive™ for SuperResolution in liquid
- NanoWizard® ULTRA Speed allows the tracking of changes in samples in real time
- LightWizard™ SNOM
  LightWizard™ SNOM expands a scanning probe microscope which, unlike the NanoWizard™ AFM, can acquire in addition to the topography also optical properties, such as fluorescence or wavelength-dependent absorption of the living specimen or individual molecules
- TAO™ (Tip-Assisted Optics module) for use in optical spectroscopy
- BioMAT™ Workstation
  BioMAT™ Workstation is used for combining capabilities of both AFM and advanced optical imaging that can be realized even on opaque samples. The key element of the BioMAT™ Workstation is the NanoWizard®II AFM system, paired with an upright optical microscope. An extensive choice of optical microscope setups means that a wide range of optical contrast methods, fluorescence techniques and even confocal laser scanning or Raman mapping is possible.
  Allowing combination with conventional optical microscopes NanoWizard is an open platform for all four major players in optical microscopes (Olympus, Leica, Nikon, Zeiss) [Pelzer 2012].
- CellHesion® Module
- CellHesion® 200
- NanoTracker™
- NanoTracker™ 2 force-sensing optical tweezers and optical trapping platform

- ForceRobot®
- ForceRobot®300, the new standard in single molecule force spectroscopy.

Figure 2 shows some representative JPK products, applications and prices. The examples provide also how different JPK technologies are combined to provide specific solutions for applications.

Figure 2: Characterizations of selected JPK products in terms of applications and prices (source: [Pelzer 2012:6].

JPK has exclusive access to the key technology of Photonic Force Microscopes (PFMs) [Pelzer 2012].

Force spectroscopy is a single molecule technique that allows the real-time study of molecular interactions on the nanoscale. Originating from the broad field of Atomic Force Microscopy force spectroscopy directly addresses the measurement of forces between and within molecules. The key to obtain meaningful results from single molecule techniques, such as force spectroscopy, is the statistical management of the results. This is where the ForceRobot®300 technology will deliver the solution.

Until recently, single molecule force spectroscopy was *a complicated procedure*. The requirement of frequent manual calibrations and alignments as well as the need for constant operator presence with the instrument made it *a long-winded task*. Useful data output was both low and slow with only a few suitable curves obtained over many hours. The *ForceRobot®300 addresses these issues* as a dedicated tool for the force spectroscopist.

The automated setup and continuous adjustments provide improvements in the efficiency of data collection while the integration of optical techniques allows targeted measurements where the molecules of interest are located. These factors, combined with the highest data quality and stability, are claimed to open the field of single molecule force spectroscopy to a new level of results.

The key to the system is the incorporation of intelligent software for experimental design, data acquisition and evaluation. Tens of thousands of force curves may be generated and evaluated in a matter of hours.

Development of molecular spectroscopic methods with the highest spatial resolution use tip-enhanced Raman scattering (TERS). Here JPK's NanoWizard® AFM systems and Tip-Assisted Optics module (TAO™) have provided a platform for the development of these experimental methods.

In addition to actual products there are CellHesion, TAO™Module, BioCell™ and ECCell™ as well as various peripherals for the SPM product range.

The Biocell™ is designed to enable optimal imaging conditions for both AFM and optical methods while allowing rapid and precise temperature control from 20-60°C.

The new JPK ECCell™ enables simultaneous AFM and electrochemistry with full environmental control. Uniquely, the cell enables simultaneous fluorescence experiments to be carried out when the JPK NanoWizard® AFM is operated on inverted optical microscopes.

The key challenge for the electrochemical cell design is to integrate the many components and control elements within a small volume around the AFM tip. This has been achieved with the JPK ECCell™, which offers the complete electrode set of working electrode, counter electrode and commercial reference electrode, together with an optional tip bias connection, for instance, for scanning electrochemical microscopy (SECM).

Electrochemical experiments usually study redox reactions of substances at a solid-liquid interface. With atomic force microscopy, high-resolution images can be obtained in liquid as the electrochemical reaction progresses.

The QI™ Advanced software module for NanoWizard® systems announced in 2012 shall deliver quantitative mechanical properties from the most difficult-to-image samples. These include the soft, sticky and brittle samples found in applications of biological and polymeric materials.

Further developments did not only refer to the instruments and combinations of their functions and mediation via appropriate software, but also the development of an efficient device for microscope control.

In 2010 JPK announced Vortis™Advanced, claimed to be the new standard in SPM Control systems with the lowest noise and highest signal speeds seen so far. Vortis Advanced is available with all of JPK's SPM systems. It claims to provide the highest performance of electronics controller for SPMs and was one of the driving forces behind JPK's development programs [JPK 2010].

Hence, completing the spectrum of offerings' types one has, for instance,

- Vortis™ Advanced fully digital SPM Control Station
- QI™ (Quantitative Imaging) mode for imaging challenging samples
- JPK even released a Petri dish heater for live cell imaging experiments.

The spectrum of usage of JPK's offerings is given by Pelzer [2012:8]. With polymers it addresses also "hard matter" surfaces.

- Life sciences,
  for instance, cell biology, biochemistry, biomedicine, molecular biology, pharmaceutical industry, cancer research, virology, microbiology, etc.
- Food production
- Cosmetics
- Characterization of
  soft materials, nanoparticles, colloids and polymers (coatings, nanostructured surfaces, etc.).

In Figure 3 with regard to its status JPK's developments, expansion and diversification are summarized addressing

- Non-organic growth
- The role of networking and cooperation for product development (particularly with researchers in public research organizations) and publicly supported grants and projects as resources
- Development trends of products, peripherals and accessories
- Customer segments and directions of further customer development (towards industrial customers)
- Sales and distribution organization and direction.

Growth will be based on ongoing product development for the *high-price, high-margin premium segments*. The *expansion of the distribution activities* is a key element of the growth strategy [Pelzer 2012].

Expansion related to sales and distribution seems to exhibit path-dependency: JPK sold its first product in Taiwan and has a strong concentration on academic customers in the Berlin-Potsdam region. Hence, its emphasis was to focus for sales on Germany/Europe and Asia, but entered the US only recently (cf. the WITec case; it sold its first product in the US and the US has become very early one of its largest single market).

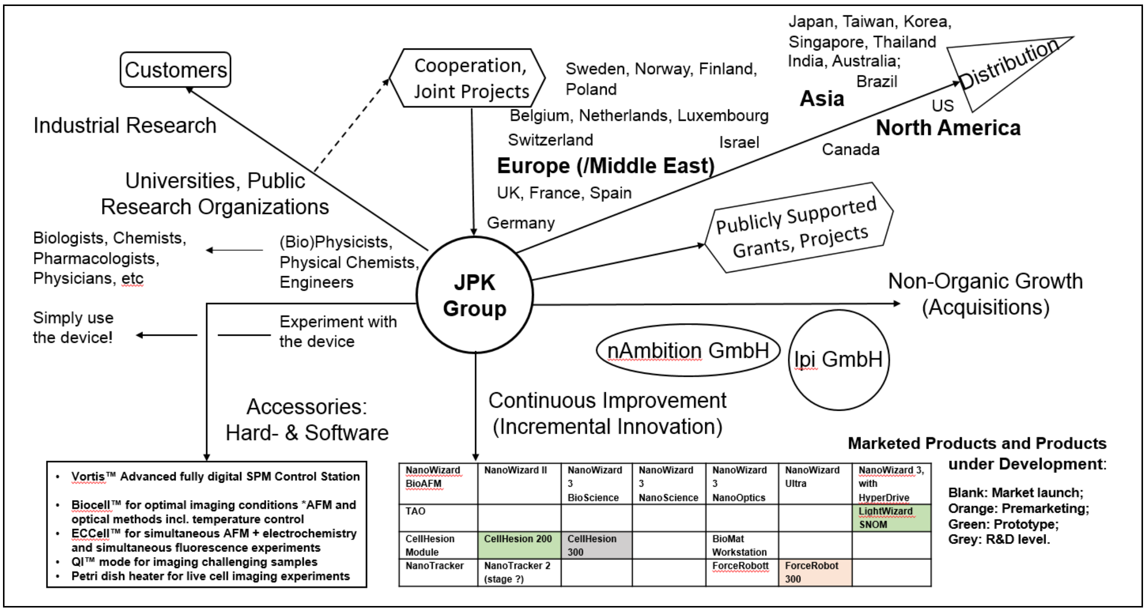


Figure 3: Overview of JPK's past and current growth activities and some key resources (Marketed Products and Products under Development from [Pelzer 2012]).

JPK Group has distributed its platform technologies across its three members as follows [Pelzer 2012:30]:

JPK Instruments AG	Ipi GmbH (merged to JPK)	nAmbition GmbH
BioSPM, Cellmechanics	PFM, Tweezers	ForceRobot, Senser

Key Metrics

The firm's finances are ensured increasingly from continuing operations. But, in addition, the company has benefited since its inception from various governmental research grants, from funding programs and requested silent participations by state-controlled investment organizations [EB].

However, it is not clear whether public financial support for R&D projects are included by JPK in the data for revenue. The government grants have been instrumental in securing the financing of the first products of a related series of "upgrades." [EB]

The most recent financing structure of JPK is 55 percent bank loans and 45 percent mezzanine capital [Pelzer 2012]. In addition to cash the company has free working capital credit lines (overdraft) of €300,000 - €400.000 [EB].

The pushed growth, however, leads to high backlog with increased inventories and accounts receivable [Pelzer 2012].

JPK's employees are highly educated, 80 percent with a graduate degree, 40 percent with a PhD [Pelzer 2012:25]. The Company's *success* will depend largely on the management and on a stable second level of employees and team competencies in all areas of the company [EB].

Concerning product sales, for instance, in addition to the NanoWizard® III BioAFM specifically the NanoTracker™ and CellHesion® contributed in 2011 to revenue growth of 15.0 percent. The company earns a significant portion of its revenues in Europe, but in Asia orders and sales increased significantly [EB].

In 2007 JPK's export range was 60 percent [Ronzheimer 2007]. Therefore, one can assume that it is currently about 70 percent.

JPK's customers are mainly from universities and public research organizations. Considering the masses of reports by JPK News or UserStories, which are almost entirely from universities or research organizations, and the presentation of reference customers [Pelzer 2012] one is led to assume that the proportion of industrial customers so far does not exceed 10 percent [EB].

In Profit & Loss statements JPK reports in Germany a specially defined "Rohergebnis" which allows in principle to derive revenue [EB]. Considering the results one finds "Rohergebnisse" of €7.561 million (2011) and €7.391 million (2012) which, based on given data, lead to revenues of €10.41 million (2011) and €10.24 million (2012).

JPK's profit showed considerable variations of over the last years and was: €164,069 (2010), €408,559 (2011), €278,326 (2012) [EB]. But, the company made a profit of € 618,000 in 2004, a profit of €517,000 in 2005 and a profit of €572,000 in 2006 [EB].

The timelines of JPK's revenues and numbers of employees are given in Table 1. They reflect JPK's continuous growth addressing essentially the life sciences markets.

Table 1: Revenues [Pelzer 2012] and number of employees of JPK.

Year	Revenue (€, mio.)	No. of Employees	References, Remarks
1999		3	
2000		4	
2001			

Table 1, continued.

2002	0.475	20	[JPK 2002]
2003	0.663	24	[Humboldt University 2003]
2004	3.050	27	[GSG Hofkurier 2004]
2005	3.864		
2006	5.084		
2007	6.643	56, 75 a)	[EKF 2008], [Ronzheimer 2007] c)
2008	6.725	50	[VÖB 2009]
2009	8.506	65	[Frey and Kramer 2010]
2010	9.510	70	[Gründen in Berlin 2011], [EKZ 2010], [Hansen 2010]
2011	10.964 (10.41 d))	70 (= 64 + 6) b)	[Pelzer 2012]
2012	10.24 d)	75	[Ernestine 2013]

a) JPK plus lpi plus nAmbition? b) Pelzer [2012] reports 64 employees for the Berlin site and 6 for the Dresden site (nAmbition); c) Ronzheimer [2007] reported on the two subsidiaries in Berlin and Dresden having 20 employees; d) derived from the “Rohergebnis” [EB].

Intellectual Properties

Most of JPK’s products, complements and accessories got protected names, trademarks or registered trademarks; for instance, NanoWizard, LightWizard, ForceRobot and CellHesion are registered trademarks of JPK.

Early on many of JPK’s technology developments and products used patents as intellectual properties for protection. The early intense claim staking by a large multitude of patents or licensing-in with exclusivity of rights ensured sustained competitive advantages and significant growth opportunities for JPK [EL].

For a sufficient overview using only the database of the European Patent Office (EPO) JPK has 117 patents or patent applications, respectively, in 44 patent families (Table 2). Pelzer [2012] reports “60 patents, licenses and applications” for May 2012. JPK has notably more patents and patent applications, respectively, than WITec [Runge 2014a].

The by far most prolific researcher of JPK cited as one of the inventors is co-founder and CTO Torsten Jähnke.

The gross patent situation by August 2014 of JPK’s patents or patent applications, respectively, is characterized as given in Table 2. Here patents/applications as well as the number of patent families (the same inventions patented in several countries) are given differentiated by the members of the JPK Group as the patent assignees (PAs).

Table 2: Numbers of patents or patent applications of the JPK Group and patent families.

Group Member	Basic and Patent Family Members	Without Patent Family Members
JPK Instruments	81	31
lpi GmbH a)	7	3
nAmbition GmbH	30	10

a) One entry has both lpi and JPK as patent assignee.

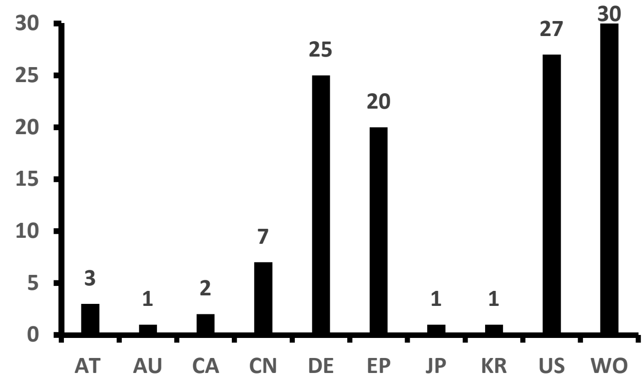
Patent applications started around 2002 (WO-DE) (Table 3) and became more pronounced in 2004 with applications at the European Patent Office (EP-patents). EP-patents are often related to WO-patents/applications of the World Intellectual Property Organization (WIPO) on the basis of EuroPCT applications (PCT: Patent Convention Treaty concerning patent (invention) equivalents in various countries ("designated states"), which build "patent (convention) families"). JPK's patenting strategy concerning key countries is displayed in Table 3.

As described above JPK focused initially on markets in Germany, Europe and Asia (Figure 3) and correspondingly it protected its technologies there.

Typical designated states of EP patents as given in EP 1523652 B1 by their country codes are AT, BE, BG, CH, CY, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SK, TR. They cover almost all the countries of the EU plus Switzerland (CH) and Turkey (TR): Apart from countries listed in Table 3 in EP-patents there appear often Great Britain (GB), France (FR), Italy (IT) and the Netherlands (NL) as designated states.

The striking observation concerning JPK's patenting strategy is that obviously it entered the US, the largest single market for SPMs, in terms of PCT-convention family applications or direct application at the US Patent and Trademark Office (US PTO) – obviously already around 2006. But organizing distribution of JPK's products across the US occurred only in 2014.

Table 3: JPK patent distribution in various countries. *)

<table>
<tr><th>Country</th><th>Priority Period</th><th>Patenting of JPK Patents in Various Countries</th></tr>
<tr><td>AT - Austria</td><td>Nov. 2007 - Apr. 2009</td><td rowspan="10">
</td></tr>
<tr><td>AU - Australia</td><td>Mar. 2004</td></tr>
<tr><td>CA - Canada</td><td>Nov. 2002 - Feb. 2004</td></tr>
<tr><td>CN - China</td><td>Oct. 2005 - Nov. 2012</td></tr>
<tr><td>DE - Germany</td><td>May.2006 – Jan. 2014</td></tr>
<tr><td>EP - Europe</td><td>Mar. 2004 - Jun. 2014</td></tr>
<tr><td>JP - Japan</td><td>Dec. 2007</td></tr>
<tr><td>KR - Korea</td><td>Oct. 2008</td></tr>
<tr><td>US - USA</td><td>Apr. 2006 - Jul. 2014</td></tr>
<tr><td>WO - World</td><td>Nov. 2002 - May 2009</td></tr>
<tr><td colspan="3">Designated states WO002003028038A2: AE, AH. AL, AM, AT, AU, AZ, BA, BE (Belgium), BB, BG, BR (Brazil), BY, BZ, CA, CH Switzerland), CN, CO, CR, CU, CZ (Czech Republic), DE, DK (Denmark), DM, DZ, BC, EE, ES (Spain), FI (Finland), GB (Great Britain), GD, GE, SE (Sweden) , SK (Slovakia), TR (Turkey)</td></tr>
</table>

*) Search in the databases of the German Patent and Trademark Office (DPMA, DEPATISnet) and the European Patent Office (EPO); considering patent assignee entries "JPK Instruments" OR "JPK Instr", lpi and nAmbtion and specifically the co-founder with his last name spelled Jähnke OR Jaehnke OR Jahnke.

It seems that JPK followed a common basic strategy for entry or conquering a foreign market: Pelzer said JPK will enter the North American market after establishing a solid base in Europe and Asia [Forbes/Wolfe 2003]. Building sufficient strength vis-à-vis a number of well-established competitors active in the US seemed to take very long.

Vision/Mission, Business Model and Risks

The metamorphosis of the vision of JPK exhibits the following steps (extracted from its Web site at various times):

- Jointly Producing Knowledge
- Paving New Ways in NanoBiotechnology
- New Web: Where Visions come to Life.

A related current *value proposition* for JPK would be, for instance,

> Based on atomic force microscope (AFM) technology JPK as a manufacturer is uniting the worlds of nanotools and life sciences and biomedical applications in academic and industrial research by offering globally leading technology and related products with accessories, if needed customized or developed by cooperation, and unique applications' expertise as well as user support at competitive prices.

According to the notion "global" Pelzer [2012:7] introduced a constraint: "JPK Instruments is the *global technology leader* and a leading *manufacturer* of life sciences atomic force microscopes *in Europe*!" (Emphases added)

From its earliest days of applying atomic force microscope (AFM) technology JPK had recognized the opportunities provided by nanotechnology for transforming life sciences and soft matter research. The JPK Group developed globally base technology, such as measuring and analytical instruments, which is claimed to enable unparalleled access at the nanotechnology level [Pelzer 2012:4] – nanotools.

Specifically, JPK Instruments AG is a manufacturer of nanoanalytic instruments – particularly atomic force microscope (AFM) systems and optical tweezers – for a broad range of research and industrial applications reaching from soft matter physics to nano-optics, from surface chemistry to cell and molecular biology.

The value proposition for firm's foundation was restricted by a certain implicit "*technology push*" orientation ("Paving New Ways in NanoBioTechnology") which requires mostly considerable user education and training.

In 2002, after the first sales of its instruments, there was the first JPK Workshop "Scanning Probe Microscopy in Life Sciences" as an important AFM event in the international life sciences field. The second one in 2003 was organized together with the University Clinic Charité in Berlin and sent together with the renowned Charité the corresponding "bio-orientation" signals of JPK into this world [JPK 2003].

Concerning user education and training in February 2006 JPK held the first JPK Instruments School for atomic force microscopy (AFM) under the banner "AFM user training for biological applications." Its emphasis was on the broad spectrum of uses, application and operation, including the preparation of biological specimens, such as DNA and lipids.

The JPK School meant that the manufacturer of BioAFM is reasserting its expertise in nano life sciences while providing clients with a special service. "There are many potential applications in the life sciences that have not yet been discovered. We want to boost our clients' knowledge by letting them share our application and technical know-how." [JPK 2006b]

As scientific instruments require input of (micro)electronic and mechanical elements relationships to related *suppliers* of relevant components are important. From its beginning the company maintained cooperative collaboration with its *key suppliers* by which requirements of its own products are transmitted to the suppliers and uninterrupted supply of JPK's production is ensured [EB].

For instance, at the end of 2005 JPK and Physik Instrumente (PI) GmbH & Co. KG could look back at five years of successful collaboration. PI, a global market leader in the field of micro- and nano-positioning technology, has been developing and manufacturing standard, custom and OEM products with piezoelectric and motor drives for over 35 years [Runge 2014b].

Through customer-specific developments, according to JPK's guidelines, PI ensured the high performance of future generations of instruments. JPK Instruments and Physik Instrumente continued working on faster, ultra-precise, high-resolution positioning systems with maximum sensor performance [JPK 2005b].

JPK Instruments decided in the early development phase of the company to bet on the technology of the market leader PI. From the very first, JPK's NanoWizard® atomic force microscopes were exclusively equipped with PI's piezo nanopositioning systems. Only the OEM modules developed especially for JPK reached the critical performance necessary for JPK products. And CTO Jähnke said, "Over the years PI has become an important part of our story of success." [JPK 2005b].

Concerning *customer segmentation* 90 percent or more are from academic or public research organizations. A further development of industrial customers is still be needed. Furthermore, it seems that additionally "simplifying" the products for routine operations by non-specialists or "non-experimentators" could enlarge the market (Figure 3).

As observed for WITec's *customer relationships* the "academic customer as an innovator" is important for JPK which includes to gain visibility, get relevant contacts and establish networking. JPK followed essentially approaches similar to those used also by WITec [Runge 2014a]:

Gaining visibility:

- The Web (home page, YouTube),
- Fairs, exhibitions, international scientific subject-related conferences or conferences or conferences of scientific societies, such as the German or American Physical Society,
- Congresses, meetings, events,
- Advertisement.

User Education and Training:

- Workshops,
- JPK School (WITec Academy),
- Instrument demonstrations,
- App/TechNotes (WITec: InFocus biannually newsletter, technical notes),
- Applications, new products & announcements,
- UserStories (WITec PaperAward:"Contribute your scientific results"),
- Tutorials on its Web: A general introduction to the different techniques.

Customer Contacts:

- Pre- and after-sales-service,
  Sales and after-sales services by highly qualified scientific personnel.
- Customer visits,
- User Meetings,

- Test measurements,
- Customization of products,
- Common projects.

Typical tasks of a marketing and sales manager for an internationally operating scientific instruments producer mean building and managing a network of direct sales and local distributors.

- Coordination of sales and marketing activities
- Development of a continuous sales pipeline
- Organic growth by regional and product diversification
- Prospecting new application fields
- Key customer support and R&D interface.

AFMs and SNOMs are complex scientific instruments and sales have to be very customer-oriented. They do not come in a one-size-fits-all model. And as a general issue of marketing when you ask potential customers, one observes: [Heyman 2005].

> "Even the people whose business is AFM sales say that it's impossible to determine whether you need an AFM or what kind you'll need, without knowing exactly which questions you want answered."

Customer-researchers may start with a basic system, say an atomic force microscope. Perhaps they would then add from a menu of operational modes to enable the study of specific sample properties. Hence, typical tasks of an application scientist of a player in this field include:

- Demonstrate the scientific instruments (customer attitude: first try, then buy)
- Test hardware- and software components
- Provide application seminars and presentations at congresses and conferences
- Cooperate closely with the sales and development staff
- Act as an interface between international customers and the development team
- Support the international applications team with installations, user training, service and technical support.

Channels for international sales include

- Localization of customer support by worldwide subsidiaries and offices and distributors (Figure 3)
- Pre-and after-sales services
- Product demos.

Customer orientation of JPK is reflected by the openness of products as one can read: "For our protein folding research, we modified our JPK system to …" Making the choice to buy from JPK was quite simple. "One of the important things about JPK instrument is its ability to provide access to the optical tip-sample junction. This helped us in modifying it for our need to attach fluorescence correlation spectroscopy to it." [JPK 2013]

Currently the JPK Group characterizes itself by the following aspects [Pelzer 2012:30]:

Various *platform technologies*:

- BioSPM, CellMechanics – JPK Instruments AG
- PFM, Tweezers – lpi GmbH
- ForceRobot, Senser – nAmbition GmbH.

An innovative *product pipeline suitable for long-term planning*:

- 15 product developments, of which nine are already in the national and international market launch phase.
- Unique Selling Proposition (USP): Imaging and nanoanalytical method for the characterization of biomolecules and single cell-biological processes.

A *scalable business model* (optimally designed to provide increased profitability without a linear relationship between cost and revenue). This means a business owner does not have to spend much more money in order to bring in a lot more revenue.

Positioned in growing, high-margin markets characterized by high prices and high quality.

A perceived *first mover* advantage.

High market entry barriers for new competitors due to high technological standards and necessary high technological expertise (and a *multitude of patents or licensing-in with exclusivity of rights* which ensures sustained competitive advantages and protection of technology).

For instance, with the recent signing of a license agreement with JPK the Autonomous University of Madrid [UAM 2014] sold the DAM (drive amplitude modulation) technology as the first patent to be sold internationally. DAM is a novel method of control. It produces images of atomic force microscopy in a variety of conditions, ranging from high vacuum to liquid, including environmental conditions.

The contact to UAM in Spain shows also that JPK is fully aware of its potential competitor Nanotec Electronica, which originated in UAM.

Looking at JPK in the context of the two other German SPM startups, WITec and Attocube Systems, apart from its position in the bio-niche, the striking differences are that JPK had a totally different *financing structure*, growth mode and exhibits very *low presence in the US market* and additionally *lacks transatlantic networking* with the related scientific community in the US – which may be partly due to the different configurations during firms' foundations.

But considering that JPK operates in the markets of Japan, other Asian countries and Europe which account for ca. 70 percent of the global market as described in the entry chapter the low presence in the US [9] can be seen as an opportunity for further growth rather than a serious risk. This is corroborated by the below list of proportional shares of key competitors in the AFM/SPM markets.

Risks for JPK will be associated with depending on public R&D funds. Generally, there also seems to be a necessity to enlarge the proportion of industrial customers across all its markets.

Competition

The gross competitive situation for AFM, SPM and SNOM is outlined in the WITec GmbH case [Runge 2014a] in terms of a 3-tiers classification.

The WITec case cites a study "Future Markets Inc., World market of Atomic Force Microscopes" from 2010 which reports proportional shares of key competitors in the AFM/SPM markets in 2009 as follows:

Company	**Share (%)**
Veeco Instruments Inc.	39
NT MDT Co.	14
JPK Instruments AG	14

Agilent Technologies	8
Park Systems Corp.	7
WITec GmbH	4
Asylum Research	3
Bruker Nano	3
Nanonics Imaging Ltd.	2
Nanosurf AG	1
Nanotec Electrónica S.L.	1

This list does not include the recent acquisitions of the relevant AFM/SPM segments of Veeco by the German firm Bruker Nano and of Asylum Research Corp. by Oxford Instruments in 2012 [Runge 2014a].

All the Tier 3 startup competitors were founded between 1997 and 1999.

1997 Nanonics Imaging, Ltd. (Israel)
1997 Nanosurf AG (Switzerland)
1997 WITec GmbH
1998 Triple-O Microscopy GmbH
1998 Nanotec Electrónica S.L. (Spain)
1999 JPK Instruments AG
1999 Asylum Research Corp. (US), an employee-owned company.

As described above Asylum Research Corp. was viewed as a competitor by JPK already on its foundation as it expressed explicitly its orientation towards biosciences. But it is not yet clear whether the acquisition of Asylum by the large British company Oxford Instruments will increase Asylum's competitive strength. For the 2011 calendar year 2011 Asylum generated revenue of $19.6 million (ca. €15 million) [Anonymus 2012].

According to Asylum's current Web site for academic and industrial customers "our instruments are used for a variety of nanoscience applications in material science, physics, data storage and semiconductors, polymers, chemistry, *biomaterials*, and *bioscience*, including *single molecule mechanical experiments* on *DNA, protein* unfolding and polymer elasticity, as well as *force measurements for biomaterials*, chemical sensing, polymers, colloidal forces, *adhesion*, and more." (Emphasis added) Asylum Research has a worldwide presence with subsidiaries in Germany, UK, and Taiwan.

One may speculate that JPK did not want to clash with Asylum in the highly attractive US market and therefore only entered the US market in 2012 with a perceived solid base for technology protection by patents or patent applications, respectively. Moreover, it would "meet" WITec GmbH there, which is well established in the US in academic and industrial research since 2002. The US is one of WITec's largest single market.

Furthermore, since 2004 also Nanotec Electronica has a subsidiary Nanotec Electronica USA, LLC in the US (Lafayette, IN) [Manta].

Nanotec Electronica [Nanotec Electronica] was founded as a privately held company by Professor Arturo Baro and three co-founders (Jaime Colchero, Julio Gomez and Jose Maria Gomez) at UAM in Madrid who started working on the development of the Scanning Tunneling Microscope (STM). Prof. Baro spent a sabbatical at IBM Zurich, where in 1981 the later Nobel

Prize winners (in 1986) Heinrich Rohrer and Gerd Karl Binnig invented the first STM and where he learned firsthand about the construction and operation of STMs. As a result of this collaboration, in 1984 C. Gerber and H. Rohrer drove the first STM to Spain, the third ever built STM.

From the beginning the startup focused on manufacturing competitive AFMs and electronics for STM control. Currently, Nanotec Electronica develops, manufactures and sells SPMs and controls worldwide. Its R&D was (and is) enhanced by numerous cooperation projects on the EU-level [Nanotec Projects].

Its key products include *Dulcinea*, a flexible control electronics claimed to be capable of operating any SPM. Dulcinea incorporates all the expected features of an SPM control system and includes as well new techniques to enable novel SPM experiments. The result of this evolution in control electronics has led to modularity and flexibility in the SPM head itself. It claims the Dulcinea Control Systems, with an open and modular design, to facilitate interfacing with any other standard AFM/SNOM/STM system available in the market. The *Cervantes AFM* is claimed to allow almost any possible measurement that an SPM can offer and successfully addresses the requirements of surface science, biology, semiconductors, magnetism, and nanoscale conductivity [Nanotec Electronica].

Moreover, it offers its WSxM software free for charge for data visualization and processing of SPM images and the SIESTA DFT software for first principle calculations.

It is reported [Spanish Nanotech Firms] that Nanotec Electronica currently has 45 employees (18 percent in R&D).

In a broad sense WITec and also Nanotec address the realms of biosciences and medicine and both have a long time presence (and prominence) in the US.

On the other hand, JPK may compete to a certain degree with Nanonics Imaging from Israel in Canada (JPK has a distributor in Canada since 2006) and less with the Swiss Nanosurf AG, a firm with 35 employees (in 2012) in Switzerland and some additional ones abroad, mainly in Germany (Nanosurf GmbH), US (Nanosurf, Inc.) and in China, which both seem to address the BioSPM field to only a minor degree.

Nanosurf, in particular, recently introduced products or developments, respectively, which address life sciences [Portalupi 2012], for instance,

- FluidFM is an AFM based solution that allows single cell experiments at high throughput and is expected to play a significant role in areas like proteomics, metabolomics, drug discovery, cell mechanics and stem cell research. FluidFM works with a hollow cantilever to locally manipulate samples.
- The ARTIDIS project (Nanosurf cooperation with the Biocentre of Basel) relies on the very high nanomechanical sensitivity of AFM to detect and differentiate between the various stages of disease in soft human tissues (e.g. breast, cartilage, skin, retina, blood vessels, bladder etc.). It is a tissues diagnostic tool.

The EC-AFM from Nanosurf allows *in-situ* monitoring of morphological changes during electrodeposition of material on an electrode surface, and studies of charged solid-liquid interfaces (cf. JPK's ECCell).

With regard to JPK's emphasis on optical tweezers it is notable that in the US according to its Web site Mad City Labs Inc. discussed in the Attocube case [Runge 2014b] also addresses optical and magnetic tweezers. It offers nanopositioning systems that enable the particle to remain centered and also beam steering nanopositioning systems which can control the laser beam path and hence the location of the optical trap.

Finally, NT-MDT Co. from Russia and Park Systems Corp. (Korea/US) from Tier 2 do not seem to play a strong role in the dedicated BioSPM arena.

However, apart from material science, data storage and semiconductors Park Systems focuses explicitly on biological science. For instance, using an unusual technique, scanning ion conductance microscopy (SICM), it obtained non-invasive images of cell surface topography and recently SICM has also been used for imaging live cells in culture medium [Runge 2014a].

The Rise and Disappearance of Triple-O Microscopy GmbH

Until 2009/2010 market research reports concerning the AFM and SPM fields, when listing firms active in the field, always cited the German startup Triple-O Microscopy GmbH founded in 1998 in Potsdam close to Berlin where JPK was founded.

One may speculate that the JPK founders were not only aware of Asylum Research and WITec, but also of Triple-O and, therefore, which niche in the SPM business they could take advantage from (BioSPM) or had to avoid. Additionally they probably could track how the Triple-O startup was financed.

The Entrepreneur and Foundation

As described by a group of researchers from TopoMetrix GmbH [Müller-Zülow et al. 1998] by 1995/1996 Scanning Near-Field Optical Microscopy (SNOM) was presented as a nanotool and a new and promising technique for testing of electronic devices (Frank Reineke being one of the authors). The non-destructive working principle of the instrument and contactless testing capability are inherent advantages of this experimental set-up. Sub-wavelength resolution could be achieved routinely under various conditions on test samples and relevant systems of interest. Contrast mechanisms like fluorescence and luminescence were well known and could be applied to the electron and optical beam testing of electronic devices.

Triple-O Microscopy was founded by Dr. Frank Reineke born in Berlin. He carried out his undergraduate and PhD studies in analytical chemistry at the Technical University of Darmstadt and stepped up to the post of worldwide sales manager and Vice President of European operations of TopoMetrix GmbH (Darmstadt. Germany), the German subsidiary of TopoMetrix Corporation [Triple-O Microscopy; Triple-O Microscopy 1999; Bloomberg Businessweek]. TopoMetrix was a very early distributor of WITec's first product [Runge 2014a].

Reineke's business idea was based on the growing need for one critically focused company to offer a full range of instruments to Scanning Probe Microscope users of all disciplines. Particularly, it was envisioned Triple-O Microscopy to introduce the "World's Only Triple Function Microscope," addressing the market by its "revolutionary new BioLyser SNOM." This innovative three-in-one modular microscope would combine all the features of a Scanning Near-Field Optical Microscope (SNOM), with an Atomic Force Microscope (AFM), and a conventional inverted optical microscope [Triple-O Microscopy 1999].

Furthermore, Triple-O's SPMs should be complementary to all existing microscopy techniques [Nanoxchange].

Triple-O established offices in Germany and the United States [Triple-O Microscopy].

Product Development and Financing

By 1999 Triple-O's product spectrum comprised [Triple-O Microscopy 1999; Nanoxchange]:

- NanoLyser 300 AFM
- BerMad 2000 Scanning Probe Microscope
- BioLyser SNOM.

The BioLyser three-in-one modular microscope was promoted to have also the *convenience* of a conventional inverted optical microscope. BerMad 2000 SPM Scanning Probe Microscope was announced as a versatile, *affordable*, high performance instrument and the NanoLyser 300 AFM Atomic Force Microscope was specifically developed for *300 mm wafer inspection*.

Triple-O focused on developments via *networking in the related scientific community*. “Other extraordinary instruments are now under development in Triple-O's university-based research centers throughout Europe.” [Nanoxchange] “All of our precision instruments have been designed by leading scientists.” [Triple-O Microscopy 1999]

That Triple-O also envisioned a “*bio-orientation*” can be inferred from a description of the “disciplines they serve” (“semiconductors, … ordered molecules, and biological and biomaterial” [Nanoxchange]) and, as cited below, from a LinkedIn profile of a person who was “Manager Life Science bei {at} Triple-O Microscopy GmbH.”

Participation in publicly financed projects, for instance, by the European Union (EU) or the German Federal Ministry of Education and Research (BMBF) contributed also to finance R&D activities of Triple-O.

For instance, during the period 2004 – 2007 Triple-O received €29,136 from the BMBF [ConsulTech 2005] and Triple-O participated in the 2020 Horizon program MAGNETUDE of the EU [2020 Horizon].

The aim of the MAGNETUDE project [2020 Horizon].was the improvement of magnetic materials for state-of-the-art read heads for magnetic data storage technology and the attendant necessity for the development of magnetic imaging techniques. This should lead to a further development of magnetic storage technology. To reach this goal, test samples had to be produced and used to optimize magneto-optic near field scanning microscopy, magnetic force microscopy and spin-polarized scanning tunneling microscopy in order to reach magnetic image resolutions in the 10 nm regime.

The project (from 2000-01-01 to 2002-12-31) had project cost of €1,325,000 and project funding of €1,100,000. Notable project participants, apart from Triple-O, included Seagate Technology (Ireland) and Trinity College Dublin (Ireland) (total number of project participants was five).

With regard to financing the start of Triple-O with an LLC legal status the author could not find an indication whether and how much the founder Frank Reineke contributed his own resources.

However, the investor Peppermint Financial Partners [Peppermint 2001] played a key role. Peppermint provided around €175,000 introduced to the startup in the form of a shareholder loan. Berlin Seed Capital was also on board; it invested more than €1 million in the initial financing round. In September 2000, Peppermint participated in the second round of financing gaining 12 percent of Triple-O [Linneweber 2002; Peppermint 2001].

The further the progress of developing an innovation is, the more expensive it will become. Financial breath of a company can disappear. And that would have happened almost to Triple-O Microscopy GmbH at that time.

By 2002 Triple-O claimed to be the first company in the world to have developed a Quantitative Magnetic Force Microscope (QMFM) – probably in the context of the MAGNETUDE project. According to Dr. Jens Ulbrich, Senior Manager of Customer Support of Triple-O, ”This device makes it possible to measure the strength of magnetic fields directly.” [Linneweber 2002].

Dr. Ulbrich joined Triple-O in 1999 [VDI 1999].

Magnetic force microscopy (MFM) provides the highest spatial resolution available for magnetic analysis and, hence, is an indispensable tool in nanoscience involving magnetic structures and appeared as a further *opportunity for Triple-O*.

This new technique can be applied, for instance, for quality control of magnetic storage media, such as hard disks. "The smaller the storage device, the greater the need for instruments that can visualize the very finest surface," said Ulbrich [Linneweber 2002].

For instance, the gross magnetic properties of dot-arrays can be characterized by the magneto-optical Kerr effect. But the micromagnetic properties of, for instance, a single Co/Pt dot will be measured by quantitative magnetic force microscopy (QMFM).

The new technology was so popular that Triple-O was able to *sell the prototype* before completion to the Californian hard drive manufacturer Seagate, its partner in the MAGNETUDE project. This situation of selling an instrument in an early development stage was the start of WITec and Attocube and their successful growth [Runge 2014a, 2014b].

But the development of the prototype cost the company more money than expected. At the end of 2001 its project budget was nearly exhausted. Only a cash infusion by Peppermint Financial Partners – the LLC partner of Triple-O – brought the project back on its feet [Linneweber 2002].

In 2001 the 13-member Triple-O team had sales of around €1 million and there was much optimism with regard to Triple-O’s future [Linneweber 2002].

"The technology is very promising," said Dr. Joachim Rautter of Peppermint at the end of 2001. QMFM was assumed to have good market prospects. "Finally, the project was initiated by the market demand," explained Rautter. Peppermint viewing itself as a “co-partner” took over Controlling and Marketing of Triple-O.

The startup and its financial backer hoped for a thriving business with QMFM. According to a market study over the coming next five years up to 400 devices could be sold (unit price: $250,000). For 2002 the partners would be satisfied with five customers. "In 2002 maybe we can do it yes to write a black zero," said Ulbrich. And for its exit Peppermint thought already of Trade Sale, which is the sale of a firm invested in to another company [Linneweber 2002].

However, after 2002 information about Triple-O’s activities no longer appeared on the Web. ConsulTech [2005] listed Triple-O under the heading “Insolvent funding recipients.” And in 2009 the District Court Potsdam through publication in the commercial register stated [Amtsgericht Potsdam 2009]: The following companies were deleted in accordance with § 141a FGG *ex officio*: Triple-O Microscopy GmbH, Potsdam.

At 2001/2002, during or shortly after the Dot-Com Recession (affecting the EU during 2000 and 2001 and the US in 2002 and 2003) it was not unusual that startups or NTBFs went bankrupt due to a lack of sales or those with financing by venture capital went bankrupt due to the inability of the investment firms to further finance their portfolio companies.

The Metamorphosis to AlphaContec GmbH

Dr. Jens Ulbrich of Triple-O seemed to be able to transfer a “rest of Triple-O” (products and employees) into another firm, AlphaContec. For instance, the LinkedIn profile of Holger Breter has the entries Manager Life Science at Triple-O Microscopy GmbH, Manager Life Science at AlphaContec GmbH and currently CEO of Amocol Bioprocedures Ltd., a cooperation partner of AlphaContec [ATeSmed].

Dr. Ulbrich gained experience in scanning probe microscopy at the GKSS (Gesellschaft für Kernenergieverwertung in Schiffbau und Schiffahrt) in Teltow near Berlin. For the last two decades the objective of the public GKSS Research Center was to research and develop the fundamentals for the technologies of tomorrow, such as material science. After studying mineralogy/crystallography at the Technical University of Berlin and a PhD in polymer physics (at GKSS) he entered Triple-O Microscopy [AlphaContec].

At Triple-O Dr. Ulbrich was Customer Support Manager. His main tasks involved relationships with domestic and foreign customers. He acted as liaison between the customer and the individual departments (development, production, sales, application or software) of Triple-O. Additionally, he was in charge of supervising foreign distributors (in China, Japan, Taiwan, Turkey, Russia and Switzerland). The main task here was technical consulting, sales training and customer visits. Other areas of responsibility included participation in trade fairs and congresses and the representation of the company to the outside [AlphaContec].

In April 2003, Dr. Ulbrich was appointed Managing Director of AlphaContec GmbH (Potsdam, borough Golm), in May 2003, he took a 51 percent majority of the shares. Actually the firm is listed as “AlphaContec Consulting & Service GmbH, Potsdam borough Golm” in the “Elektronischer Bundesanzeiger – Electronic Federal Announcements” [EB] and focused on biotech and nanotech.

Since the mid of 2002 AlphaContec worked to transfer SPM processes and methods into the life sciences and environmental areas [AlphaContec]. AlphaContec seems to be a group comprising two loosely bound companies. The business of the other partner, “AlphaContec – Communication and Internet,” is information and communication technology [ATeSmed].

Combined with scanning probe microscopic approaches AlphaContec developed and applied conventional *biometric approaches* as an origin to start describing individuals by *molecular markers* (molecular diagnostics, molecular recognition).

AlphaContec offered two SPM-devices originating with Triple-O [TASNANO-1].

- BerMad 2000 Scanning Probe Microscope, developed with Nanotec Electronica (Madrid)
- BioLyser SNOM, the multi-purpose microscope enabling applications in various fields by different heads (AFM, SNOM, light microscopy).

As described for the TASNANO project, “BioLyser scientists in AlphaContec are experts in the detection of proteins and nucleic acids at surfaces of solid samples (ELISAs, RIAs, hybridizations) and at biological specimens at cellular, subcellular and molecular levels by various microscope methods (low temperature transmission electron microscopy – TEM, SEM, immunoelectron microscopy, gold labelling).” [TASNANO-1] RIA means Radio Immuno Assay; ELISA (Enzyme-linked immunosorbent assay) is a biochemical technique used mainly in immunology to detect the presence of an antibody or an antigen in a sample.

Additional products of AlphaContec were [ATeSmed]:

- A control unit for scanning probe microscopes and electron microscopes (development with the University of Wuppertal)
- Specialized electronics for novel cantilever and special applications.

AlphaContec had a long list of prominent cooperation partners [ATeSmed], for instance, Fraunhofer Institut für Biomedizinische Technik (Bergholz-Rehbrücke), Bergische Universität Wuppertal, Institut für Technische Physik der Universität Kassel and Nanotec Electronica, Madrid.

TASNANO was an EU project with twelve partners (five from Germany) funded with €2,150,000 for the period Jan. 1, 2005 to Dec. 31, 2007 [TASNANO-2]. Specific goals of “Tools and Technologies for the Analysis and Synthesis of Nanostructures” were

- Tools for manipulation-processes at molecular level,
- Tools for chemical and biological reactivity characterization,
- Tools for thermal characterization,
- Tools for nano-pattering below 10 nm.

AlphaContec's role in TASNANO was [TASNANO-2]: The biological functionalization of cantilevers with proteins, nucleic acids and other biopolymers and the characterization of these functionalized cantilevers. The goal was the adaptation of bioassays (ELISAs, RIAs, nucleic acid hybridizations) to the nanometer scale by means of (arrays of) functionalized cantilevers with piezoresistive readout; conventional assays will be performed in parallel to verify the results. This would enable its cantilever assays to be a common platform for fast screening and molecular profiling for diseases, applications in food industry and environmental research.

Furthermore, AlphaContec ran a project entitled "New scanning probe microscope for nano-biotechnology – carrier-bound bioanalysis" (03/01/2005 – 07/29/2007) with the BAM in Berlin (Bundesanstalt für Materialforschung und -prüfung – Federal Agency for Materials Research and Testing) funded by the Technologiestiftung Berlin (Technology Foundation Berlin) in the context of the EFRE program of the EU [5]. The goal of the project was the development of a "rapid prototyping apparatus for nanotechnology applications," particularly a new scanning probe microscope for nano-biotechnological applications, especially for deposition of biochemical functional molecules to templates [TSB].

The last entry signed by Dr. Jens Ulbrich as Managing Director for AlphaContec Consulting & Service GmbH into the Electronic Federal Announcements [EB] was on June 4, 2010.

Looking for the BerMad 2000 Scanning Probe Microscope on the Web one finds currently only the association with Nanotec Electronica. For instance, in the context of PSA-skin adhesive bond formation BerMad 2000 (Nanotec Electronica, Madrid, Spain) was used to estimate the fine surface structure of the skin (PSA: pressure-sensitive adhesive).

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Notes

1. Wikipedia: *Deutsche Wiedervereinigung*.
http://de.wikipedia.org/wiki/Deutsche_Wiedervereinigung;
German Reunification. http://en.wikipedia.org/wiki/German_reunification.

2. Wikipedia: *Charité*. http://en.wikipedia.org/wiki/Charit%C3%A9,
http://www.charite.de/en/charite/.

3. FUTOUR: Das Programm FUTOUR 2000 – Förderung und Unterstützung von technologieorientierten Unternehmensgründungen in den neuen Bundesländern und Berlin (Ost);
The Program FUTOUR 2000 subsidizes and supports foundations of technology-oriented enterprises in the new federal states and Berlin (formerly belonging to the GDR) after the Reunification. In 1997 TOU became FUTOUR (1997-2000) and FUTOUR 2000 (2000-2003).
Subsidies were essentially non-repayable grants or silent participations of the public investment firm tbg–Technologie-Beteiligungs-Gesellschaft mbH) for ten years.
This is an amendment and maturity extension of financial assistance by the German Federal Government. It followed a model program TOU for subsidizing technology-oriented enterprises in the old federal states before Renunification and was called TOU-NBL (1990-1996), cf. also
EC ¬EUROPÄISCHE KOMMISSION (2003): Staatliche Beihilfe Nr. N 354/2003 – Deutschland Programm FUTOUR 2004. Brüssel, den 07.10.2003.
http://ec.europa.eu/eu_law/state_aids/comp-2003/n354-03.pdf.

4. Deutsche Ausgleichsbank – DtA.
http://de.wikipedia.org/wiki/Deutsche_Ausgleichsbank,
http://www.handelswissen.de/data/themen/Finanzierung/Foerderprogramme/Bundesprogramme/Deutsche_Ausgleichsbank’
The publicly owned DtA, Bonn, offered different types of loans and subsidy of livelihoods and business startup. In 2003 DtA became part of the federal government owned KfW banking group (KfW Mittelstandsbank).

5. EFRE – ERDF:
http://de.wikipedia.org/wiki/Europ%C3%A4ischer_Fonds_f%C3%BCr_regionale_Entwicklung.

   Der Europäische Fonds für regionale Entwicklung (EFRE, umgangssprachlich auch EU-Regionalfonds) ist ein wichtiger Strukturfonds der Europäischen Union, der für

den wirtschaftlichen Aufholprozess der ärmeren Regionen sorgen soll. Um dies zu realisieren, werden unter anderem mittelständische Unternehmen unterstützt, damit dauerhafte Arbeitsplätze geschaffen, Infrastrukturprojekte durchgeführt und technische Hilfsmaßnahmen angewandt werden.
The European Regional Development Fund (ERDF) is a fund allocated by the European Union. The ERDF aims to strengthen economic and social cohesion in the European Union by correcting imbalances between its regions, for instance, focusing on innovation and research and support for small and medium-sized enterprises (SMEs) – REGIONAL POLICY – INTEREGIO.
http://en.wikipedia.org/wiki/European_Regional_Development_Fund,
http://ec.europa.eu/regional_policy/thefunds/regional/index_en.cfm.

6. tbg – Technologie-Beteiligungs-Gesellschaft mbH. https://www.kfw.de/KfW-Group/About-KfW/Organisation/T%C3%B6chter-und-wichtige-Beteiligungen/.
tbg now is a subsidiary of the KfW Group and is solely focused on previous commitments. All new business in the field of equity finance is now being handled by the business unit Mittelstandsbank. This includes financing offers for the seed and start-up phases as well as offers to sustainably improve the equity base of German small and medium-sized enterprises (SMEs).

7. NanoBioNet e.V. and cc-NanoChem e.V.: *Members*. http://www.nanobionet.de/index.php?id=72, http://www.nanobionet.de/index.php?id=72&tx_r3membermgmt_pi1%5Bmember_id%5D=63&cHash=e6ed4e2794.

8. Wikipedia: *Optical tweezers*. http://en.wikipedia.org/wiki/Optical_tweezers.

9. JPK announced recently the opening of their US offices in Southern California on 1st January, 2015. Heading up this new organization is Dr. Stefan Kaemmer who has been appointed General Manager of US Operations. Dr. Kaemmer has broad experience in SPMs and worked previously in various roles in SPM companies based in Japan (Hitachi) and the USA (Veeco/Bruker).
The US distribution then additionally covers Darcy Microsystems and Ragona Scientific. Additionally, JPK is moving by January 1, 2015 to Colditzstr. 34-36, D-12099 Berlin, Germany.

JPK (2014b): *JPK announces the opening of US offices in Southern California and the appointment of a General Manager, Dr Stefan Kaemmer*. New, Dec. 2, 2014. (last access 12/6/2014).

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