FIBER-TOP TECHNOLOGY AT A TURNING POINT:

DECISION MAKING IN AN ACADEMIC TECHNOLOGY TRANSFER PROCESS

A CASE ON EFFECTUATION THEORY FOR THE COURSE "ENTREPRENEURSHIP FOR PHYSICISTS"

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While on his way home on the train, Professor Danilo Gravina sat thinking about the last meeting of his busy day. Martin Groot, interim director of the Technology Transfer Office (TTO) of the VU University Amsterdam, had been quite clear. By the end of the month, he wanted Danilo to have presented the fiber-top case to the TTO board, who would then evaluate whether to continue or stop the project. But Danilo was still in a quandary.

On the one hand, his academic group at the VU was making steady progress on the development of the manufacturing process of the devices he had invented and patented. He was confident that, in a year or so, he could deliver market-ready sensors in large volumes at a competitive price.

On the other hand, it was not entirely clear to him which market those sensors could serve. Danilo and his team had received a large number of expressions of interest from professionals operating in a wide range of fields. Yet, it was far from certain that those expressions of interest could be converted into sales or followed by other purchase orders.

Danilo also had to keep in mind several potential obstacles that were standing in the way of the commercialization of his invention, including his limited financial resources, his potential conflict of interest as both inventor and VU employee, his commitment to spend most of his working hours on his academic duties, his limited network, and his lack of experience in the technology transfer process.

Martin, who had been following the project since its inception, had always been keen to help Danilo to develop the case. For this reason, he had recently organized a meeting with Albert de Boer – a serial entrepreneur who was looking for new opportunities in the high-tech field. After that meeting, Albert had confirmed his interest in knowing more and, possibly, in founding a company based around Danilo's invention. The details, however, were still vague, and Danilo was not convinced that he could keep control if Albert was given too much decision power.

The only certain aspect of this whole situation was that Danilo's case was at a turning point. The TTO's board wanted to see a clear strategic plan, and Martin could not delay them any longer.

The fiber-top case

Danilo Gravina (PhD in Physics, University of Pavia, Italy) had joined the VU University in Amsterdam in 2005. Starting as a young assistant professor on a five year temporary contract, he had initially planned to develop a laboratory for high precision experiments in fundamental physics. But now, at the beginning of 2010, things were looking considerably different to what he had imagined they would. Most of his group was working at the edge of physics and engineering, trying to exploit and further develop a new technological platform that Danilo had first introduced at the end of 2005: the fiber-top cantilever (see Exhibit 1). Thanks to this invention and all that had followed, he had been promoted to Associate Professor on a permanent contract and had received a large number of international awards and a couple of prestigious (and very generous) research grants. This situation had put Danilo in the spotlight. He was internationally recognized as the pioneer of this technology, which was generally considered as something new and potentially revolutionary. And he had enough research money to continue developing his invention and to test it for different applications.

The VU University Amsterdam had filed an international patent application to protect Danilo's invention. According to a preliminary review by the examiner, the approach suggested by Danilo was novel, innovative, and useful. The chances of seeing it granted were high.

Encouraged by the feedback received from his colleagues, a couple of years after he had come up with the idea, Danilo had begun to look at the business case surrounding the fiber-top cantilever in somewhat greater detail. Despite his lack of experience with the technology transfer process, but supported by a small grant from a Dutch funding agency and an external consultant, he had even drafted a business plan to bring his invention to market (see Exhibit 2). The plan had been analyzed by a group of three experts, who had concluded:

> *"The Expert Panel considers the case as a high potential one and even believes that the business plan drafted is too modest. The strategic value of the business case might well by far exceed the value based on the projected turnover in the coming five years."*

Still, there was one major problem.

> *"The business plan, however, hinges on a strong assumption: a low cost, routine manufacturing process. The plan may be successful only if this target is met."*

The starting point of the business model initially developed by Danilo involved the foundation of a company that could produce, distribute, and sell fiber-top based instruments. In his business plan, Danilo had decided to focus on the market for atomic force microscopy, where fiber-top cantilevers seemed to offer the most evident advantage with respect to the existing competition. A fiber-top atomic force microscope was expected to consist of two main parts: the instrument itself and a set of fiber-top probes. The instrument itself accounted for most of the costs of production as well as the largest projected revenues. The fiber-top probes, on the contrary, were intended as consumable items, which might have to be replaced once a week or even more than once a day, depending on the application. The problem was that it could take Danilo's group up to 8 hours to manufacture a single fiber-top cantilever, in a series of steps that involved the use of very expensive equipment. Danilo had estimated that, due to the complexity of the fabrication process, one fiber-top cantilever could cost his group more than €1000 (without even taking into account that many fiber-top sensors would break during the production process) – forcing him to enter the market at a price per probe that was considered way too high for any potential customer. In his business plan, he therefore had assumed that, in one way or the other, he could reduce the cost of fabrication (and, hence, the price per probe) by a factor of 100.

After spending quite some time and energy in looking for solutions to this problem, Danilo had most recently been testing a new fabrication technique he had designed, which, in the long term, could significantly cut the costs of manufacturing. The technique, which he called *align-and-shine*, had been successfully used to produce a couple of samples, but was still in a very early phase of development. Still, Danilo was convinced that it was a viable direction to pursue. For this reason, he had convinced the TTO to file another patent that could protect the main fabrication steps of this new approach. Unfortunately, however, to make *align-and-shine* interesting for a commercial utilization, Danilo needed funding for one more year of work for at least two people, as well as a few hundred thousand euros in equipment and consumables (without any guarantee of success, of course).

Danilo and the TTO had also been analyzing another potential solution to the fabrication cost problem. Fiber-top cantilevers were known to offer four particularly interesting features for the potential user: they were easy to use, they were suitable for remote sensing, they were suitable for utilization in harsh environments (such as liquids, explosive gases, extreme temperatures, et cetera), and they were extremely small – just 0.1 millimeters across (see Exhibit 1). Yet, during a discussion with some colleagues who were interested in testing the technology in their own field of expertise, Danilo had realized that the dimensions of the sensor were not always that relevant. Some users could find high added value in the application of their interest even if the devices were 30 times larger. Fabricating larger devices was a much easier task when compared to the struggle Danilo's team was facing with the original 0.1 millimeter design – so much so that a 3 millimeter across fiber-top cantilever could already be produced for a few tens of euros per piece. Danilo, however, did not like this solution very much. He was convinced that any laboratory with a minimum of microtechnology facilities could produce these larger devices, which, incidentally, were not covered by the claims of the patents filed and were so close to the prior art that a new patent application was out of the question. In the several discussions on this topic, Danilo had often been heard to say:

> *"Why should I do it larger if I can do it 0.1 millimeters? Everyone can make it 3 millimeters. What is special about a 3 millimeters device? With a 0.1 millimeter device, we can offer so much more to our customers…and we can also maintain our unique position in the market, nicely protected by our patents."*

Another unresolved issue that was casting a shadow over the entire project was related to the fact that fiber-top technology was still a technology in search of a market. In his business plan, Danilo had focused on atomic force microscopy simply because it seemed to be the most obvious field where the invention could have an impact. Alongside that, however, he had already listed a large number of other potential applications (see Exhibit 3). Some might solve a problem in a niche market; others might address the needs of more mainstream customers; and, for some others, the market did not even exist yet. Danilo was not sure about which option he should pursue, and no one at TTO had been able to help.

Besides that, Danilo had to account for a series of less obvious but equally difficult issues.

Obstacles on the way

Since the very early phases of his career, Danilo had always been attracted to the idea of starting his own company. Apart from the excitement and genuine fun that he was expecting to experience on the way to commercialization of his invention, he was convinced that taking this step would help him define a unique professional profile that could give him some (much needed) visibility in the academic environment. Furthermore, he was attracted to the idea that, with a bit of luck, he might radically improve his personal financial situation. The invention of the fiber-top cantilever was the first realistic opportunity to make that dream come true. That path, however, contained risks, uncertainties, and downsides that Danilo was not used to dealing with.

Because of his family situation, he was not in a position to take any cut in his salary. The Dean of the Faculty of Exact Sciences, who saw this whole case as an opportunity to take a first step to create a more entrepreneurial image for the Department of Physics, was allowing him to spend one day a week on the development of the business case in exchange for half of Danilo's holidays. But that was all. Of course, a significant part of the official academic research activity Danilo was involved in was related to research work on fiber-top technology and its applications. But Danilo had very high ethical standards, and had already drawn a clear delimiting line between academic research and technology transfer. The latter was carried on by him alone, using the time granted by the Dean and supported by a few valorization grants, which, however, were about to end.

Another problem that Danilo was facing was his lack of experience. Even though he could count on his academic stature to gain privileged access to the innovators and early adopters, as a physicist by training he had not developed the skills and know-how necessary to successfully bring products to the market. Furthermore, Danilo had no personal capital to bring to the table, except for a few thousand euros that he had inherited a few months earlier. Martin had often encouraged him to apply for a loan of €120,000 that the TTO was willing to provide, but Danilo was not comfortable with that idea, even though the conditions of the loan were favorable to him (only half of the capital had to be given back, with a 3% annual interest rate). Danilo simply could not sleep at the idea of being personally liable for such a large amount of money.

Another potentially viable option was a "family-friends-and-fools" venture. A couple of students had proposed to Danilo that they join forces with him to create a company in which they could each contribute a small amount of capital and 20% of their time. The father of one of these students, who had just retired from a CFO position in a private firm, had even offered to take care of all the financial reporting requirements and administration in exchange for a small share of the new company. Danilo liked this idea. However, even if they did join forces in this way, he was still not sure whether the team would have everything that was needed to develop the project. Moreover, Martin was strongly opposed to this approach, to the point that he had said that he would withdraw his support if things went in that direction.

Albert de Boer

Well aware of Danilo's limits in terms of technology transfer know-how and available capital, Martin had decided to look in his network for a professional entrepreneur who might be interested in navigating this case through all the minefields inherent in starting a business. After a few unsuccessful calls, he had bumped into Albert de Boer – a serial entrepreneur with whom he had done business before, and who, apparently, was searching for a new technology to invest in. After Martin had pitched the fiber-top project, Albert had agreed to analyze the case further.

Martin knew that Albert had just sold the shares of one of his latest companies, and thus had some capital available. He also knew that Albert had the experience and the network to build a new company and lead it through uncharted territories. After gathering more information, he estimated that Albert could put up to a few hundred thousand euros in the project, plus 50% of his working time – a very interesting opportunity that Danilo needed to explore.

The meeting

A few days after their casual meeting, Albert had called Martin to confirm that, after reading the material provided and doing some further research, he was convinced that he could help. On the basis of his enthusiastic reaction, Martin had organized a meeting for Danilo and Albert to get to know each other. During the meeting, the two had had time to present themselves to each other and discuss their vision, in a relaxed and positive atmosphere. Albert had been impressed by Danilo's passion and by his communication skills. Danilo had the ambition an investor likes to see, and, although there was clearly a lot of work to do, he had convinced him that the technology had great potential. Danilo had also been quite pleased as to how the meeting had gone. Albert clearly had entrepreneurial skills, while preserving a relatively humble attitude.

Still, Danilo was struggling. If Albert were to invest, the whole atmosphere around the project might abruptly change. Decisions might have to be taken solely for commercial reasons, and the invention might be transformed into something designed to do only one thing: sell. To achieve that purpose, Danilo's idea might have to be completely altered, without any consideration of the scientific and intellectual merits. Danilo was not even entirely sure that Albert had grasped all the benefits that the idea behind fiber-top technology could bring. More importantly, when Martin had mentioned that there was the possibility to fabricate larger devices at a lower cost, Albert had reacted in a way that Danilo could not easily accept:

> *"That's interesting! Maybe the tiny devices…the 0.1 millimeter ones, I mean…are something for the future, then. One could first try to create a market for the larger low-cost devices, find the killing application, generate some revenue, and take it from there."*

Danilo had the feeling that, if he joined the project, Albert could push the 0.1 millimeter devices aside – an idea that the scientist was extremely unhappy about.

Time for a decision

Looking at the scenery outside the window of the train, Danilo was now trying to make sense of everything that he knew. What was the best strategy to follow? How could he combine his academic ambitions with the technology transfer opportunity he had in front of him? Was he ready to become an entrepreneur, or was it better to leave the technology transfer process to someone else? Was Albert the right person to move on with? Was the loan offered by Martin a better alternative? What was he really ready to commit to and compromise on? He only had a few days to make up his mind and arrange his thoughts in order to make a convincing pitch. The TTO board wanted an answer.

TASK FOR STUDENTS

In groups of 4 or 5 people, write a summary (maximum of 200 words) that describes Danilo's dilemma. Then, prepare a 10 minute presentation (maximum of 12 slides) in which you analyze the situation and propose a strategy for Danilo to get through the current impasse. Use the framework of effectuation theory (bird in hand, affordable losses, crazy quilt, leverage on contingencies, et cetera) to support your arguments.

Print your summary and the slides and be prepared to present. During the presentation, a maximum of 2 people per group are allowed to go on stage. All the other members of the group can participate during the Q&A after the presentation.

Remember, there are many possible right answers (although there are also some that are clearly wrong!).

EXHIBIT 1: FIBER-TOP TECHNOLOGY

Concept: Fiber-top cantilevers are created by carving a miniaturized diving board out of the cleaved end of a 125 micron diameter single mode optical fiber, as illustrated in Fig. 1.1.

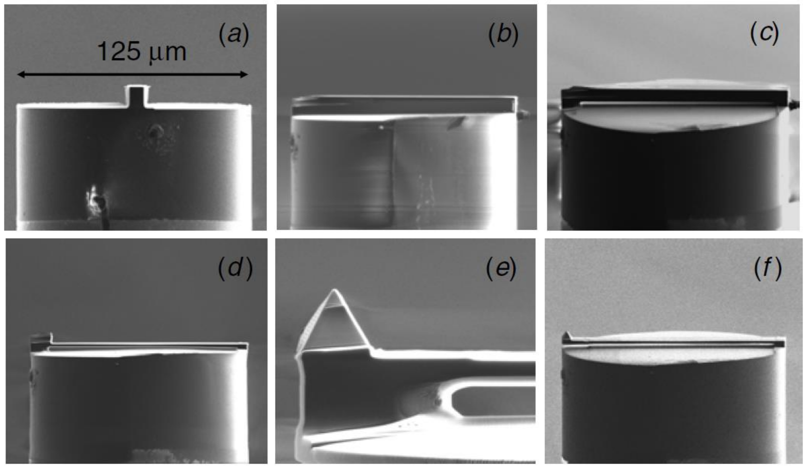

Fig. 1.1: Fabrication of a fiber-top cantilever. The cleaved end of a single mode optical fiber (diameter = 125 μm) is first carved in the form of a thick rectangular ridge, suspended over the core of the fiber (a-c). The ridge is then thinned down (d) and equipped, if needed, with a sharp triangular tip at one of its ends (e). Finally, the part underneath the tip is cut away to free the cantilever (f).

Working principle: The light of a laser beam coupled to the proximal end of the fiber travels through the core of the fiber (diameter = 9 μm), reaching the machined end. Here, part of the light is reflected at the fiber-to-air interface and part of the light is reflected by the cantilever itself, as illustrated in Fig. 1.2. The two reflected signals propagate back into the fiber towards the proximal end, interfering with each other. The amplitude of the interference signal obviously depends on the separation between the fiber-to-air interface and the cantilever. Measuring the amount of light propagating back at the proximal end, one can thus assess how much the cantilever has bent, and, therefore, detect any event that may have caused that mechanical deflection.

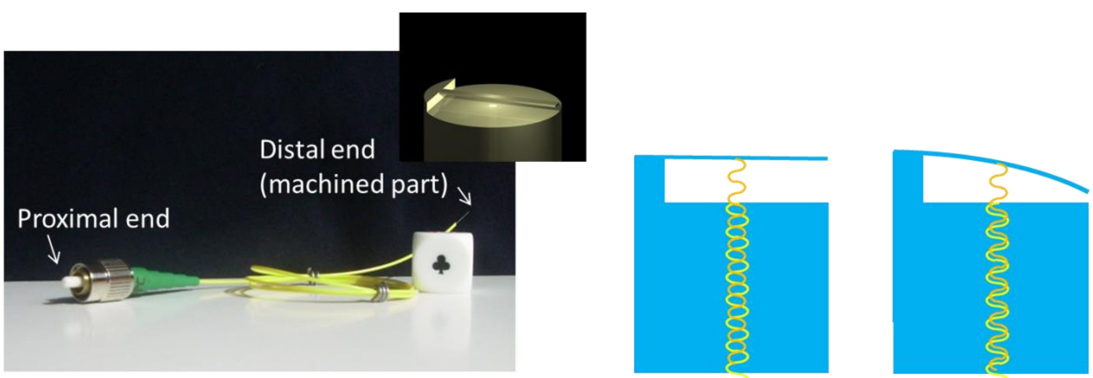

Fig. 1.2: Working principle of a fiber-top device. If an external event makes the cantilever bend, the amount of light received back at the proximal end changes, allowing one to detect that event.

Exemplary application: Fig. 1.3 shows, by way of example, the use of a fiber-top cantilever in atomic force microscopy mode.

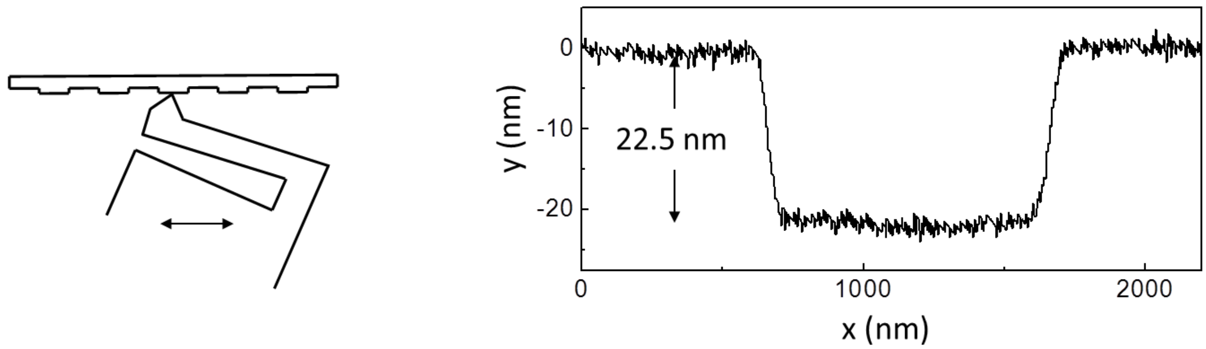

Fig. 1.3: Application of fiber-top technology to atomic force microscopy imaging. The tip of a fiber-top cantilever is brought into contact with a sample and scanned over its surface. While scanning the surface, the tip follows the valleys and asperities of the sample. Looking at the light coming back from the proximal end, the user can measure how the cantilever bends as it goes through those valleys and asperities, allowing him/her to gather high resolution images.

EXHIBIT 2

THE BUSINESS PLAN

- CONFIDENTIAL -

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Contents

1 Executive summary

This document describes the road map to the foundation and entrance to market of FT Probes & Instruments – a new company that will be formed for the purpose of manufacturing and marketing probes and instruments for plug-and-play Atomic Force Microscopes (AFMs).

AFMs allow scientists to routinely assess the morphology and the mechanical properties of organic and inorganic materials at the nanoscale, but they are generally considered too complicated to be put in the hands of untrained users outside specialized research laboratories. FT Probes & Instruments has now the possibility to overcome this difficulty and revert this trend. The point of strength of the new company lies in the core technology of its products: the fiber-top cantilever. Fiber-top cantilevers are a new generation of miniaturized probes that combine the mechanical properties of micromechanical systems with the optical properties of optical fibers. The monolithic structure of the device, the absence of electronic contacts on the sensing head, and the simplicity of the working principle offer unprecedented opportunities for the development of plug-and-play AFMs for applications inside and also outside research laboratories.

FT Probes & Instruments will bring two products into the market: fiber-top probes (consumable) and fiber-top readout systems (equipment). Fiber-top probes will be introduced at different levels of the value chain, namely, direct sale to end-users, sale via international distributors, and sale via the distribution channels of AFM manufacturers. Fiber-top readout systems will be exclusively provided to AFM manufacturers via OEM contracts. Thanks to the user-friendly character of fiber-top probes, AFM manufacturers will be finally able to bring their instruments outside specialized research laboratories, where a new generation of customers will benefit from the possibility to use plug-and-play miniaturized AFMs in a whole series of applications that are not accessible to standard systems. Furthermore, customers that already possess an AFM will be offered the opportunity to convert their old instrument into a much simpler fiber-top based device at a convenient cost and with evident technical advantages. The market will thus gravitate towards fiber-top probes and readout systems, of which FT Probes & Instruments will be the only supplier.

FT Probes & Instruments is seeking for 700 k€to pursue its development and enter the market. The company will be created in 2009 and is expected to become profitable in 2013, with an expected turnover per employee growing from 43 k€in 2010 to 537 k€in 2014 and a total turnover growing from 85 k€in 2010 to 5.4 M€in 2014.

2 Description of the business opportunity

2.1 Technical description of the existing technology

Fig. 1 shows a schematic view of an Atomic Force Microscope (AFM) as currently available on the market. Three main elements can be distinguished: the *probe*, the *scanner*, and the *readout*. The *probe* consists of a miniaturized diving board, called cantilever, with a sharp tip under its free hanging hand. This piece should be considered as a consumable that users use and replace very often (up to once a day or more). The *scanner* is an electronic translational stage that brings a sample to contact (or almost in contact) with the tip of the cantilever and then moves the sample while keeping the tip in contact (or almost in contact). The *readout* allows one to detect deflections of the cantilever, and it is based on the so-called *optical triangulation technique*. The light of a laser beam collimated onto the free hanging end of the cantilever is reflected towards a position sensitive light detector that measures the direction from which the light is coming. From the incoming direction, it is possible to detect the movements of the cantilever. This principle is used in specialized research laboratories to obtain information on the nanoscale morphology and on the mechanical properties of the sample underneath the tip.

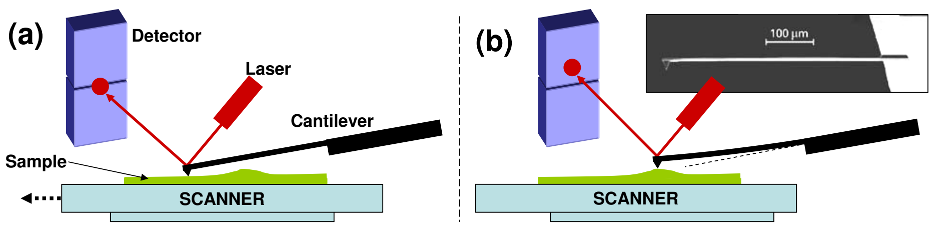

Fig. 1: Sketch of an optical triangulation readout system during contact imaging mode atomic force microscopy as used in commercially available AFMs (not to scale). Inset: a scanning electron microscope image of a micromachined cantilever.

2.2 Market needs and trends

At present, the market for AFMs relies heavily on customers from specialized research laboratories. None of the AFMs currently available on the market, in fact, is sufficiently user-friendly to attract customers from other sectors, where it is not easy to find the necessary skills to put an AFM to work. AFMs, however, can certainly provide unique information on the morphology and mechanical properties of a sample. It is thus commonly believed that, if it were possible to develop a plug-and-play AFM for utilization beyond research laboratories, the new instrument would be well received by the industrial and medical markets, where a new generation of customers could take advantage of the unique properties of this product.

It is thus not surprising that, to enlarge the selling volume, many companies have been recently introducing new products aiming at:

- simplifying the technical procedures needed to put an AFM to work, in the attempt to make AFM technology more user-friendly and thus more appealing for untrained users
- reducing the overall dimensions of the instrument, in the attempt to create new applications in fields where only small/portable devices can be used

Those efforts, however, were not sufficient to create new customers. AFMs are still too difficult to be used, and their dimensions are not sufficiently contained to trigger new applications.

The weak point of the companies already established in the AFM market lies in the fact that their products rely on the optical triangulation, which cannot be simplified or miniaturized any further. This weakness is the point of strength of FT Probes & Instruments.

2.3 Technical description of the new product

The aim of FT Probes & Instruments is to bring to market a new concept that eliminates the optical triangulation and overcomes the practical and technical limitations of the existing AFMs. To achieve this goal, the new company will rely on a unique patented technology: the *fiber-top cantilever*.

Fiber-top cantilevers are a new generation of miniaturized probes obtained by carving a cantilever directly on the cleaved end of a $\simeq 0.1$ mm diameter optical fiber (see Fig. 2). On the opposite end, a connector allows the user to easily plug the fiber-top probe to a readout system designed to inject light into the fiber. After traveling through the fiber all the way to the opposite end, the light impinges on the cantilever. The cantilever reflects the light back into the fiber. The light reflected into the fiber propagates all the way back to the readout system. The readout system analyzes the back propagating signal and, using that information, provides measurements of any tiny movement of the cantilever at the opposite end of the fiber.

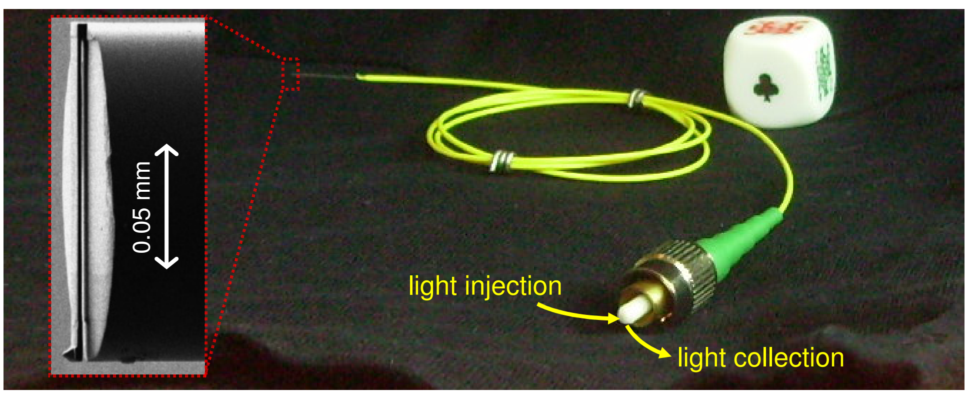

Fig. 2: A fiber-top probe. In the zoomed area: scanning electron microscope image of the sensing head of the probe.

2.4 Advantages of the solution

The optical triangulation used in commercially available AFMs has two main limitations: (i) it forces the user to align the laser on the cantilever, and (ii) it cannot be miniaturized. The alignment procedure is unavoidable and requires technical skills that make commercially available AFMs too complicated to be accepted by users outside specialized research laboratories. It also requires a series of mechanical manipulators and optical elements that increase the price and the size of the instrument. Concerning miniaturization, it is important to point out that, while the cantilever is indeed a micromachined device, the size of the laser, the light detector, and the very same length of the optical path cannot be reduced any further. This mechanical problem does not allow utilization of AFMs in small volumes. Furthermore, it makes measurements in liquids particularly tedious. Different AFM manufacturers offer different solutions to this issue, which all reduce to two choices: either the user is forced to put the sample inside a small volume liquid chamber designed by the AFM manufacturer (with a non-negligible risk of spill-put on delicate parts of the instrument) or he/she is forced to limit the scan inside small droplets of liquid. This limitation is particularly severe in a market that heavily relies on biophysics applications, where samples are typically analyzed while immersed in biological fluids.

Fiber-top technology eliminates the alignment procedure. The cantilever of a fiber-top probe is carved at the end of an optical fiber that can be simply plugged to a the readout. This process is as easy as putting a power cord into a plug.

Fiber-top technology also eliminates the miniaturization problem. The diameter of the optical fiber is on the order of 0.1 mm. If necessary, the fiber can be made several meters long, and then plugged remotely to the readout, which can be packed in a $10 \times 10 \times 5$ cm^3 box. It is thus easy to envision, for example, the development of an AFM where the fiber-top probe is rigidly connected to the scanner via a long, thin, semirigid nose that can be easily immersed in beakers, petri dishes, or small apertures.

With a view to medical and industrial applications, it is also important to stress that fiber-top probes can be sterilized and can be used in harsh environments (e.g., liquids, high electromagnetic fields) without any deterioration of their sensitivity, which is equal to or better than the sensitivity of commercially available AFMs and other competing technologies.

Fiber-top technology can be easily integrated in existing instruments. AFM manufacturers will thus have the opportunity to convert their complicated optical triangulation head to a plug-and-play fiber-top unit adapt also for users that do not possess particular technical skills. Furthermore, thanks to the reduced dimensions of fiber-top probes and of the fiber-top readout, and thanks to the possibility to keep the fiber-top readout several meters away from the sensing end of the fiber-top probe, AFM manufacturers will have finally the possibility to implement a new generation of portable AFMs with ultra-miniaturized head for utilization in and outside research laboratories.

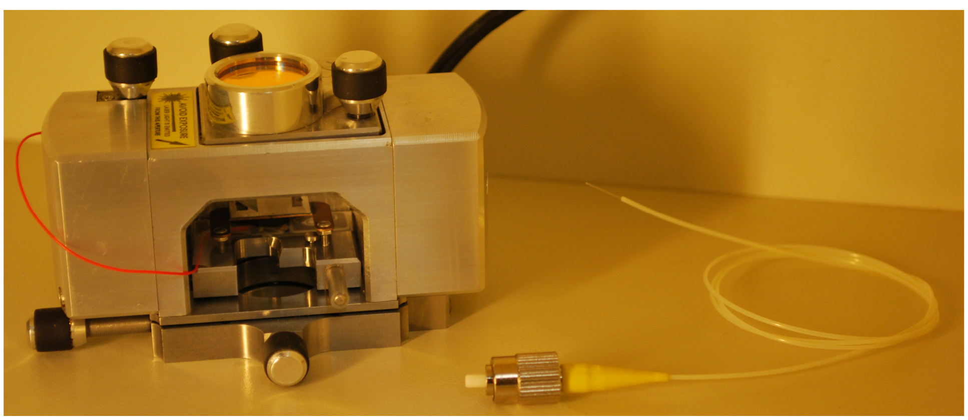

Fig. 3: Fiber-top probe (right) versus an optical triangulation head (left).

3 Business model

3.1 Strategy

FT Probes & Instrument will manufacture two products: fiber-top readout systems and fiber-top probes. Fiber-top readout systems will be customized to the needs of AFM manufacturers by means of NRE contracts. AFM manufacturers will then put the readout systems on the market, giving the opportunity to AFM users to choose between a complicated optical triangulation head or the user-friendly fiber-top based head. FT Probes & Instrument will collect revenues for each fiber-top readout system sold via OEM contracts. End-users who will choose a fiber-top head will then need to replace often (in some cases even once a day or more) their fiber-top probes, of which FT Probes & Instruments will be the only manufacturer. Customers will have the possibilities to buy fiber-top probes directly from the new company or from the distribution channels of AFM manufacturers.

The project leader is already in contact with some AFM manufacturers (e.g., Veeco Metrology and Attocube Systems) who expressed their interest in converting their AFMs to fiber-top technology. Those companies also suggested that the products introduced by FT Probes & Instruments may finally allow them to develop new, plug-and-play, compact AFMs that cannot be implemented with current optical triangulation readout systems. There are thus all the premises to expect that the AFM market will gravitate to fiber-top probes and fiber-top readout systems, of which FT Probes & Instruments will be the only manufacturer.

3.2 Manufacturing

Fiber-top readout systems will be manufactured according to the scheme reported in Fig. 4. All the components will be bought from external companies and assembled at FT Probes & Instruments. After testing, the systems will be packaged and shipped to AFM manufacturers.

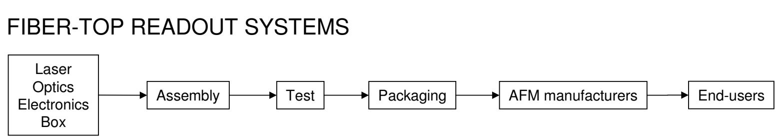

Fig. 4: Manufacturing diagrams of fiber-top readout systems.

Fiber-top probes will be manufactured according to the scheme reported in Fig. 5. After fabrication, each fiber will be inspected under optical microscope, packaged, and shipped to the customer directly or via the other sale channels.

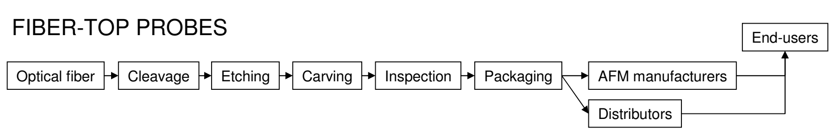

Fig. 5: Manufacturing diagrams of the fiber-top probes.

3.3 Initial offer and evolution

Fiber-top readout systems will be sold to AFM manufacturers at the price of 4000 €per unit. In the first 5 years, this price will not be altered. Fiber-top probes will be initially put into the market at the price of 100 €/ea. for direct customers and 70 €/ea. for other sale channels. In 5 years, prices of fiber-top probes will decrease by 20%. More details can be found in section 5.

3.4 Marketing

FT Probes & Instruments will initially contact all the major AFM manufacturers to illustrate the advantages of fiber-top technology and to demonstrate that, with minor technical efforts, it is possible to convert the old optical triangulation head in a new fiber-top head. This approach will secure OEM contracts with some of those companies for the distribution of fiber-top probes and fiber-top readout systems, of which FT Probes & Instruments will be the only manufacturer.

To promote fiber-top probes among end-users, FT Probes & Instruments will benefit from the marketing network of the AFM manufacturers that will implement fiber-top technology in their products. Considering that fiber-top technology is supposed to conquer a significant part of the market and to enlarge it beyond current expectations, in fact, it is in the AFM manufacturers' interests to promote fiber-top probes. Still, FT Probes & Instruments will activate its own market network via expositions at international conferences, direct contact with end-users, and other channels of advertisement (specialized journals, websites, et cetera).

3.5 Human resources

FT Probes & Instruments will be founded by the project leader in the second half of 2009. In the first few months, the new company will rely on an Advisory Board of three people: the founder, an engineer with expertise in AFM design, and a professional with solid experience in entrepreneurship. The Advisory Board will have the responsibility to select the personnel and to be sure that the new company follows all the administrative and technical steps to bring the products to market within the expected time frame. By the end of the first half of 2010, FT Probes & Instruments will number 3 employees (the CEO and two employees with 0.5fte contract), with an expected increase in human resources as reported in the following table.

	2010	**2011**	**2012**	**2013**	**2014**
Management	1	1	1	1	1
R&D and Support	0.5	0.5	1	1	1
Sale		0.5	1	1	1
Financing	0.5	0.5	0.5	1	1
Production		1	2	4	6
Total	**2**	**3.5**	**5.5**	**8**	**10**

4 Competitive analysis

4.1 Targeted market evaluation

The following table shows the current and expected global market volume of the AFM industry (source: BCC Research).

	2007	2008	2009	2010	2011	2012
AFM systems (CAGR 20%)	197 M$	236 M$	283 M$	340 M$	408 M$	490 M$
AFM probes (CAGR 6.5%)	7 M$	7.4 M$	7.9 M$	8.4 M$	8.9 M$	9.5 M$

The projection does not take into account that the introduction of fiber-top technology will allow AFM manufacturers to convert their complicated old AFMs into plug-and-play devices for a new category of users outside research laboratories. Fiber-top technology will thus increase the number of customers and, eventually, the market volume beyond current expectations. Having the exclusive license on fiber-top technology, FT Probes & Instruments is the best candidate to lead this market revolution.

4.2 Direct competitors

A complete competitive analysis has been performed by an external consultant, who concluded that fiber-top probes are unique in their kind and that, since FT Probes & Instruments has exclusive worldwide license on fiber-top probes, the new company has no direct competitor on its core technology.

Concerning fiber-top optical readout systems, the new company will bring to the market customized instruments optimized to convert existing AFMs to fiber-top probes. The only potential competitors for this product are the very same AFM manufacturers, which might prefer to develop their own readout system. However, FT Probes & Instruments will rely on a special design that guarantees exceptional and long-term stability. Still, the new company will make sure to propose agreements that are sufficiently well balanced to make it more convenient for the AFM manufacturers to accept the OEM approach.

4.3 Competing technologies

A complete competitive analysis has been performed by an external consultant, who reached the following conclusions.

There are more than 10 companies that can provide conventional (i.e., non fiber-top) cantilevers fabricated with standard micromachining processes. The most relevant companies are the very same suppliers of AFMs (e.g., Veeco Metrology) and a few companies entirely focused on probe marketing (e.g., Nanosensors and Novascan). The price per probe ranges from 30 €to 300 €, and the overall market is in the order of 7 million €. None of those companies represents a real threat for the success of FT Probes & Instruments, which is bringing to market a completely new product with evident technical advantages.

Concerning the readout, there are a few companies manufacturing products that could replace, in general, the systems produced by FT Probes & Instruments. The cost of systems similar to the ones commercialized by the new company typically exceeds 5000 €. Those products are obviously not optimized for utilization in existing AFMs, and, therefore, do not represent any threat for the new company.

5 Financial projections

5.1 Turnover evolution and margin

The following table indicates the expected turnover and gross profit of FT Probes & Instruments.

	2010	2011	2012	2013	2014
Turnover	85.4 k€	630.6 k€	1418.1 k€	2833.3 k€	5370.1 k€
Gross profit	24.1 k€	212.9 k€	561.3 k€	1212.5 k€	2318.8 k€

The projection is based on the analysis summarized in the table in the next page, which is based on the following assumptions:

- The new products will be launched on the market in the second half of 2010
- The number of fiber-top based AFMs sold per year with respect to the total amount of AFMs sold worldwide (calculated from the market evaluation reported at page 8, assuming an average price per AFM of 120 kUS$) will proceed according to the following trend: 0.5% in 2010 (second semester), 3% in 2011, 5% in 2012, 8% in 2013, 12% in 2014.
- Each customer owning a fiber-top based system (regardless when it was bought) will need an average of at least 30 probes per year.
- All new customers will purchase fiber-top probes from AFM manufacturers.
- 30% of the old customers will purchase fiber-top probes directly from FT Probes & Instruments, 70% via the other sale channels.

It is important to stress that, in the projection, the total amount of AFMs sold worldwide is calculated according to the trend estimated by an external source (BCC Research), which does not take into account that the introduction of fiber-top technology will enlarge the AFM market well beyond current expectations. It is thus reasonable to envision that the profit of FT Probes & Instruments will be significantly larger than the conservative figures reported in the table.

	2010	2011	2012	2013	2014
FT readout systems					
Number of systems sold per year	14	102	204	392	706
Price to customer per system	4.0 k€	4.0 k€	4.0 k€	4.0 k€	4.0 k€
Cost of sales per system	3.0 k€	2.8 k€	2.6 k€	2.5 k€	2.4 k€
Gross margin	25%	30%	35%	37.5%	40%
Turnover	56.0 k€	408.0 k€	816.0 k€	1568.0 k€	2824.0 k€
Gross profit	14.0 k€	122.4 k€	285.6 k€	588.0 k€	1059.0 k€
FT probes - direct sale					
Number of probes sold per year	0	126	1044	2880	6408
Price to customer per probe	100 €	90 €	85 €	80 €	80 €
Cost of sales per probe	46 €	38 €	34 €	30 €	30 €
Gross margin	54%	57.8%	60%	62.5%	62.5%
Turnover	0.0 k€	11.3 k€	88.7 k€	230.4 k€	512.6 k€
Gross profit	0.0 k€	6.6 k€	53.2 k€	144.0 k€	320.4 k€
FT probes - distributors					
Number of probes sold per year	420	3354	8556	18480	36132
Price to customer per probe	70 €	63 €	60 €	56 €	56 €
Cost of sales per probe	46 €	38 €	34 €	30 €	30 €
Gross margin	34.3%	39.7%	43.3%	46.4%	46.4%
Turnover	29.4 k€	211.3 k€	513.4 k€	1034.9 k€	2033.5 k€
Gross profit	10.1 k€	83.9 k€	222.5 k€	480.5 k€	939.4 k€

5.2 Financial synthesis

There exist two possible scenarios for the development of the company.

- Scenario A: the company will buy all the equipment needed to develop its products in the first 6 months after foundation. The estimated cost of the equipment is ≈ 450 k€.
- Scenario B: the company will initially rent the equipment needed to develop the probes from the Vrije Universiteit Amsterdam. The company will anyway need ≈ 100 k€in the first year to buy instruments necessary for the manufacturing of readout systems and for testing the probes. After 3 years, the company will buy the equipment needed to be completely independent.

A cash flow projection for the two scenarios is reported in Fig. 6. In both cases, the company is expected to become profitable in 2013.

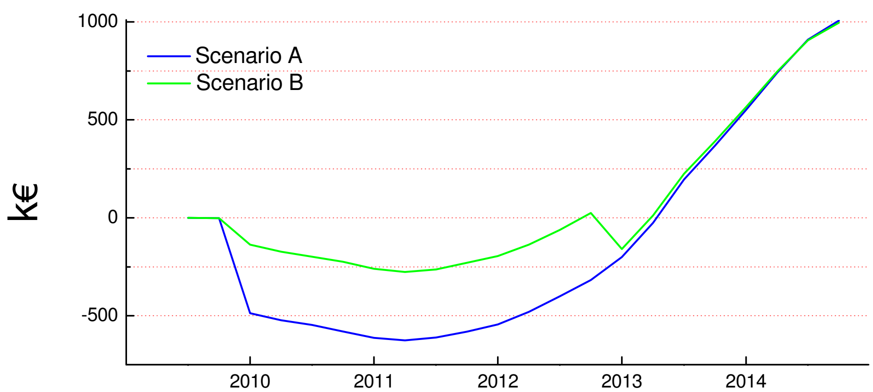

Fig. 6: Cash flow projection for the to scenarios described in the text

EXHIBIT 3: POTENTIAL APPLICATIONS OF FIBER-TOP TECHNOLOGY

The following is a partial list of applications of fiber-top technology according to potential users who contacted Danilo Gravina.

- Atomic Force Microscopy
- Nanoindentation
- Flow measurements / hydrodynamic force measurements
- Electromagnetic field measurements
- Pressure measurements
- Temperature measurements
- Vibration measurements
- Acceleration measurements
- Detection of chemicals (e.g., hydrogen)
- Detection of biochemical agents
- Measurements of pH
- Measurements of humidity
- Photoacoustic spectroscopy

