From laboratory to factory: Heliatek's photovoltaic film

by

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Overview

Why not cover roofs and building facades with supple and light adhesive film which is as easy to fit as a carpet rather than install heavy, opaque, solar panels which are only available in pre-formatted, restrictive sizes? Could this same film also cover cars, telephones and computers, making each one a source of electricity but with a small carbon footprint? Heliatek is making this dream a reality. Heliatek is a spin-off jointly created by the universities of Dresden and Ulm. It has been able to convince companies such as ENGIE and BASF to invest in the development of its key technology for the energy transition. Heliatek has had to evolve from producing a prototype in a university laboratory to large-scale manufacturing, simultaneously with expanding its business from an entity similar to a start-up to a rigorous and disciplined organisation. Its development benefitted from an ideal German ecosystem in Saxony, which has had the means to support disruptive technologies over the long-term.

Report by Sophie Jacolin • Translation by Rachel Marlin

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Before joining Heliatek in Dresden, I had worked in the United States and China. After I finished my studies (I have a degree from an engineering school specialising in electronics and IT, and an MBA), I helped to build the US subsidiary of a very high-tech French company called Axon' Cable. Throughout the eleven years during which I worked for Axon' Cable, I did every conceivable job ranging from sales, marketing, engineering, production to accountancy. The company had a start-up feel to it without formally being called a start-up.

One of Axon' Cable's American rivals hired me to manage its North American operations consisting of three factories near Boston, one in San José, and one in Mexico. Five years later, the company was bought by the Hong Kong company Johnson Electric, the world leader in small electric motors. The company's head office was moved to Shanghai, and I became the CEO. This relocation was the perfect opportunity for me to perfect my knowledge of Lean Manufacturing and Gemba Kaizen with help from a Japanese consultant who came to instruct me for one week every six weeks. The Shenzhen factory of Johnson Electric produced one million small electric motors every day, and employed 25,000 people. Today, I am able to put to good use what I learned from this industrial experience in a completely different setting, developing a start-up.

A unique solar solution

In 2011, when I was thinking about changing track professionally, I was offered the management of a very high-tech start-up specialising in solar energy called Heliatek, based in Dresden. I knew nothing about clean energy, and I did not speak a word of German, but I accepted the job.

Heliatek has perfected the manufacture of organic photovoltaic films which can be fitted onto a large number of supports, thereby combining greater efficiency for organic photovoltaic materials with an extremely small carbon footprint.

Unusually for a company in this industry, Heliatek owns the raw materials from which it creates its products. In its organic chemistry laboratory, it synthesises molecules which do not exist naturally, and which pick up photons and then transforms them into electrons. This synthesis makes it possible to create solar cells which break the world record for efficiency in the laboratory with 13.2% of incident energy transformed into electricity. The most energy-efficient solar panels reach levels of 20 to 22% compared to those which one can find in the marketplace where the best results are 18%.

Of all the energy produced in the world today, our films have the smallest carbon footprint, 20 grams of CO_2 per kilowatt/hour.

A strategic decision was taken very early on to incorporate solar cells into supple plastic films rather than to produce solar panels with a glass base which would have been in competition with the existing offer. Consequently, Heliatek created a manufacturing procedure adapted for this. Its films provide unlimited possibilities of use. They can equip portable telephones as well as trucks, containers, public benches, roofs and building facades. One of my challenges was to focus the company on the market where it could be most profitable, the construction sector.

Advantages of the Saxony ecosystem

Heliatek has benefitted from its local and national environment. It is the result of a spin-off created by the universities of Dresden and Ulm. Dresden University, founded in 1828, is one of the best universities in Germany and has 37,000 students and 520 professors covering many disciplines ranging from medicine to semi-conductors, geography, construction, and so on. TU Dresden (Technical University), within Dresden University, is a public

limited company and has commercial partnerships with companies in order to promote research. TU Dresden sold patents to Heliatek at its creation in exchange for shares in Heliatek's capital. A sister company, 'Dresden exists', has sixteen employees and helps students to create companies. It played a key role when Heliatek first started.

When I arrived in Dresden, I was struck by the enthusiasm of politicians to help new companies. At that time, Heliatek had sixty employees. The President of Saxony, an engineer who is passionate about technology, wanted to meet me as soon as possible. He started networking so that we could find potential investors.

The regional and federal authorities want to re-industrialise Saxony and the other *Länder* of former East Germany. After reunification, Saxony welcomed Volkswagen, Porsche and Audi. It also developed a high-tech sector from scratch. Today, Dresden is the leading cluster for semi-conductors in Europe, ahead of Eindhoven, Grenoble and Sophia Antipolis. Bosch has just announced that it intends to set up a semi-conductor factory there. One should also add that Dresden is the largest cluster in the world for organic semi-conductors, after Korea.

We therefore have a complete ecosystem which brings together universities and advanced Fraunhofer research institutes, as well as manufacturers of materials, equipment and finished products.

From the laboratory to industrial production

Heliatek's origins date back to 1991 when a group of researchers from Dresden Technology University's Institute of Applied Photophysics received grants to work on organic semi-conductors for three years. When this source of funding dried up between 1995 and 2000, the money was redirected from projects other than organic semi-conductors to enable work to continue. Over the next five years, the Ministry of Research made significant financing available to support programmes regarding Organic Light-Emitting Diodes (OLED) and Organic Photovoltaics (OPV). In 2005, a partnership was created between Dresden University and Ulm University, the latter specialising in chemistry.

In 2006, the pace accelerated. 'Dresden exists' financed the first three part-time jobs (lasting six months) of the programme, and federal grants paid the remaining amount. After fund-raising with a seed capital fund, Heliatek was created. In exchange for shares in the new company, Dresden University transferred ownership of its patents to Heliatek, and Ulm University sold its exclusive licences.

At the same time, Heliatek signed a cooperation agreement with Dresden University to obtain the rights to future patents which the latter would produce, and to have access to the Institute of Applied Photophysics' equipment. In Ulm, Heliatek rented university premises and negotiated access to equipment which was necessary for analysis. Whereas Dresden University appeared optimistic in this venture, Ulm University anticipated that it would not work and was against the use of public money to create a company.

In 2007, after initial fund-raising with Bosch and BASF, these two companies invested 4 million Euros in Heliatek. The R&D team continued to develop technology. Two years later, at the height of the financial crisis, Heliatek raised 22 million Euros and invested in its first pilot manufacturing line. Due to its lack of experience in this field, it spent more than a year in talks with suppliers merely to determine which machines were necessary. The initial equipment arrived in September 2011 and the manufacturing line started functioning a year later. The line functions according to the 'roll-to-roll' process whereby the organic material is evaporated under an ultra-high vacuum onto a roll of PET. Fifteen to twenty layers are then successively placed onto the material, each one 5 to 20 nanometres thick. The resulting film is 500 metres long and 30 centimetres wide. The successful manufacturing line meant that Heliatek could prove to its investors and the market that its manufacturing solution, unique in the world, was viable.

I joined Heliatek in September 2011 when it was the right moment to launch the transition to large scale industrial production. The investors assured me that I could raise funds in one year, and that afterwards I would have plenty of time to devote myself to mass production. I have kept raising funds ever since, and this long-awaited industrial 'leap' should take place in 2019.

In 2013, the well-known German industrialist Stefan Quandt, part-owner of BMW and shareholder in companies such as Gemalto, took a stake in our company. We continue to develop our technology and we have learned to manufacture solar films on our production lines. We install test installations on building facades and roofs in Germany, Singapore, China, India, Belgium, the United States and France.

Developing a new industrial process is extremely complicated, and it is a voyage into the unknown because one does not know the extent of one's ignorance. It is difficult, in these conditions, to anticipate future problems. One has to redouble one's reactivity and creativity. Thanks to the quality of our teams, we have been able to solve problems which have occurred on the pilot manufacturing line.

One of Heliatek's key skills is its ability to encourage public financing for its R&D department, and then to manage the work of numerous partners in order to reach a common goal. We started collaborations on various development subjects with financial help from the European Union, Saxony and the German government. As a result, over the past eleven months there have been ten European projects, sixteen German projects and six Saxony projects which together account for more than 11 million Euros of grants in total. For example, in the context of the SEPOMO (Spins in Efficient Photovoltaic devices based on Organic MOlecules) programme, we are working with the universities of Groningen, Oxford, Chemnitz, Würzburg, Mons, Dresden and Angers, as well as with the Spanish National Research Council, Merck and Eurecat, the Catalan Research Institute.

Thanks to these collaborations, we have been able to improve the performance of our solar cells and also to develop nanomaterials for the organic photovoltaic cells, as well as new manufacturing processes (laser ablation, for example), new products (such as transparent films), and new applications. I have noticed that European grants are increasingly oriented towards new applications as it is considered that the technology has already been acquired and so is a 'safe bet'. Paradoxically, the European Union continues to fund research on classic semi-conductors developed in the 1950s and 1960s. I am defending the case for it to continue its financing of research into organic semi-conductors which have only been in existence for twenty years. I find it a great shame that in France the possibilities provided by these grants are insufficiently exploited by start-ups.

Even in the context of partnerships as open as ours, we have had to deal with the 'Not Invented Here' syndrome which discourages anything which is not made in one's backyard. This syndrome is even more noticeable when one is the world leader of a technology and has one of the best teams of researchers. To offset this phenomenon, I have made sure that there is a constant flow of young researchers, post-docs and interns who are of the opinion that anything is possible and whose inexperience is a breath of fresh air. Their naive questions make us constantly question ourselves and help us to move forward.

In 2014, we decided to raise 65 million Euros in order to finance a tool for large-scale manufacture. One difficulty was transitioning to a width of 1.2 metres (from 30 centimetres) and another difficulty was the production of 1 million square metres per year (from a few thousand). In the end, we raised 82 million Euros, half of which came from new shareholders (ENGIE, Innogy and BNP Paribas), one quarter from a loan from the European Investment Bank, and the remaining quarter from grants from the Saxony Regional Council matched by European grants.

The specification of new manufacturing procedures is difficult, as is the ordering of equipment. Furthermore, potential manufacturers invoice their equipment offers because they devote a great deal of time in drawing up the necessary specifications. Very early on, we chose not to order a turnkey factory from a specific supplier in order to protect ourselves from being copied, and to avoid the setbacks which solar panels have had in Europe. We must not forget that when China made solar panels a strategic priority, all it had to do was to make deals with machinery merchants and to buy the raw material, silicon, on the global market.

Therefore, we divided the manufacture of our factory into seven key processes which we distributed among seven different manufacturers, and we decided to assemble the parts ourselves. Naturally, this method of working is long, onerous and complicated, but at least it makes it difficult for a company to copy us.

We have suffered a great deal – and continue to suffer – from the robust German economy. Machine prices have increased by 15 to 20% since 2014, and therefore product delays from our suppliers have increased from

six to twelve or even eighteen months because they are flooded with orders and cannot satisfy all their customers, including ourselves.

When we received our equipment at the beginning of 2018, we set about qualifying each of the manufacturing processes. The complete machine weighs as much as an A380 Airbus. At the beginning of 2019, we will be able to start debugging the entire line. We intend to start mass production by the autumn of 2019, with the production of a 1.2-metre-wide film.

Heliatek's seven challenges

In hindsight, our industrial experience has given rise to several challenges.

In the first instance, we have had to learn to solve technical problems linked to production and the specification of previously unknown equipment. With regards to this, the main difficulties, which we had underestimated, are related to the close links and interdependency between the processes and the products. For example, the adhesive (epoxy, acrylic or silicone) which is fixed on a film may have an impact on the process, as the adhesive itself has an impact on the encased product which in turn has an impact on the adhesive, etc. Our team, which did not have an adhesive specialist, took three years to solve this problem. Therefore, I would suggest assigning experts in related processes earlier on in the operation.

A second challenge lies in sourcing the equipment and monitoring its manufacture. There is no question of 'improvisation' when 50 million Euros spent on investment is at stake. We were aware of problems related to our pilot line which forced us to ask for help from outside consultants to work on our problems with suppliers during the course of the project. As far as our second line is concerned, we created a team purely for this line, assisted by consultants who are familiar with this type of equipment for semi-conductors. They help us to draw up the contract, and prepare the future stages, make reviews and handle intermediary payments. These were areas which we had ignored the first time.

We also had trouble evaluating our suppliers and their manufacturing capacity to produce raw materials because we became the world's first user of certain components. As a result, we now put chemists in touch with our buyers in order to increase their bargaining position when they speak to manufacturers. We also benefit from the five-to-ten-year head start which the OLED (Organic Light Emitting Diodes) industry and the industry of the mature ecosystem of raw materials manufacturers associated with it has on us. Without this, Heliatek would quite simply not be able to expand.

We have to ensure a balance between the product and the demand by targeting the right level of technicity. We are not a manufacturer of solar panels, and therefore we are not in competition with those in this market. It is more advantageous for a building which can be equipped with solar panels to use a solar panel manufacturer's solution rather than our solution. As far as we are concerned, we solve specific problems. We provide the smallest possible carbon footprint, ease and speed of installation, and custom-made film up to 1.20 metres wide and 2 kilometres long.

We do not take part in direct customer sales. We created a network of distributors and partners using two channels. On the one hand, we sell our film to glass manufacturers (AGC), concrete manufacturers (LafargeHolcim), steel manufacturers (Kingspan) and membrane manufacturers (Huesker) so that they can use it in their products: LafargeHolcim is therefore able to deliver pre-cast concrete producing electricity to sites. This solution is especially adapted to new buildings. On the other hand, we have partners, such as ENGIE or Innogy, which use our HeliaSol® film with its double-sided adhesive for existing buildings. This product is so easy to put in place that people could compare us to fitted carpet dealers.

Of course, we constantly have to improve the performance of our products regarding its efficiency, practicality, cost and durability which is currently twenty years. At the end of this period, our products will still be able to supply 80% of the electricity which they supplied in the first year of the implementation of the scheme.

In the end, the greatest challenge we faced was to change the mentality of the teams. In the beginning, a start-up needs to rely on a flexible and creative culture, enabling it to solve problems rapidly. However, having invested 50 million Euros in a production line, our company needed its employees to have a culture which reflected discipline and knowledge of the processes, both of which are conducive to mass manufacturing volumes. To this end, we are trying to adapt our organisation, recruit new employees from the industrial sector, and above all to accompany teams in order to prompt radical changes in behaviour. This is the aim of Heliatek's '2.0 Project'. This is an extremely difficult exercise: I failed to execute this change in 2017, and this almost side-lined us. Since then, the management team has been strengthened by the arrival of two new directors in charge of operations and finance. We have formalised the intended transformation, and we are taking back control of the machine even though we have to increase the number of our employees from 100 to 170 during 2018. 2019 will therefore be a critical year for Heliatek, but I have no doubt that we will be able to manage it, because of our excellent team.

Discussion

Ready to change course

A speaker: *How do you encourage your teams to take part in a dynamic transformation while preserving the company's culture?*

Thibaud Le Séguillon : The kind of people we want to recruit has changed. We do not now hire as many creative researchers with a 'start-up' attitude as meticulous colleagues who have experience in the car industry or with semi-conductors, and are used to mass industrial production.

I think that a good half of our employees work for Heliatek primarily because they believe in our products. This attachment to the company is helped by ever-present in-house communication. When our numbers allowed me to, I invited the entire team to lunch once a week to explain to them our progress and the company's strategy. This was also the opportunity for one of our engineers to show us his work. Today, I still communicate personally about Heliatek's strategic vision.

I have had to resort to consultants to help me to change course in the organisation, because clearly, I could not manage to do so alone. We run workshops encouraging employees to come up with ideas about the way in which the company ought to change in order to be successful. We also have to convince them that the practices which have been tolerated up until now will no longer be tolerated, for example, short-circuiting a sales process in order to gain time. German employees, unlike their American or Chinese counterparts, need long, very detailed explanations in order to embrace change. With regard to this, the fact that I do not speak their language proficiently helps as we get to the heart of the matter more quickly.

A highly protected procedure

Speaker: *What is your product's energy yield in a real-life situation?*

T. L. S.: Our energy yield is 13.2% in the laboratory on a 1cm² piece of glass, and approximately 5 to 6% on the pilot line. It should increase to 7 to 8% in 2019 on the second manufacturing line, and then 8 to 9% a year-and-a-half later. One must not forget that a client does not buy a yield but buys kilowatt-hours. Therefore, this rate of efficiency is relative. Besides, it is difficult to compare an organic semi-conductor with photovoltaic

panels because of its unique characteristic which is that it does not have a negative temperature coefficient. One of the paradoxes of photovoltaic panels is that their efficiency decreases with heat, compared with our product where the more sun there is and the hotter it is, the more efficient the yield.

There are two ways of manufacturing OLEDs and OPVs. Either one evaporates small molecules in a vacuum, or one prints large molecules, polymers. We are the only company in the world to use the first solution for OPVs. For OLEDs, this same method replaced the second two decades ago.

Some of our rivals print the small molecule. These are companies in France (Armor), Brazil, Germany or Japan (Mitsubishi). None of them have a performance, efficiency, yield or durability to match ours.

Speaker: *It is often suggested that as well as a product one should sell one's installation system. If you go through distributors, do you not risk cutting yourselves off from the end client?*

T. L. S.: Our sole profession is to manufacture films, and this is a rather complicated process in itself. If we wanted to broaden our area of activity, we would need financial investment, know-how, and teams in the field. We prefer teaming up with partners who are able to give us a comprehensive system. My dream is to become some sort of 3M, but not an ENGIE! But thanks to us, ENGIE can give its clients a unique product, and ENGIE can pay for its installation in return for a contract to supply local, 'green' electricity for twenty years. During this period, it can sell all its other services.

Speaker: *You are working on improving the product and perfecting the industrial process at the same time. Is it necessary to do this simultaneously? It is difficult to combine these separate activities which have different timescales.*

T. L. S.: This is the reason I slowed down the development of the product in favour of the process. Today, our R&D teams are focussing on our new production tool and have cut costs on other activities, because if we fail to take this step, we will cease to exist. From now until the end of 2018, our R&D department will get up to speed again, or even accelerate, in order to concentrate on fundamental subjects.

Speaker: *How do you protect yourself from the risk that a rival, notably a Chinese rival, might get hold of your technology?*

T. L. S.: We have created three forms of 'defence'. Firstly, we have control over the basic chemical material. This is a fundamental difference compared to the traditional solar market whose components are commodities. Secondly, our process is not only precise, but complex to analyse by an outside party. It is difficult to make a cross-section of a sheet 250 nanometres wide which has twenty layers. If an industrialist wanted to copy us, he would have to employ three of our engineers at great cost. Thirdly, we are the only company which has a grasp of the entire process because the manufacturers of our machines only take part in specific sectors at specific times. Once again, a potential rival would have to hire several of our engineers in order to reconstitute the entire manufacturing line.

We are very active in the patent field. We have already 243 patents granted or pending to date. Our management committee meets every six to eight weeks to review any new ideas and to study ways in which we can protect our inventions.

Speaker: *There are no impassable barriers to entry in terms of technology. Would it be possible for three of your engineers to become self-employed and compete against you?*

T. L. S.: If three of my employees created their own company, they would not be able to access the raw material which is essential to the implementation of the solution. The patent has been written so that our most active molecule is not mentioned, but is still protected. An outsider will eventually manage to reproduce it sooner or later, but with great difficulty. Therefore, we are slowing down the competition. This is also the reason why we are developing new molecules all the time.

Speaker: *Prices in the solar sector are still dropping because they are influenced in particular by Chinese companies. Will you follow this trend?*

T. L. S.: We are not in competition with the manufacturers of solar panels, and so I refuse to enter into a price war with them. If a client were to hesitate between buying our solution or a photovoltaic solution, I would advise him to buy the latter. We intervene when we have to solve a specific problem, whether it is linked to the carbon footprint or the aesthetics or the weight which a roof or a façade can carry. A year's production at Heliatek (1 million square metres) could cover the large Parisian Villepinte convention centre. In other words, our surface area is not enormous. We are focussing on a very high-end product which has an additional justification other than the price of the electricity provided. I should add that if Germany and France agree on a price per tonne of carbon which is greater than $100, our prices will immediately be competitive.

An infinite market

Speaker: *What is the size of your market, and what level of sales do you hope to achieve?*

T. L. S.: I am more focussed on a turnover of several billion Euros than on a level of sales. No-one knows the size of the market. I have discussed this at length with our industrial partners such as LafargeHolcim and AGC. The only thing they could tell me was that in Europe, 200 million square metres of glazing and 100 million square metres of metal cladding were fitted every year to new buildings. The National Renewable Energy Laboratory estimates that 8.2 billion square metres of roofs could be equipped with solar panels in the United States on buildings which already exist. If one estimates that 30 to 50% of these buildings cannot carry the weight of traditional panels, our market would then be roughly equivalent to 3 to 4 billion square metres. Innogy reckons that if it sold our products to its clients in Germany, this would represent several million square metres. However, our industrial tool is not currently able to exceed 1 million square metres. Market size is therefore not what is stopping us.

Speaker: *Construction is obviously a huge market but not very innovative. This is not true of the car industry. Why are you concentrating on the former, and how are you going to make it more innovative?*

T. L. S.: I once worked for a car supplier so I know that this sector has unique challenges regarding qualification time and ramping up production volumes. Qualification time for new technologies may be as much as four years. Then one needs a further three or four years to integrate a platform, after which one has to start quickly mass production. Of course, we have studied this possibility. Audi and Volkswagen were in competition with each other to work exclusively with us at Heliatek, but we refused to grant either exclusivity. In the end, Audi still had contact with us. A Japanese manufacturer is also interested in our technology. Sooner or later, we will focus our attention on the automobile sector, but this requires resources and time, neither of which we have yet.

As far as the construction industry is concerned, it is slow, conservative, and does not understand the importance of electricity. This is an advantage for us because we present our technology without having to dispel any preconceived ideas. After the 2009 economic crisis, the large construction companies' profit margins collapsed. They built them back up by reducing capacity, and now they need to innovate. We are handing them innovation on a plate. There is no need for them to develop a new sort of concrete or glass: all they have to do is to stick our film on their surfaces.

Another lever in our favour is the European regulation which has stipulated that, as of 2020, all new buildings must be 'positive energy'. In France, under the 2020 thermic regulation, new materials will have to be documented with papers describing their carbon footprint. This is a great opportunity for Heliatek !

Whereas the construction industry is conservative, property owners need to prove that they use locally-produced 'green' electricity. These are the people whom we hope to influence. The risk would be that the inertia of those involved in the building sector will slow down our market penetration. Nonetheless, we have a full-potential production capacity of 'only' 1 million square metres of solar film per year, and we predict that in 2020 we will have approximately 420,000 square metres available for this production tool. If we were to equip our

factories as we currently do for an important hydrocarbon group, this would only represent 42 projects, each one occupying 10,000 square metres. This is a reasonable target.

When public authorities think about the long term

Speaker: *What are the exit possibilities for your investors?*

T. L. S.: Our venture capitalist investors now want to exit Heliatek's capital, and this is a legitimate request. However, our industrial investors, such as ENGIE, Innogy, BASF and Stefan Quandt do not necessarily want to do this.

Heliatek is for sale, and always has been, for the right price. I think that sooner or later a large group like 3M, Eastman Chemical or Fujifilm might be interested.

I am also working on a stock market flotation in 2020 or 2021. In order to penetrate new markets, we will need money. After the construction sector, we will turn our interest to transport (truck trailers, cars), and then mass consumption products such as computers and mobile telephones. An e-book manufacturer has suggested that if they stuck our films to their products, they would never need to be plugged in.

To succeed in this sort of application, we will have to lower our cost prices. Variable costs feature prominently in our economic model and are specifically linked to raw materials. These costs are extremely sensitive to economies of scale. Therefore, our challenge is to find the market which is ready to accept a high price in order to increase our production capacity and lower our cost prices. We will then be able to access broader markets. We intend to install ten manufacturing lines, which would represent production of 10 million square metres of film every year. Despite this, we would still be a very small player in the construction market. Another solution would consist of licensing our technology so that third parties can make our film under our brand name and with our raw materials, but in their factories.

Speaker: *How did the German authorities agree to finance your development without any hope of immediate return on investment?*

T. L. S.: The German authorities' strategy is to create an ecosystem of semi-conductors which will bring tomorrow's high-tech jobs to Dresden over a long-term period. This strategy still exists despite changes in the Saxony government. On a federal level, we are in contact with State secretaries who have been following companies like ours for years.

Europe has missed the boat in terms of OLEDs, but is the world leader in OPVs thanks to German and EU funds. One of my fears is that Heliatek may be bought by a Chinese or Korean group. This would be excellent news for our investors, but a catastrophe for European industrial and innovation policy if a foreign group were to reap those benefits.

Speaker: *What would have been your objective if you had been located in Silicon Valley?*

T. L. S.: It would have been a recipe for disaster! Our ideas might have been the most original, the marketing of our product would have been the most sophisticated, but it would have been just hot air. The level of expertise in Silicon Valley does not match that of my team of researchers. Apart from Germany, Japan and Korea are the only countries where our technology can be developed due to their knowledge of organic semi-conductors and machine manufacture. The American company Kateeva is an exception, but does not manufacture anything which is unique. American investors would have given us larger investments earlier on in the process, but would not have waited as long as those investors which are still with us today. Our American rival raised $250 million and bought a factory which used to belong to Agfa, and which was supposed to produce 10 million square metres of film every year, but it has since gone bankrupt.

Speaker: *Would things have been very different for your company if you had had more financing more quickly?*

T. L. S.: We took some decisions by default because we lacked funds. Additional funding would have enabled us to move forward more quickly. It is very complicated raising money in Europe. Corporate funds like those at ENGIE, BASF and Total each have between 20 and 100 million Euros at the most, and have ten companies in their portfolio. This is clearly insufficient. European venture capital funds are similar. We lack the support which is necessary to lead technological innovation in Europe. The next European programme for research and innovation (FP9) will start in 2021 and will last seven years. Such a time horizon has no flexibility.

I am a member of the Joint European Disruptive Initiative (JEDI), a Franco-German body aimed at supporting massive public and private investment in certain areas where it is essential to get ahead, and where one will inevitably have to take risks. It will have to show that it is agile, capable of taking rapid decisions and, in the event of failure, capable of closing down the company promptly. Europe risks losing the technology battle because of the sluggishness of its innovation.

Presentation of the speaker

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