Advanced electrochemical process research

Prof. Frank Gielen, Prof. Johan Deconinck, Dr. Leslie Bortels, Vrije Universiteit Brussel (VUB), Brussels, Belgium

Elsyca is a research based spin-off company of the Vrije Universiteit Brussel (VUB, Brussels). Elsyca combines 20 years of research and expertise in the domains of electrochemical transport processes and 3D fluid dynamics. The research has resulted in a number of software tools that allow a very fast and precise simulation of 3D electrochemical processes that are used in industrial applications: chemical reactor design, galvanics, electrochemical machining (MEMS) and electronics.

Elsyca's software products replace expensive "trial and error" testing, reduce design and material costs and improve the product & process quality.

Although Elsyca was founded in 1997 its history goes back to the seventies when the department of Electrotechnical Engineering (ETEC) of the VUB began modelling electrochemical cells. Jointed research work with the VKI (von Karman Institute for Fluid Dynamics) has extended existing knowledge with sophisticated models of mass and charge transfer. In 2003, Elsyca received a first round of venture capital financing from BI³, the seedcapital fund of the VUB.

Scientific basis

In 1976, the ETEC research group of the VUB started to become involved in industrial consulting contracts related to electrochemical processing (i.e. anodising). One of the goals was to optimise the electrical parameters of the electrochemical reactor in order to obtain a homogenous deposition of material on the anode. This consulting work was the basis for the first computer simulation program that allows the optimal form of an electrochemical reactor to be calculated.

The first simulation models were based on the Potential model and are coupled with potential drops in electrodes and electrical networks such that they form closed electrical systems.

Further research and feedback from industry showed that the simulation results could be improved by taking into account other phenomena in addition to the electrical parameters. By 1985, the Ph.D research work of Johan Deconinck had demonstrated that electrode motion and the changing shape of the electrodes (due to the deposition of material) had a significant beneficial impact on the models. They were included in the simulation model and are continuously being improved in order to deal with time dependent processes such as electroforming, electrochemical machining and corrosion.

In the next phase of the research it became clear that the motion of ions in the liquid and the mass transport phenomena transport due to convection, diffusion and migration needed to be taken into account. Herman Deconinck, the brother of Johan and a professor at the VKI is an expert in numerical fluid mechanics. This was the ideal basis for a jointed multidisciplinary research project between VUB and VKI. From 1992 onwards, VUB and

VKI were awarded research funding from consecutive European Brite-Euram programs. This resulted in the development of numerical solvers for laminar and turbulent fluid flows. Those solvers are needed in the multi-ion transport and reaction models where there is interaction between the electrochemistry and the fluid flow.

VUB/ETEC and VKI are continuing their jointed research to improve their models for electrochemical processes. Some of the more recent research topics include electrochemical processes in electro-osmotic flow and gas-evolving electrochemical processes with two-phase flow.

From science to spin-off

Today universities are asked not only to play an active role in science and technology research but also in turning their research into innovative applications. To support this new role the VUB has created the appropriate context, structure and processes. The VUB R&D interface group actively manages the university's contract research and patent portfolio and it has developed the necessary mechanisms to support the creation of spin-off companies. VUB R&D promotes the support for collaborative research with industry and continuously raises the awareness of the young researchers towards technology transfer and knowledge exploitation. VUB R&D has also invested heavily in the creation of competencies and tools that are needed to turn research into potential commercial applications such as the development of

▲ Fig. 1: Elsyca's software visualizes a 3D model of a virtual chemical reactor.

business plans and access to seed capital with the creation of the BI³ fund in 2002.

In this environment the VUB/ETEC team had all the ingredients that are needed to create a successful venture: the many years of outstanding multidisciplinary scientific research that provide a solid basis for the development of industrial applications; while the long track record of collaborative research with many diverse partners from industry that has given the team a good insight into the types of industrial problems that they could solve with their technology. Add to that the ambition and drive of a motivated team and you have a new spin-off company: Elsyca was created in 1997. Under the impetus of the EC Value program and with the aid of the Value Relay Centre of the Flemish Government, a technology transfer contract has been agreed between the VUB, VKI and Elsyca.

Elsyca first started as a consulting company that offered simulation software and engineering solutions for electrochemical applications. Elsyca's industrial objectives consist in applying the technology of electrical, fluid flow and electrochemical modelling for:

- consultation in the field of cathodic protection and electrochemical engineering,
- provision of unique CAD integrated state-of-the-art simulation software and expert solutions that enhance the process design, the production tools (reactors) and the products for the electrochemical industry.

Applications are found in plating processes for micro technology, semiconductors, automotive, aerospace & aeronautics. Some examples are:

- Electrochemical etching, anodizing and electrochemical colouring of aluminium;
- Design of high speed plating processes for copper, zinc and tin;
- Electrochemical machining of steel work pieces;
- Electroforming of copper and nickel work pieces;
- Modelling of cathodic protection of buried pipes and tanks;

The high levels of qualifications of the team combined with diverse and extensive industrial experience provide the perfect resource mix needed to successfully tackle and solve real-life problems. As a result, Elsyca is able to perform high-level electrochemical consulting and electrochemical simulations (predictions/optimizations) that are very close to reality and in line with market requirements. The products and services of Elsyca create value for their customers at different levels:

- Faster time-to-market: No more need for numerous time-consuming trial-and-error lab experiments. Elsyca's software creates a virtual electrochemical reactor and simulates the effect of different combinations of parameter settings in minutes instead of weeks. [Figure 1]
- Cost reduction: The customers spend less time in their laboratory and the improved process parameters allow faster production. There is no more post-processing to eliminate excess material deposits and in general less material is used in the improved electrochemical production process.
- Better quality: The optimization of the process parameters creates higher uniformity while the software tools allow to find higher quality process configurations to be found which would never be identified by using lengthy laboratory experiments.

Over the years, this knowledge and experience has earned Elsyca the business of many leading companies including Robert Bosch, Agfa, Corus, Bekaert, Philips, Andreas Stihl, CERN, EADS, Kohler Mira, Kogas, Gasunie and many others.

In 2002, the success of the consultation services made Elsyca decide that there was a need to transform the software tools used by the consultants and scientists into professional software packages that could be sold together with services to their customers. In order to grow their market and develop the professional software products, the company started to look for external financing. This financing was provided by BI³, the seed-capital fund of the university.

▲ Fig. 2: Simulation of material deposit on a brake caliper.

This has helped Elsyca to create a unique integrated- value proposition based on virtual design. Elsyca's approach allows customers to model their electrochemical reality, accounting for the physico-chemical parameters of the electrolyte bath, the complete geometry of the electrochemical cell, the electrode reactions and all process parameters ranging from flow rates to DC or pulse reverse parameters. This methodology is applied and encapsulated in all of Elsyca's engineering services and software solutions. Moreover, product development is highly application-oriented, led by customer requirements in several markets.

Elsyca has proven that... an academic spin-off can become a leader in a niche market.

In 2003, Elsyca reached the commercial and technical targets that were included in the business plan. For 2004, the revenues and growth rate are expected to exceed the business plan.

Conclusion

Elsyca has proven that despite the lack of size, resources and a new undiscovered market, an academic spin-off can become a leader in a niche market. The focus of the VUB/VKI research and the ability to identify meaningful applications are important success factors. However, equally or even more important is the fact that Elsyca started as a consulting company. This was not only a way to generate cash in the early days of the company but it has also put the engineers in direct contact with the market and the customers. Since Elsyca had (and still has) to create its own new market this is more valuable than any overpriced market-analysis report. Finally the team had the vision to hire commercial and business oriented people and to look for external financing at the right moment. Today Elsyca has the talent and the team to implement its vision and move to the next stage of their development: to become a global leader in electrochemical intelligence.

About the authors

Johan Deconinck received his M. Sc. Degree in Electromechanical Engineering from the VUB, in 1976 and the PhD degree in Applied Sciences in 1985. Since 1998 he is professor of Electrical Engineering and Electromagnetic Field Theory of the VUB and is head of a research group performing "numerical electrochemistry".

Leslie Bortels received his M.Sc. degree in electrical engineering from the VUB in 1992 and his Ph.D. degree in electrical engineering in 1996. He joined the Electrotechnics Department from Technical VUB in 1992. He is a NACE certified cathodic protection technician.

Frank Gielen received a Master degree in Telecommunication System Engineering from the Royal Military Academy in Brussels (1985) and has a Ph.D. in Computer Science from the VUB (1993). Since 2002 he is senior investment manager of BI3, the seed capital fund of the VUB, where he is responsible for dealflow generation, capital raising and hands-on interim VUB management activities for the newly created spin-offs.

At the crossroads of physics and archaeology: the OSIRIS Project

Y. Renotte^a, D. Laboury^b, B. Tilkens^a, V. Moreau^a, M. Morant^c

^a Hololab, Dept. of Physics, University of Liège, allée du 6 Août, 17, B-4000 Liège, Belgium

^b Egyptological Dept. and European Center for Archaeometry of the University of Liège (ECA), University of Liège, quai Roosevelt, 1B, B-4000 Liège, Belgium

^c Interface Entreprises-Université de Liège, quai Van Beneden, 25, B-4020 Liège, Belgium

Archaeology, as the Science which studies the material remains of human behaviour, naturally stands at one of the crossroads between the human Sciences and Science (physics, chemistry, biology, etc). This connection is precisely a way to define what nowadays it is customary to call Archaeometry, that is the combination of laboratory techniques with the traditional methodology of the historical and archaeological investigation to deepen the analysis, the knowledge and the interpretation of ancient works of art, monuments and archaeological objects. Archaeology is also permanently confronted with the problem of recording the objects of its study, since excavated relics of the past are always exposed to a progressive and often irremediable process of defacement, and, finally of annihilation. In order to find a solution to this important and still unresolved problem, the OSIRIS Project aims to develop one or several devices that allow by optoelectronic process-

▲ Fig. 1: Moiré effect on an Ancient Egyptian Relief (copy of the relief Brussels MRAH E 2157)