



Henk Leeuwis
Executive vice president LioniX

LioniX

Leading the micro and nano revolution



We live in a world where markets ask for ever-smaller technical systems and applications. LioniX is leading in this field. The company puts a clinical laboratory on a chip and a chemical factory on your desktop.

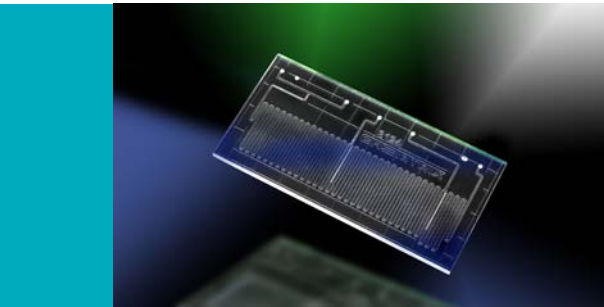
LioniX is a leading co-developer, manufacturer and provider of products and components based on cutting-edge micro/nano technology for its original equipment manufacture (OEM) customers. Additionally, LioniX is spinning out new product companies. The company's core technologies are integrated optics and microfluidics, both areas with enormous potential. The latter arises because, on the one hand, there are many new and potentially interesting applications possible while, on the other, production is possible with the same equipment and employee skills already present in the company. Moreover, the emerging field of 'optofluidics' is being paired with nanochemistry based surface functionalization to create important applications such as the biochemical sensor and the 'Lab-on-Chip' systems for the life sciences, health and process industries, and optical chips for data processing in telecommunication.

'Our cutting-edge chips enable the products of our innovative customers.'

Micro electronics originated from the batch processing of 'silicon wafer' manufacturing technologies i.e. integrated electrical circuits on a chip. The early 1980s saw the emergence of sensors based on the same micro technology and this application area has continuously broadened since then. What are now called 'Microsystems' are being applied to many products, such as sensors in vehicles, medical and industrial automation, as well as inkjet nozzles in printers and planar waveguides (optical 'fibres' on a chip) in telecom components. Nanotechnology is the result of the continuing 'top-down' trend towards miniaturization in combination with new 'bottom-up' innovation in such fields as bio chemistry. Further miniaturization is undoubtedly inevitable in the future. As LioniX is at the core of this trend, the numbers of applications can only grow in the coming years.

Design for manufacturing

Henk Leeuwis, executive vice president at LioniX, points out that it requires increasing levels of innovation to be able to match the >



- ▶ demands of the customers: *'With our 'design for manufacturing' strategy, we develop micro/nano based products in such a way that they suit the requirements of economically feasible volume chip manufacture, be it small quantities in our facilities or mass volumes to be produced in specialised foundries.'*

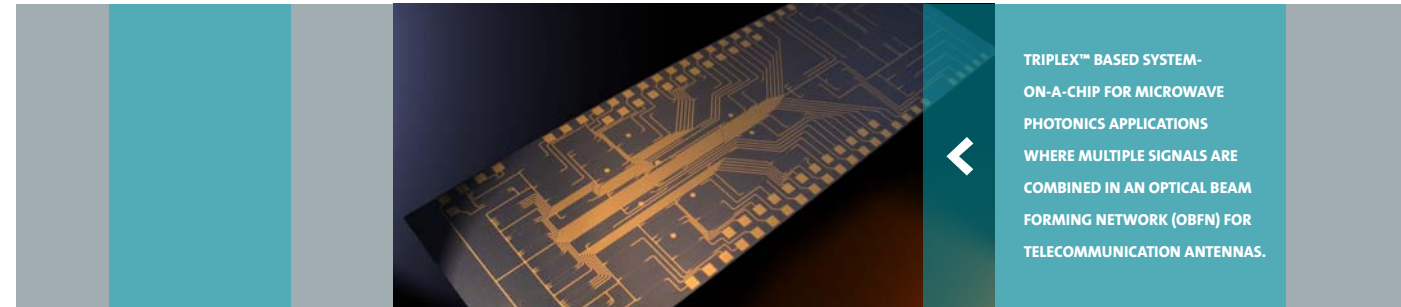
LioniX's customers operate in tele/datecom, industrial process control, life sciences and space markets. These include OEMs, multinationals, start-up companies as well as research institutions from around the world that can be characterized as the leading edge in their field. By actively maintaining and extending its network of partners with complementary technologies, LioniX is able to offer its customers complete solutions, and control the process of development into production as well as the manufacturing of the final product.

To meet the high requirements of its customers, LioniX has an experienced management and a team of first class MEMS-MST (micro electro/micro systems technology) engineers and designers. LioniX works closely with the world-renowned MESA+ Institute for Nanotechnology at

the University of Twente and by actively participating in research projects, LioniX guarantees the application of its established cutting-edge technologies.

Lab-on-a-Chip

Henk Leeuwis is a firm believer in the integration of optics in analytical microfluidic systems: 'It will bring us functional as well as economic advantages'. This optofluidics competence gives LioniX an unrivalled expertise in so-called 'Lab-on-a-Chip' technology. Lab-on-a-Chip is an emerging technology that makes it possible to measure, analyse and determine genetic properties of extreme tiny volumes of liquids and gases. This results in much faster and better controlled processes as well as lower costs per experiment or analysis. In these developments, close cooperation is necessary between 'micro/nano' and 'bio' experts. LioniX has built up a strong position in this field and, in particular, life sciences and health are interesting markets for these applications. Many experiments or tests in life sciences and health profit from small volume processing, reducing expensive reagents cost and increased speed. This might include, for example, quick checks for certain diseases



at the general practitioner, fast detection of bacteria in food or water (testing for Legionella in water takes up to a week in the conventional laboratory) and many kinds of environmental analyses. Many applications in the chemical industry also offer new opportunities.

Desktop chemical plants

The chemical industry is under pressure to become more flexible and to minimize the time to market. But the present, volume-oriented, batch processing technology is preventing this from happening. Here 'micro reactor' technology opens up possibilities. Over ten years ago LioniX started a research project for Siemens designed to explore the suitability of chip based reactors. The goal is to build a complete chemical plant in a desktop format applying flow chemistry in micro reactors. This is a promising and emerging technology in the area of fine chemistry and pharmaceuticals. These desktop chemical plants enable R&D on biochemical processes on the micro scale with unique features such as extremely low reagent consumption, fast mixing, and optimal control of process conditions. LioniX provided Siemens with a feasibility/concept

study on micro reactor systems based on its knowledge in micro fluidic components and micro sensor and analysis techniques. A first working model of the basic part of such a system has been built with the help of LioniX and this resulted in a new product line at Siemens Automation and Drives five years later.

Since then LioniX has been very active in this field, among others by spinning out Chemtrix BV, which currently supplies desktop chemical plants to pharmaceutical companies. These allow for fast and efficient production of their first kilos of working pharmaceuticals and for fast upscaling of their production by numbering up the amount of micro reactors in a system.

Integrated Optics

Another area in which LioniX is active is integrated optics. An example of the use of integrated optics can be found in telecommunication. Applications such as mobile telephones, broadband internet and HDTV have brought about an enormous increase in data relay. Replacement of electrical processing functions by much faster optical ones and the potential of



'The 'Lab-on-a-Chip system' competence and platform approach of LioniX enables all kind of biochemical, genetic and microbiological analyses.'

► miniaturization stimulate the development of optical components for the telecom infrastructures (fibre-to-the-home). LioniX develops and produces optical 'systems-on-a-chip', which make possible faster and more efficient data and signal processing.

A good example is so-called 'Optical Beam Forming Networks' in ultra flat 'smart' antennas. These are designed to meet future requirements for broadband communications capable of maintaining user connections in trains, cruise ships and aircraft with telecom satellites, even at high speeds. The application is facilitated by the implementation of the company's proprietary planar waveguide technology 'TriPleX™' for 'true-time-delays' (TTD) with other required optical functions integrated in a system-on-a-chip. These TTDs make the steering of antenna beams without mechanically moving parts for broadband signals technically and economically feasible in the near future. Present microelectronics-based systems are far too expensive and sizable for such broader applications compared with those in telecom satellites. In this case LioniX is spinning out a new company SATRAX BV with the mission to become the leader in TTD-based electronic

beam-steering antenna systems in the market for real-time broadband SatCom applications for high-speed vehicles.

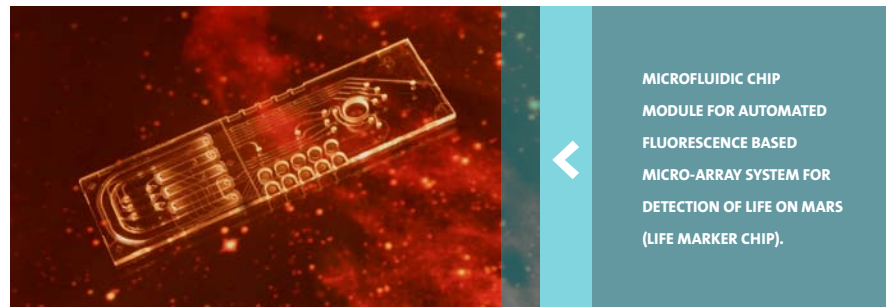
Integrated optics can also be found in biosensors. LioniX has developed a highly sensitive biosensor for real-time on-site monitoring of contaminants and biochemical substances in water. These sensors can be tailored for the detection of any specific chemical substance. They can be used for water quality monitoring, detection of contaminants in commodities, detection of biochemical warfare agents, monitoring of greenhouse gas levels and detection of bacteria and viruses. In the same application area LioniX' spin-out Capilix was founded in 2005 to develop proprietary micro 'Capillary Electrophoresis' (CE) platform technologies for on-line analysis in various 'water' related and industrial environments.

Revealing life on Mars

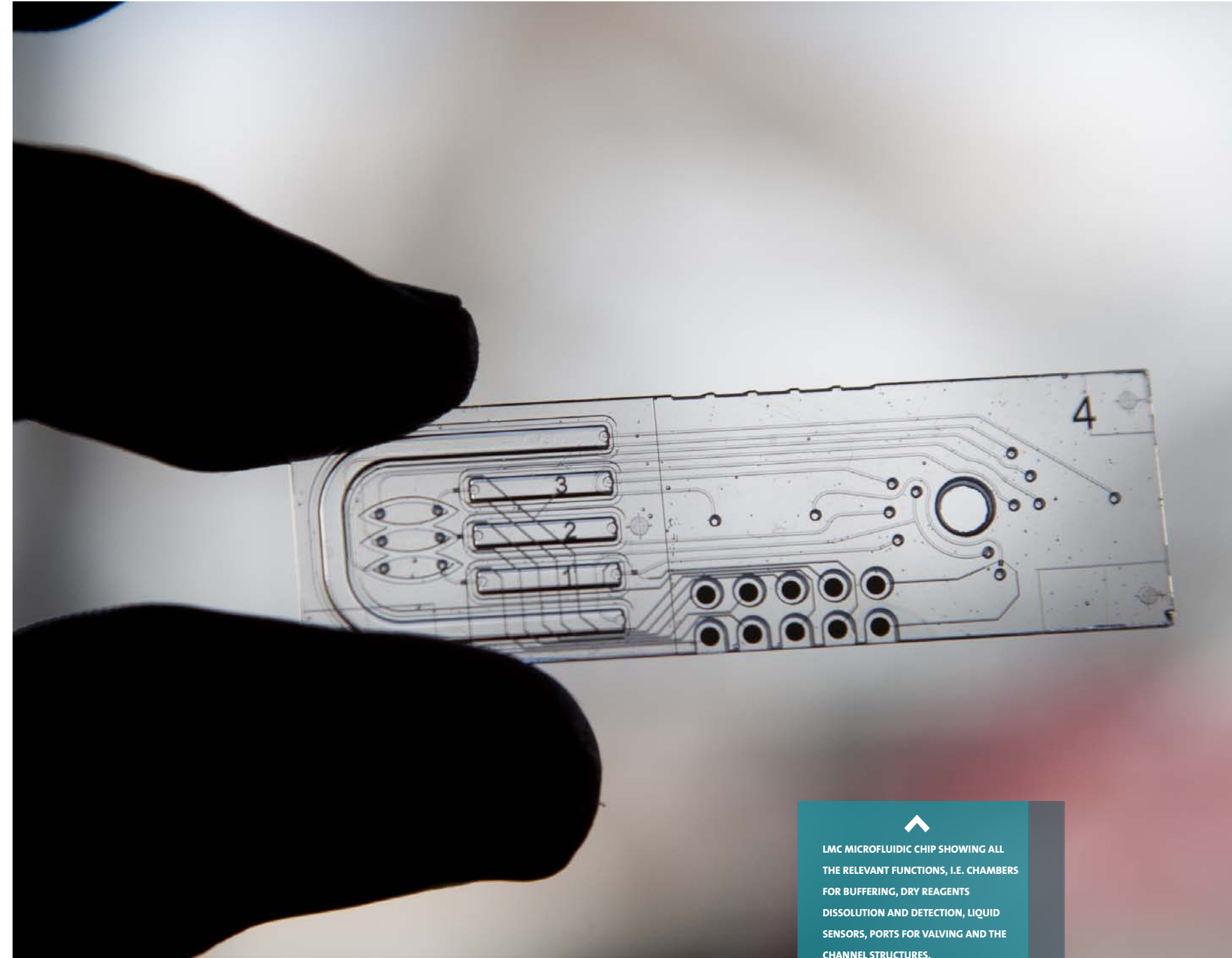
Establishing whether life ever existed on Mars, or is still present on the planet, is one of the great outstanding questions of our time. It is also a prerequisite to preparing for future human exploration of the red planet. To address this important objective, ESA and NASA will launch the ExoMars mission in 2018. The mission comprises a Mars Lander and a rover equipped with an analytical instrument suite and a drill in order to take rock samples up to two meters below the surface, as biomolecules do not survive the harsh surface environment. The Life Marker Chip instrument is dedicated to the detection of the biomolecules which would refer to life.

LioniX is involved in the mission with the design and fabrication of microfluidic and integrated optical chips right in the heart of the Life Marker Chip Instrument. It will be the only one capable of directly identifying molecules of unequivocal biological origin (the others rely on indirect methods) and it will be the first on Mars to do this. This instrument relies on novel laboratory-based antibody micro-array technology implemented in an extremely miniaturised instrument.

This is just one example of an endless array of possibilities when looking for crossovers and integrating the applications and systems that LioniX helps to develop.



MICROFLUIDIC CHIP
MODULE FOR AUTOMATED
FLUORESCENCE BASED
MICRO-ARRAY SYSTEM FOR
DETECTION OF LIFE ON MARS
(LIFE MARKER CHIP).



LMC MICROFLUIDIC CHIP SHOWING ALL THE RELEVANT FUNCTIONS, I.E. CHAMBERS FOR BUFFERING, DRY REAGENTS DISSOLUTION AND DETECTION, LIQUID SENSORS, PORTS FOR VALVING AND THE CHANNEL STRUCTURES.