NOT AS CRAZY AS IT SOUNDS: THE INKJET PRINTER MICRO-FACTORY

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Just imagine no longer using the household printer to make your birthday invitations, but instead for printing the batteries that power your small radio, or a loudspeaker for your MP3 player. “A crazy idea,” you say? “Not at all,” replies Jan G. Korvink, Director of the FRIAS School of Soft Matter Research. For four years, the engineer has been researching how inkjet printers can be successfully employed in manufacturing “working microsystems”.

“Almost everyone has a printer at home, but hasn’t the least idea of its potential. Inkjet printers allow us to print metamaterials, electronic components and sensor control systems cheaply and easily,” explains Jan Korvink. “I find the thought fascinating that in future, in place of pictures using four colours, we will be able to print specific components using four special materials.”

The idea came to the English-born professor whilst working on developing new sensors for nuclear magnetic resonance tomography with one of his MA students. “Many NMR sensors are deposited onto a defined base, a substrate. At some point during the experiments we asked ourselves, why don’t we simply print the sensors?” Jan Korvink recalls. Since then his team has been examining the behaviour of metals, various ceramics and special plastics, so-called polymers, in inkjet printers. The scientists are particularly interested in how the printed droplets behave both on making contact with the substrate and during drying. By observing the interaction between the deposited drops and the substrate, shown for instance by the contact angle, they gain information as to whether the material coats the substrate well, or whether it is liable to bead. The researchers also need to know whether all the constituent particles distribute themselves evenly in the drying droplets, or whether they increasingly migrate to the edge, which then appears noticeably darker than the inside of the droplet. “We call this unconventional behaviour of some liquids the coffee stain phenomenon,” explains one of the MA students.

He and his colleagues in the team also investigate which conditions are necessary to ensure that valuable nanoparticles do not clot, or how polymers survive the printing process in different solvents. “Or we test whether or not the drops are ejected from the print head at the correct speed, and dry on the substrate as desired,” says Jan Korvink, describing two of the many experiments which are necessary if the printing of functional microstructures is actually one day to be made possible. Of course it is also important for a certain material to always display the same properties, irrespective of how often the printing process is repeated.

And in addition, it is a great help that industry continues to work on advancing the printers: they are becoming ever better, and the droplets ever smaller. This is important for the team at the FRIAS School of Soft Matter Research, as it ultimately wants to print both micro and nano structures – on glass, metal and plastic. Several tricks can also be employed to make plastics electrically conductive; at the same time they are transparent and flexible. This combination of properties is extremely advantageous for certain applications, and is already the subject of enquiries from industry. “Electronic components need to become increasingly smaller, and mechanical flexibility plays an ever greater role,” Jan Korvink explains. His goal is therefore to produce “transparent electronics from jet nozzles – for sensors, electrodes or display screens.”

Structures made from silver ink are also considered for application in increasingly tiny electronic components, and are already printed in Jan Korvink’s laboratory. The silver lines which, after being heated once, can conduct electricity, are just 30 micrometres thick, half the width of a hair. “Within only half an hour, we can print microstructures which, in a classic electroplating process, would need to be left to grow layer by layer,” explains the FRIAS Director. Together with a team led by Dr. Markus Walther from the university physics department, they have used this method to develop printed metamaterials for Terahertz optics.

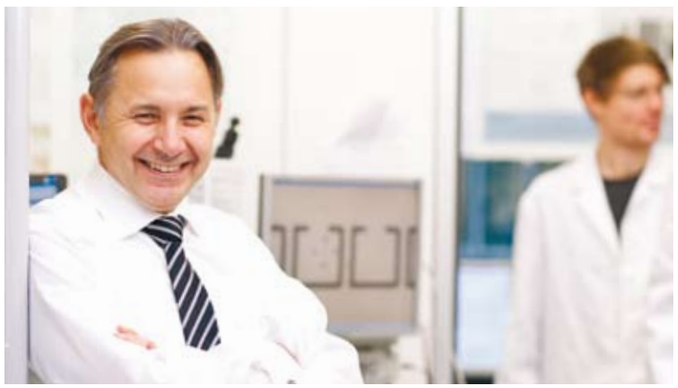
However, not only inanimate material is pushed through the print head nozzles in his laboratory. In collaboration with Osamu Tabata, External Senior Fellow of the FRIAS School of Soft Matter Research, the group is also experimenting with DNA. The genetic molecules provide a shaping substance for forming “intelligent polymers”. Three-dimensional structures are also conceivable which could organise their own spatial arrangement thanks to the chemical properties of the DNA.

Although some of these projects may appear to the layperson to be pure science fiction, several groups have proven that it is possible to print materials which truly function. And the FRIAS Director is bursting with ideas for further applications, such as the use of inkjet printers in micro-manufacturing micro NMR sensors. “We will then be able to build sensors for MRI scanners completely differently, much more cheaply and compactly, and will be able to use this technology for entirely new applications,” enthuses the engineer. He wants to see them used in environmental technology for identifying specific chemicals, or in food monitoring systems. In future, they may therefore contribute to changing the fact that half of all foodstuffs are lost on the way from field to consumer.

The engineer envisages a molecular sensor that can be read by magnetic resonance scanners, which could be integrated into food packaging and recycled along with it.

These projects no longer “only” focus on developing inkjet printers for the production of “intelligent” micro components. Entire systems are needed for these applications, and they can only be achieved through collaborations. One of Jan Korvink’s important co-workers, who was also involved in earlier research work on nuclear magnetic resonance technology, is Jürgen Hennig, a medical physicist at the Radiology Clinic of Freiburg University Hospital and former Internal Senior Fellow in an interdisciplinary research group at FRIAS. The FRIAS Director also collaborates with other FRIAS Fellows, such as Pep Espanol, Sauro Succi and Miko Elwenspoek, on work mainly dedicated to his second research focus: simulation tools for designing better micro and nano systems. “It is immensely stimulating to discuss things with the other Fellows, to find crossovers in our research projects and then to devise joint strategies,” concludes Jan Korvink, who greatly values the environment in the School of Soft Matter Research.

Dario Mager, head of the inkjet printing team.



Jan G. Korvink at his lab.