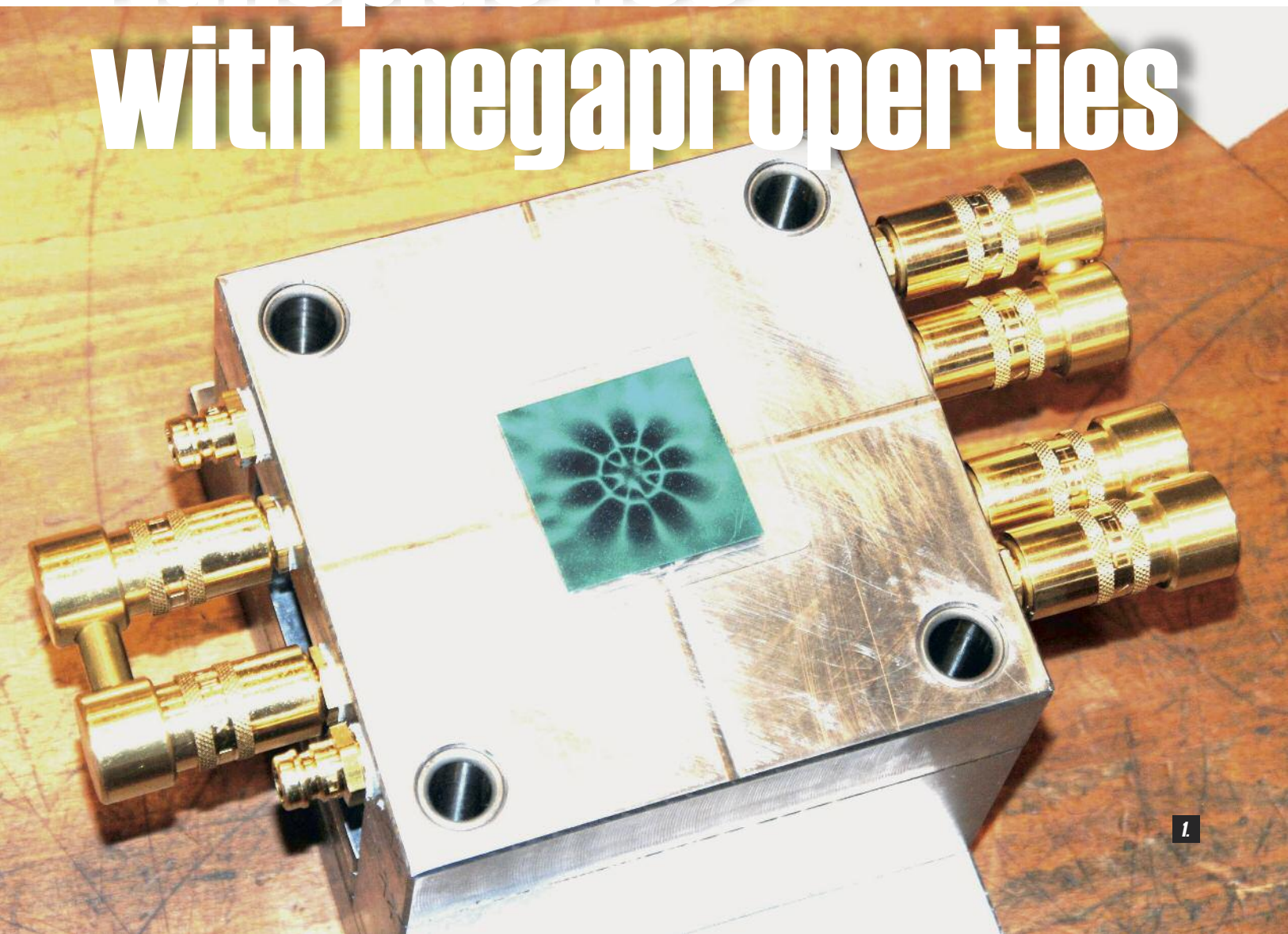
The Institute for Applied Plastics Research (iRAP) in Fribourg deals with most activities in polymer processing, with a concentration on two main areas: materials with high added value, their improvement and selection, and the processes linked to developing ecodesign in plastics with a focus on injection molding.

Nanoplastics with megaproperties



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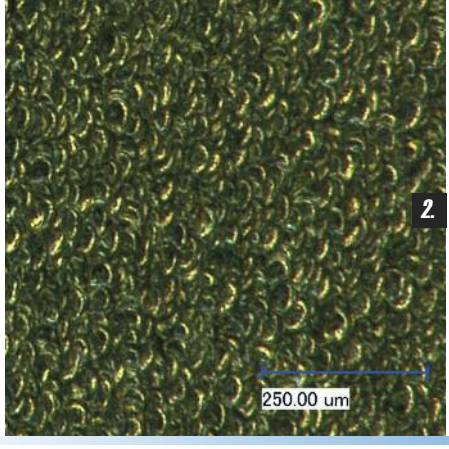

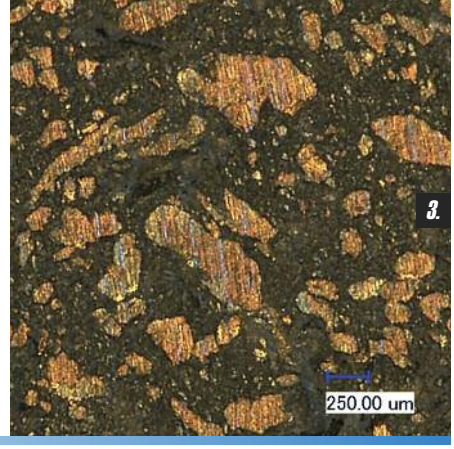

1. Injection mold with an integrated magnetization technology. The lines on the blue piece visualize the magnetic field of an injected composite magnet.

2. Laser texture on a mold surface. The effect of textures and coatings on demolding of the polymer was analyzed. The blue bar corresponds to 250 micron.

3. Network formed by electrically conductive fillers (bright red) in a plastic matrix (brown). The blue bar corresponds to 250 micron.

The iRAP Institute at the School of Engineering and Architecture in Fribourg has several key projects in the domain of micro and nano materials.

What is the Eurostar «Superslip» project for instance?
In the context of an European project, we evaluate the influence of surface coatings and surface textures on plastic parts sticking to the injection mold. A specific test mold was conceived in order to install cylindrically shaped inserts and to measure the force arising during the ejection phase. The ejection force is directly correlated with the polymer sticking to the mold's surface; this was used as criterion for the effect of a surface treatment. Figure 2 shows a typical laser surface texture that was characterized in this project. The Superslip project brought to light a new generation of CrN-based surface coating that was combined with ion implantation.

What about «SigmaPlast» project?
The «SigmaPlast» project represents indeed one of the main strategic axes of the iRAP Institute and is carried out in collaboration with eight industrial partners. It falls within the field of polymers with high added value. We have assessed the potential and durability of highly electrically conductive hybrid polymers for a potential application for circuit boards in electronic or mechatronic products. Hybrid conductive polymers are systems composed of a plastic matrix with a network of electrically conductive fillers (see Figure 3) capable of conducting electric currents and/or thermal heat fluxes as well as serving as an electromagnetic shield. An important outcome of the SigmaPlast project was the development of a new hybrid polymer suitable for conducting high electric currents of several amperes.

In your **«Dielectric and magnetic nanofillers» project,** using nanoparticles allowed you to greatly increase the **dielectric response of a polymer?**
Polymers are systematically used as insulating components in electric storage media such as capacitors. However, polymers commonly show a very low dielectric response that therefore lowers the electric storage capacity. In this project, we demonstrated that silica-coated iron oxide (hematite) nanoparticles integrated in a PMMA matrix were able to increase the dielectric response by a factor of 15. Furthermore, the iron oxide provides a tunable magnetic response that enables control of the dielectric and magnetic properties of polymers by integrating one single filler material.

«Polymers with high added value are one of the main strategic directions of the iRAP Institute.»

Dr Stefan Hengsberger, professor of physics and nanotechnology, member of the institute iRAP

A similar principle in your **«Magplast» project** involving **nanomagnets?**
The objective of the Magplast project was to inject polymer pellets into the mold that were highly filled with ferromagnetic particles in combination with a magnetization of the plastic part (see Figure 1). One of the project's main challenges was the conception of the mold with an integrated magnetization technology that can withstand the injection pressures and temperature. Nowadays, we manage the production of composite magnets with our partner's specifications and the technology is now integrated into their production line.

Also a start-up developed a new technology for micro-/ nanostructuring tools used in **injection molding?**
The micro-/ nanostructuring of polymer surfaces offers tremendous potential for added functionality to be integrated into plastic products, such as holographic optical effects for security features. The start-up company Morphotonix (www.morphotonix.com) faced the challenge of developing a new technology for the direct micro-/nanostructuring of tools used in injection molding. The quality of the grating reproduced on the plastic part was investigated by changing the different parameters of injection molding and of the grating. In this project we could demonstrate that the quality of the plastic reproduction depended greatly on mold temperature, viscosity of the plastic, injection speed and direction, and back pressure.

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