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To the website: www.ist.fraunhofer.de/en.html

HEATING CONDUCTORS FOR LOCAL TEMPERATURE CONTROL OF MICRO-SIZED PLASTIC INJECTION MOLDS

In the production of moldings by the injection of thermoplastic, thermosetting or elastomeric materials, flaws or defects can arise in the surface quality of the plastic molding. In addition, defects also frequently arise when the heated material solidifies unevenly due to contact with the colder mold wall, thereby reducing its flowability too rapidly. Since the melt by cooling too rapidly does not fill out all mold cavities, the production of optical molded parts, the accurate reproduction of microstructures, or the production of thin-walled parts is, for example, not possible. This represents a major problem especially in the field of miniature and micro injection molding. The Fraunhofer IST is therefore pursuing the approach of using thin-film heating elements specially developed for use in the injection mold in order to heat directly the area where the melt is in contact with the mold wall and thus achieve a high quality of contour reproduction accuracy during the injection-molding process.

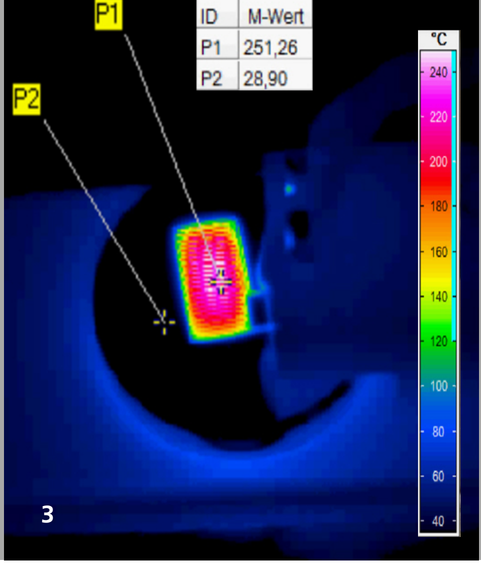
Preparation of the sensorized thin-film system

At the beginning of the development process, the first step was to construct base bodies from ceramic material with heating structures made of copper. In a second step, steel base bodies were then used which were coated homogeneously with insulating layers of Al_2O_3, afterwards heating structures were added. Both the insulation layers and the copper layer were deposited by the physical vapor deposition process. During the development process, heating structures with different layer thicknesses and designs were created at the Fraunhofer IST. An example of a meander-shaped heating structure is shown in Figure 1. It was found that significantly higher heating output levels could be achieved with the more complex meander design. Figure 2 shows a first micro-sized injection mold with a heating structure of this kind. A new structuring process was developed for production, consisting of a combination of photolithography, laser structuring and wet chemical etching.

Verifying the functional capability of the heating structures

In order to verify the functional capability of the heating structures, they were provided with electrical contacts at the Kunststoff-Zentrum in Leipzig gGmbH (KUZ) and power applied to them in a test rig (see Figure 3). Here a high dynamic in the heating rates was obtained as a function of the resistance achieved, depending on the design of the heating structure. Accordingly, a temperature increase of 100 K from a tempera-

Fraunhofer Institute for Surface Engineering and Thin Films IST | Bienroder Weg 54 E | 38108 Braunschweig | Germany



ture level of 373 K to 473 K was, for example, possible within a second at an output of approx. 120 W (energization with a protective extra-low voltage of 30 V). In a second test set-up it was also possible to carry out successful long-term tests with the aforementioned parameters involving around 60,000 test cycles. No damage to the layer was detected, even after the long-term tests. This indicated general suitability for the first utilization of heating layers under exposure to injection molding stresses.

Outlook

In the next step the Fraunhofer IST, in collaboration with the Kunststoff-Zentrum in Leipzig gGmbH (KUZ), aims to provide the heating structures with a final abrasion-protection coating and to investigate the long-term stability of the structures. As part of the "R&D funding of non-profit external research institutions in eastern Germany (INNO-KOM-OST) – Market-oriented research and development module (MF)" this project will continue to be supported by the Federal Ministry of Economics and Technology (BMWi).

1 *Flat base bodies showing the process steps: steel coated with Al_2O_3 (back left); with insulation and copper layer homogeneously deposited on it (back right); with meandering heating structure (front).*

2 *Micro injection mold with copper heating structure.*

3 *Thermographic image of a meander-shaped heating structure connected to a 40 V voltage, thereby producing a thermal output of 180 W (temperature rise of 170 K in 3 s from 353 K to 523 K).*

CONTACT

Dr. Saskia Biehl
Phone +49 531 2155-604
saskia.biehl@ist.fraunhofer.de