PAUL SCHERRER INSTITUT PSI

n|w Fachhochschule Nordwestschweiz
Hochschule für Technik

INKA NANOTECHNOLOGY

INSTITUT FÜR NANOTECHNISCHE KUNSTSTOFF-ANWENDUNGEN

APPLYING NANOTECHNOLOGY IN POLYMERS CREATES INNOVATIVE SOLUTIONS IN GROWING MARKETS

We are experiencing a rapidly growing market for innovative products in microsystem-technology. In particular the life-sciences call for disposable microsystem-solutions in polymers. In analytical systems for example, microfluidic components fabricated in cards or compact discs are already on the market. These systems can be supplied with additional functions through integration of micro- and nanostructures which for example can alter or optimise surface properties or add sensing functions. Currently many prototype microfluidic systems are made of silicon chips because this technology is readily available in many labs. Alternative polymer chips can not only be mass-fabricated at lower cost, but provide additional advantages such as high transparency, bio-compatibility and easy handling and disposal.

New application areas will open up through the modification of polymer surfaces by micro- or nanopatterns with topological and/or chemical contrast, the so-called "lotus-effect" being a prominent example. In general, micro- and nanopatterning of polymer surfaces allows the controlled modification of their optical, mechanical, chemical and several other properties.

Many polymer parts and structures in components continuously become smaller and traditional toolmaking for replication of thermoplastic materials is reaching its limits. At the same time, nanoscience has discovered new properties and functions of nanostructured materials and surfaces, but no viable fabrication technologies are available yet. Both reasons suggest to combine the competences in micro-/nanotechnology and polymer engineering to enable advanced research and development for future nano-products. This is the core motivation for the founding of INKA which can offer this combination for interested research partners.

Facsimile of Gutenberg bible page

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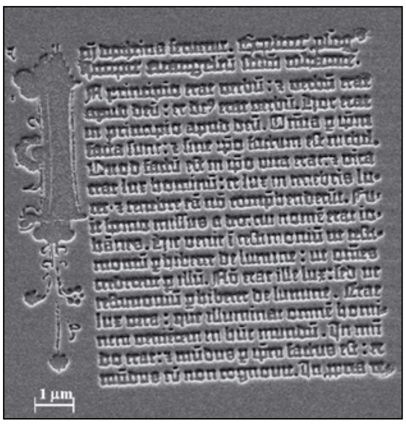


Bible page replicated by injection moulding on compact disc. Height of letters: 300 nm

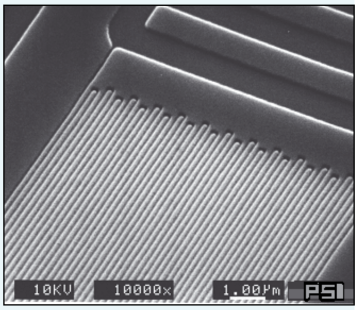
BACKGROUND

In December 2004 the Paul Scherrer Institut Villigen/Schweiz (PSI) and the University of Applied Sciences Nordwestschweiz (FHNW) together founded the "Institut für nanotechnische Kunststoff-Anwendungen, INKA", in English "Institute for Application of Polymers in Nanotechnology". The PSI has a long tradition in scientific research in particular in conjunction with large facilities like neutron- or synchrotron sources. More than 10 years ago the Laboratory for Micro- and Nanotechnology (LMN) was founded within the PSI and has developed into a major player on an international level in selected areas of nanotechnology. The FHNW operates since many years the only polymer technology center IKT (formerly ZKA) in Switzerland where students can take undergraduate and graduate courses in polymer engineering and technology. A close cooperation with the "Kunststoff-Ausbildungs- und Technologiezentrum (KATZ)" in Aarau/Switzerland safeguards up to date research and educational resources.

FHNW - Technik main campus at Windisch

Inside of PSI-SLS building

GOALS AND SYNERGIES



Master for embossing of interdigitaded electrodes for a micro-electrochemical sensor

The strategic goal for INKA is to become the preferred research partner in Switzerland and elsewhere for companies and institutions who require innovative solutions in polymers where small dimensions are of relevance.

INKA builds on the existing strengths and competences of the PSI and FHNW and fully exploits the synergy between these institutions. PSI thus gets access to polymer technology, engineering know-how and talented students, the FHNW on the other hand can access scientific know-how of PSI, a unique research infrastructure including clean-room laboratories, advanced analytical equipment etc. So INKA will develop into a research partner who can offer the complete set of competences for problem-oriented research in the fields envisioned. Last but not least INKA will be very attractive for students since it can offer training and education in one of the most advanced, interdisciplinary research fields.

Press in cleanroom for hot embossing lithography of nano-patterns in polymer-layers

COMPETENCES AND FACILITIES OF INKA

The toolmaking for micro- and nanoreplication is done at the PSI-clean room laboratories (>300 m^2 class 10 or 1000). There INKA is provided with state of the art processes:

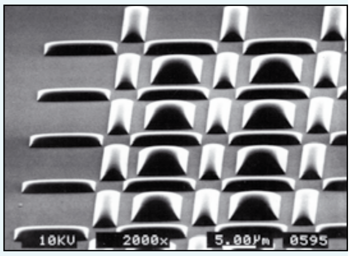
- Lithography: optical (up to 200 mm Ø substrates), electron-beam, X-ray (13 nm EUV exposure),
- Pattern-transfer: wet and dry etching, nickel electroplating,
- Thin-film technology: several CVD and PVD equipment.

Polymer engineering laboratory at FHNW/Technik

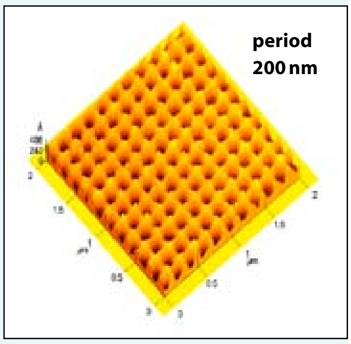
In addition, we operate several hot-embossing machines in a clean-room environment for micro- and nanopatterning of substrates up to 150 mm Ø.

A unique capability is the X-ray interference lithography (XIL) setup at the Swiss Light Source (SLS). Here we can expose periodic nanopatterns into polymers with feature sizes down to 15 nm.

Injection-moulding, extrusion and other polymer processing capabilities are available at the FHNW and the KATZ. All this is completed by a vast variety of modern analytical equipment such as scanning electron microscopes, several atomic force microscopes, optical characterisation tools etc.



Test-pattern in polycarbonate for optimising micro-injection



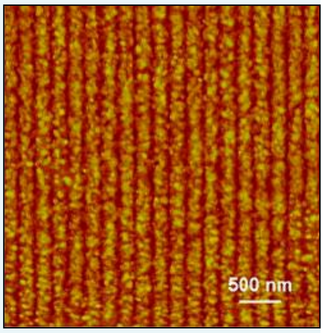
Calibration chip in polycarbonate for scanning probe microscopes

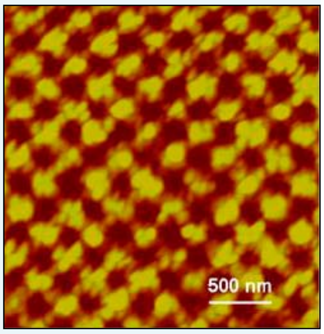
RESEARCH PROJECTS

Several successful research projects in the area of polymer micro- and nanostructuring have been carried out jointly by PSI and FHNW in the past years which form a reference basis for a successful future. Corporate partners in these projects were: Bayer AG, Leverkusen; AWM Moldtech, Muri; OVD Kinegram, Zug; Leister, Sarnen; Nanosurf, Liestal and others. Some of the results are given in the publications listed below. INKA has recently started with smaller projects with several industrial partners. Others are under negotiation.

We are looking for research topics and problem-oriented projects in the field of interest of INKA which shall be carried out in a close and trustful cooperation with industrial or academic partners. There are possibilities for

- small or exploratory projects, e.g. carried out by students in the form of a semester- or diploma thesis at practically no cost to the partner,
- more extensive and longer term projects to be carried out by professional staff, which can be partially financed for example through the Swiss CTI-scheme or directly by the partner.





Grafted nanopatterns of polymer-brushes on ETFE using a proprietary PSI process

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FURTHER INFORMATION

Please consult these web-sites
http://www.fhnw.ch/technik/inka
http://lmn.web.psi.ch

Relevant Publications

H. Schift, J. Gobrecht, B. Satilmis, J. Söchtig, F. Meier, W. Raupach; "Nanoreplication in a network", Kunststoffe-plast europe 6 (2004) 22 – 26

S. Park, H. Schift, C. Padeste, B. Schnyder, R. Kötz, J. Gobrecht; "Anti-adhesive layers on nickel stamps for nanoimprint lithography"; Microelectr. Eng. 73-74, (2004) 196 – 201

H.-P. Brack, C. Padeste, M. Slaski, S. Alkan, H. Solak: "Preparation of micro- and nanopatterns of polymer-chains grafted onto flexible polymer substrates", J. Am. Chem. Soc. 126 (2004), 1004 – 1005

H. Schift, S. Park, J. Gobrecht: "Nano-Imprint Molding Resists for lithography", J. Photopolymer Sci. Technol. (Japan) 16, No 3, 435 (2003)

H. Schift L. J. Heyderman, C. Padeste, J. Gobrecht: "Chemical nano-patterning using hot embossing lithography", Micoelectronic Eng. 61-62, 423 (2002)

H. Schift L. J. Heyderman, J. Gobrecht: "Efficient replication of nanostructured surfaces", Chimia 56, 543 (2002)

L. J. Heyderman, H. Schift, C. David, B. Ketterer, M. Auf der Maur, J. Gobrecht: "Nanofabrication using hot embosssing lithography and electroforming", Microelectronic Eng. 57-58, 375 (2001)

H. Schift, L. J. Heyderman, M. Auf der Maur, J. Gobrecht: "Pattern formation in hot embossing of thin polymer films", Nanotechnology 12, 173 (2001)

L. J. Heyderman, H. Schift, C. David, J. Gobrecht, T.F. Schweizer: „Flow behaviour of thin polymer films used for hot embossing lithography" Microeletronic Eng. 54, 229-245 (2000)

S. Köppel, H. Schift, M. Gabriel, W. Kaiser: "Spritzguss stösst in immer kleinere Dimensionen vor", Kunststoffe/Synthetics 2/1999

Master-structure of nano-optical element. Outermost zones are 40 nm wide