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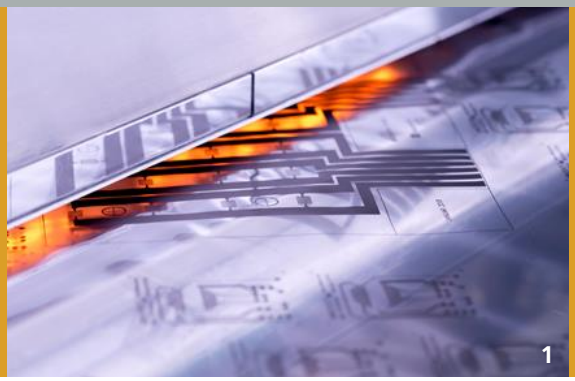
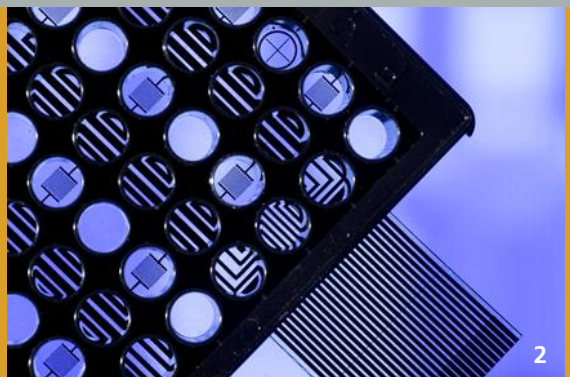




1 *Roll-to-roll printing: Close-up view of printed sensor foil in near-infrared (NIR) drying unit.*
2 *Roll-to-roll printed sensor foil assembled with 96 well plate.*

Functional printing for biological and medical applications

Fraunhofer Institute for Biomedical Engineering IBMT
Prof. Dr. Heiko Zimmermann
Joseph-von-Fraunhofer-Weg 1
66280 Sulzbach
Germany

Contact

Cell Models & Toxicology
Thorsten Knoll
Telephone +49 6897 9071-452
Fax +49 6897 9071-402
thorsten.knoll@ibmt.fraunhofer.de

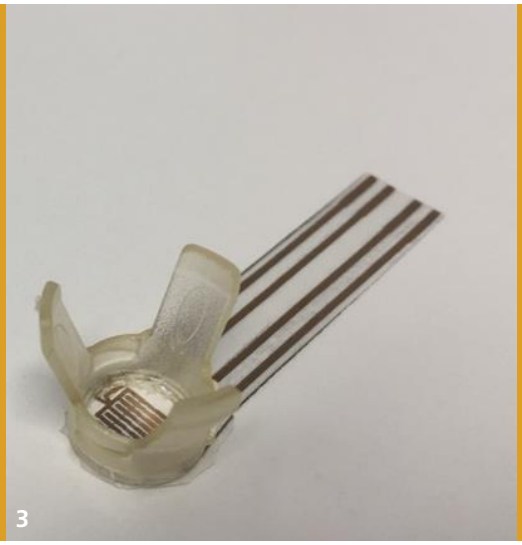
www.ibmt.fraunhofer.de

Description

IBMT has developed methods for printing functional structures on polymer foils for biological and medical applications. Depending on the feature size, the materials and the desired manufacturing volume, either roll-to-roll gravure printing, ink-jet printing or screen-printing is used. Functionalized surfaces with protein patterns for improved cell adhesion or directed growth of biological cells can be realized as well as electrically conductive structures, e.g. for skin electrodes. Using adhesive layers, the printed films can be integrated into cell culture devices (Petri dishes or culture plates) or can be applied directly to the site of use, for example on the skin. Ink-jet printing and screen-printing provide design flexibility whereas roll-to-roll printing is suited for large volume production.

Advantages

- Functional inks on flexible substrates
- Biocompatible materials
- Low equipment costs
- Large-area surface functionalization
- Hardly any waste
- High throughput (mass production)
- Wide range of micro structures (20 µm – centimetres)



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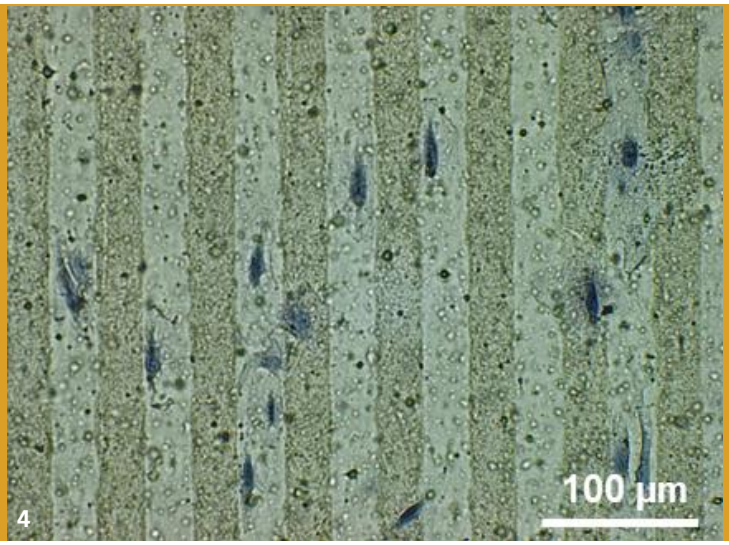

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Examples of applications

Electrical cell impedance spectroscopy
Printed sensor foils with carbon-based electrodes are used as bottom part of culture plates. Cells grow directly on the sensor foil that directly measures cell impedance and gives online information about the behaviour of the cell layer.

Skin sensors
The foils with electrically conductive sensor structures are combined with adhesive films. These serve as electrical insulation for the electrode tracks and for the connection of the sensor foil with the skin or other surfaces. Possible applications are measurement of sweat, EEG, EMG.

Cell cultures
Fraunhofer IBMT has successfully functionalized large area foils by protein microstructures for directed growth of cells or for influencing cell adhesion. The correspondingly functionalized foils can be applied in cell culture dishes or flasks. Furthermore, bigger protein spots can be used for selective cell adhesion at defined areas on the substrate.

Technical data

Foil materials: PS, PP, PET, PU, PI
Inks: Carbon, graphene, silver, gold
Typical foil thickness: 50 – 150 µm
Typical foil width: 0.2 m
Smallest printable structures

- Roll-to-roll printing : 20 – 50 µm
- Ink-jet printing: 80 µm
- Screen printing: 100 µm

Literature

A. Schultz et al. (2019), "Novel Cost-Efficient Graphene-Based Impedance Biosensor for the Analysis of Viral Cytopathogenicity and the Effect of Antiviral Drugs", Frontiers in Bioengineering and Biotechnology 9.

T. Knoll et al. (2016). "High-resolution gravure printing of graphene biosensors," Proceedings of The Global Conference on Micro Manufacture, Incorporating the 11th International Conference on Multi-Material Micro Manufacture (4M) and the 10th International Workshop on Microfactories (IWMF) (4M/IWMF2016), Kongens Lyngby.

Our offer

- Development of biomedical devices with printed structures
- Printing of customised microstructures on foil substrates
- Development of customised printing processes suited for mass production
- Biological testing of material combinations (substrate + ink) according to ISO 10993

3 *Ink-jet printed sensor foil assembled with cell culture device.*
4 *Roll-to-roll printed protein patterns with cultivated cells on PET film.*