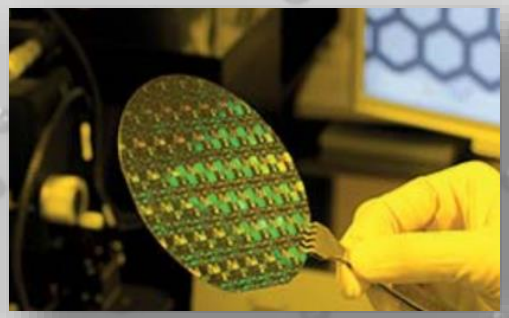
EPIC Meeting on Wafer Level Optics 2019, 7-8 November 2019, Neuchâtel, Switzerland

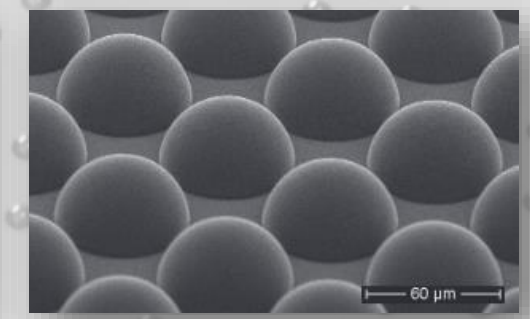
Cross-functional photopolymers for microoptics manufacture

Arne Schleunitz, Chief Technology Officer

micro resist technology

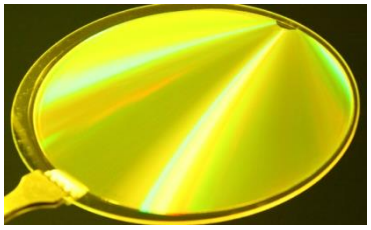
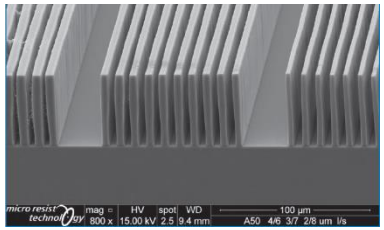
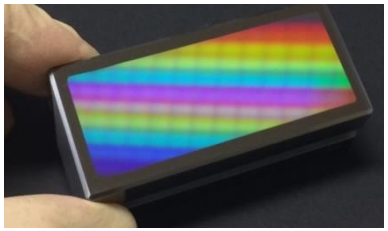
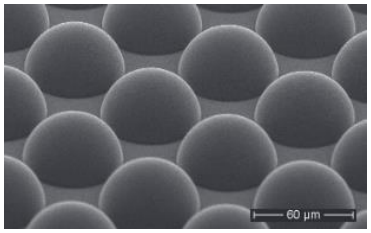
EPIC
European Photonics Industry Consortium

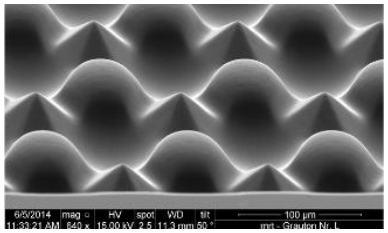
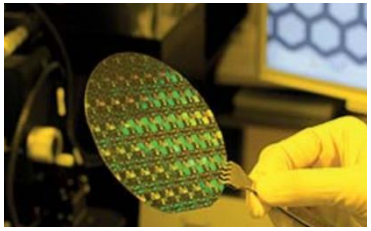
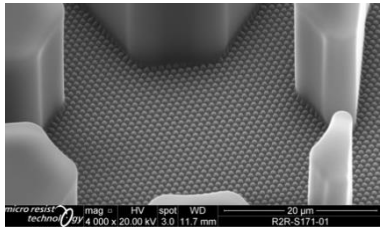
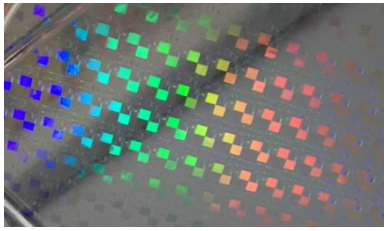




micro resist technology – Who we are …

Specialized in providing innovative (photo)resists, (photo)polymers and ancillaries, we support our high-tech costumers as a single entry point to high performance materials, technologies and process solutions

- *Established:* 1993
- *Employees:* 50+ (2019)
- *Location:* Berlin, Germany (Corporate office, logistics and manufacturing)
- *Facility*: 3.450 m² incl. clean room (300 m²)
- *Certifications:*
  ISO 9001:2015
  ISO 14001:2015

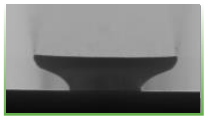
TÜVRheinland® CERT ISO 9001 ISO 14001

- *Fields of business activities:*
  - Manufacturing: formulation / synthesis
  - Customer services / Application engineering
  - Researching advanced materials and processes
  - Lithographic services

micro resist technology – What we offer …

Negative Photoresists

UV lithography



Lift-off process
Etch mask, Inkjet Printing
Mould for electroplating
SM & MM waveguides

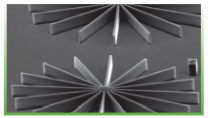
ma-N 400 EpoCore InkEpo
ma-N 1400 EpoClad

E-Beam/ Deep UV lithography

Etch mask
Stamp/
template manufacture

ma-N 2400
mr-EBL 6000

Laser lithography @ 405 nm, 2PP



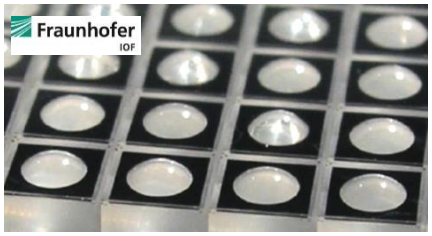
Mould for electroplating
Stamp/
template manufacture

mr-DWL

X-ray lithography

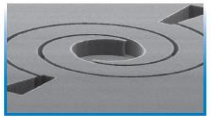
Mould for electroplating
Stamp/
template manufacture

SU-8
SU-8 2000
mr-X



Positive Photoresists

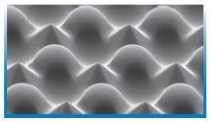
UV lithography



Microsystems technology
Mould for electroplating
Etch mask

ma-P 1200
ma-P 1275
ma-P 1275HV

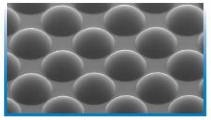
Greyscale lithography



Master generation

ma-P 1200G

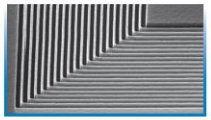
Thermal reflow



Microlens fabrication

ma-P 1200G
ma-P 1200/ HV

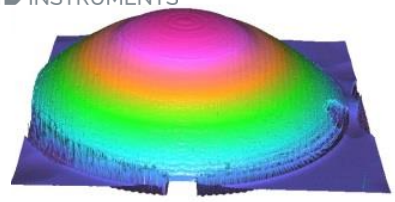
E-Beam lithography



Etch mask
Template fabrication

mr-PosEBR

HEIDELBERG INSTRUMENTS



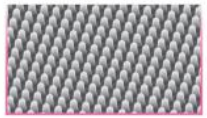
Nanoimprint Materials

Thermal nanoimprint

Etch mask
Micro/nanofabrication

mr-I 7000R
mr-I 8000R
mr-I 9000M
SIPOL

UV-NIL, Photo-NIL



Etch mask
Micro/nanofabrication

mr-NIL210
mr-UVCur21
mr-XNIL26
mr-NIL6000E

Roller-type nanoimprint

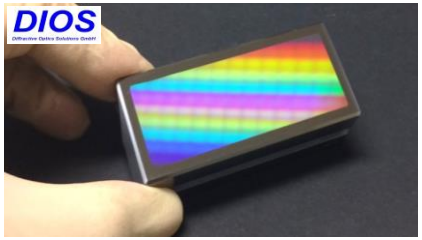
High throughput process
Permanent applications

mr-UVCur26SF

Working stamps

UV replication
Polymer stamp fabrication

OrmoStamp®



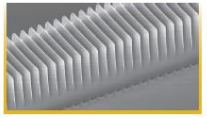
Hybrid Polymers

Micro optical components

UV replication/ imprint
Inkjet printing
Direct laser writing/ TPA

OrmoComp®
OrmoClear®FX
OrmoClear®
InkOrmo

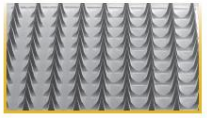
Optical waveguides



UV replication/ imprint
UV lithography

OrmoCore
OrmoClad

Bio applications



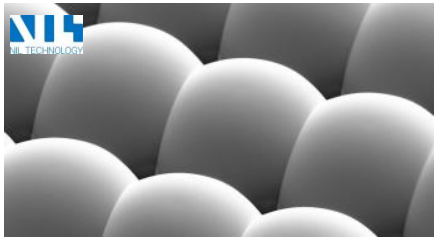
UV replication/ imprint
Direct laser writing/ TPA

OrmoComp®
OrmoClear®FX

Transparent polymer molds

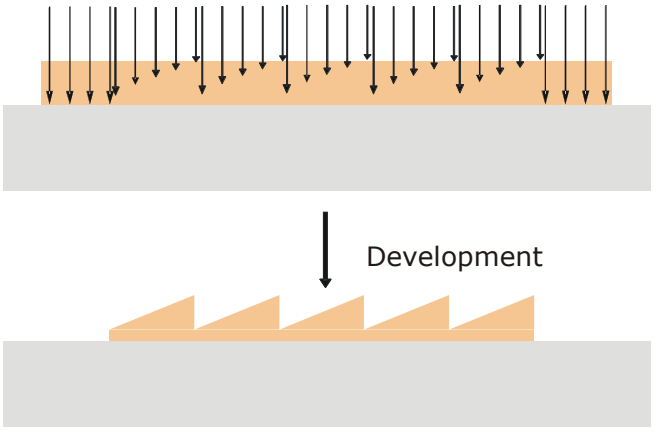
UV replication/ imprint

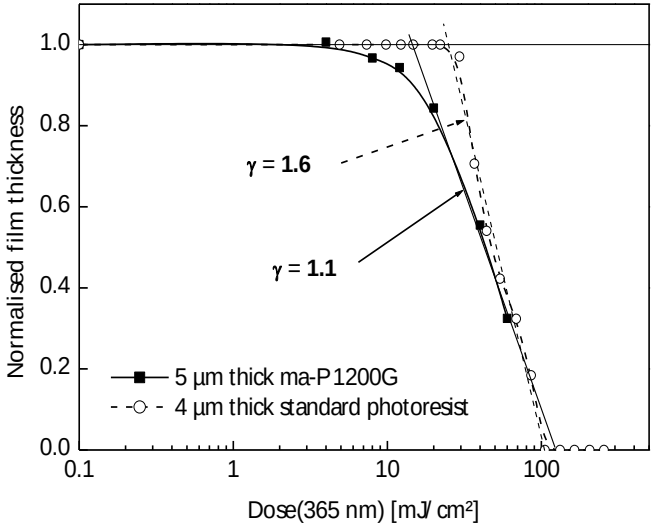
OrmoStamp®



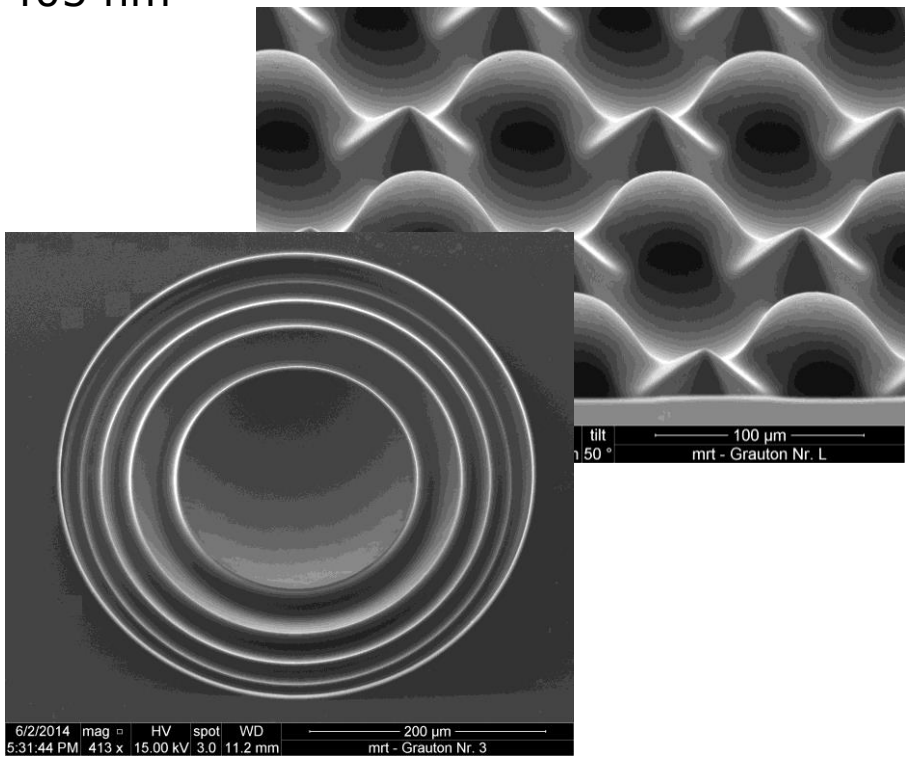
ma-P 1200G – Optimized photoresist for greyscale resist master

UV-laser direct writing (dose variation) into positive tone photoresist





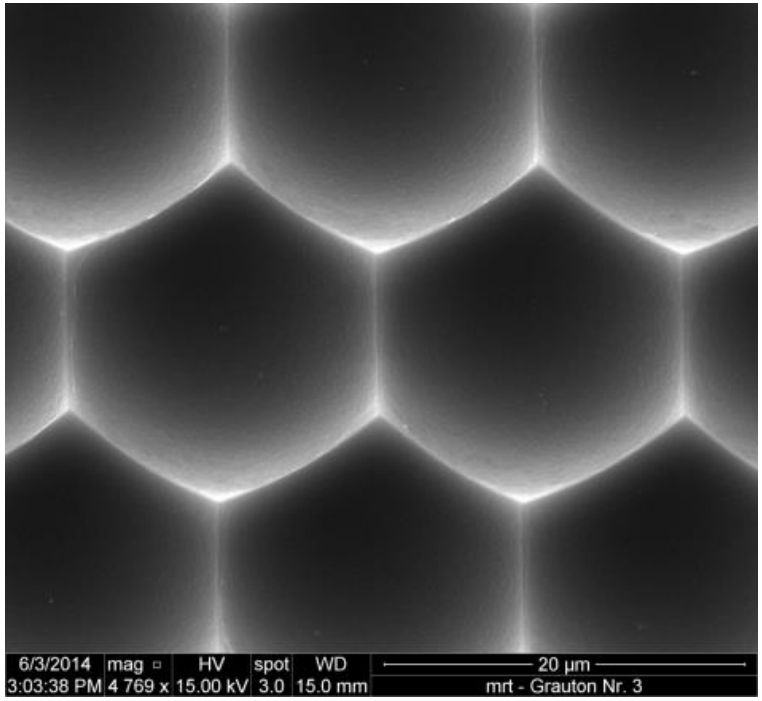
Patterning examples ma-P 1275G (~ 30 µm) exposure with HIMT DWL66+ @ 405 nm



C. Schuster et al., Proceedings of the 41st Micro and Nano Engineering (MNE2015), 21-24 September 2015, Wed-A-p47.

Patterning examples for micro-lens array and individual micro-lens

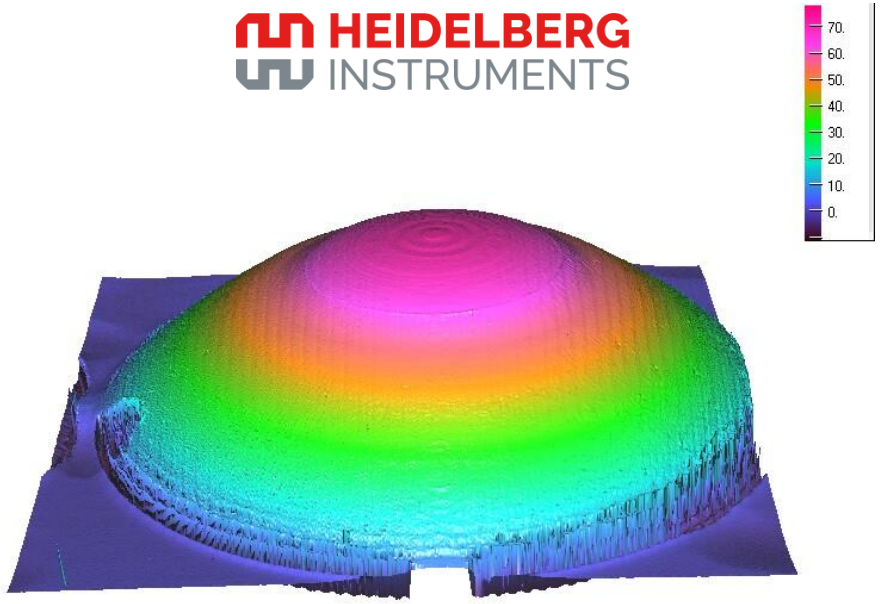
State-of-the-art



MLA exposure with **DWL66+** at 405 nm, thickness: 40 µm

Update 2019

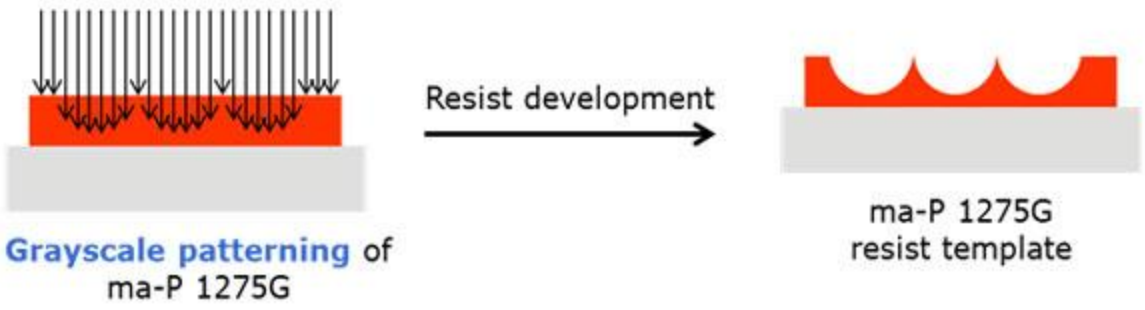
HEIDELBERG INSTRUMENTS

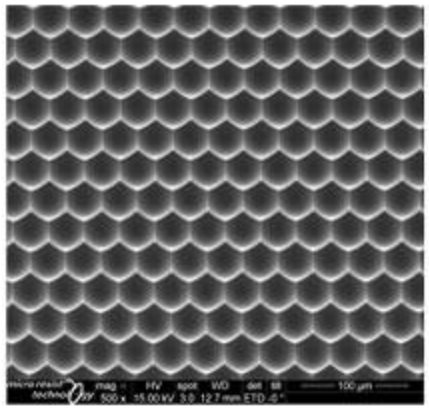


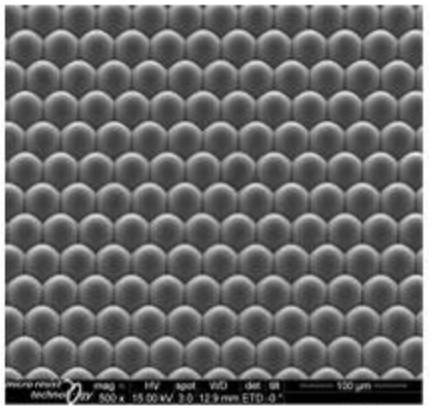
micro lens height: 80 µm

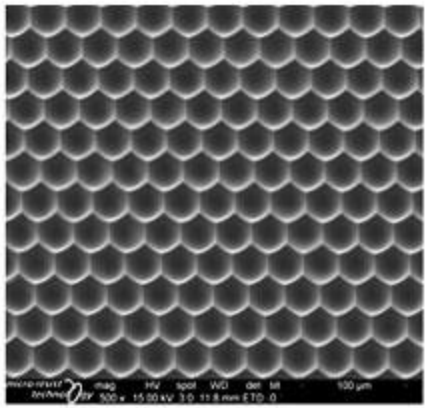
Micro lens exposure with **DWL 66+** at 405 nm, writemode III, 100 mW

ma-P 1200G – *Resist master fabrication and replication*





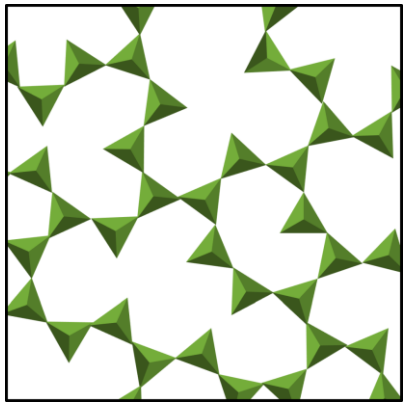




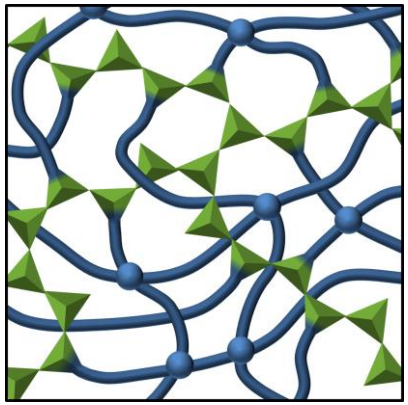
UV-curable inorganic-organic Hybrid Polymers

Multifunctional lithography material with negative tone resist behavior and custom-designed properties

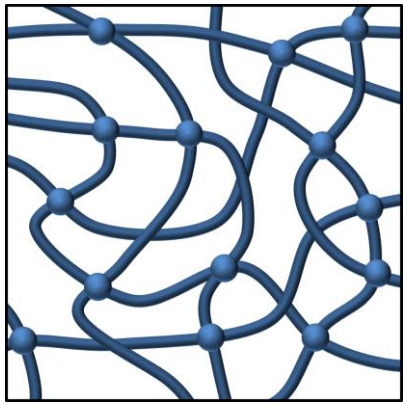
Inorganic Glass



Hybrid Polymer



Organic Polymer



Mechanical stability
Transparency
Thermal stability
…

Adhesion
Optical properties
Flexibility
…

Crosslinking
Photoimagible
Elasticity
…

Functionalization

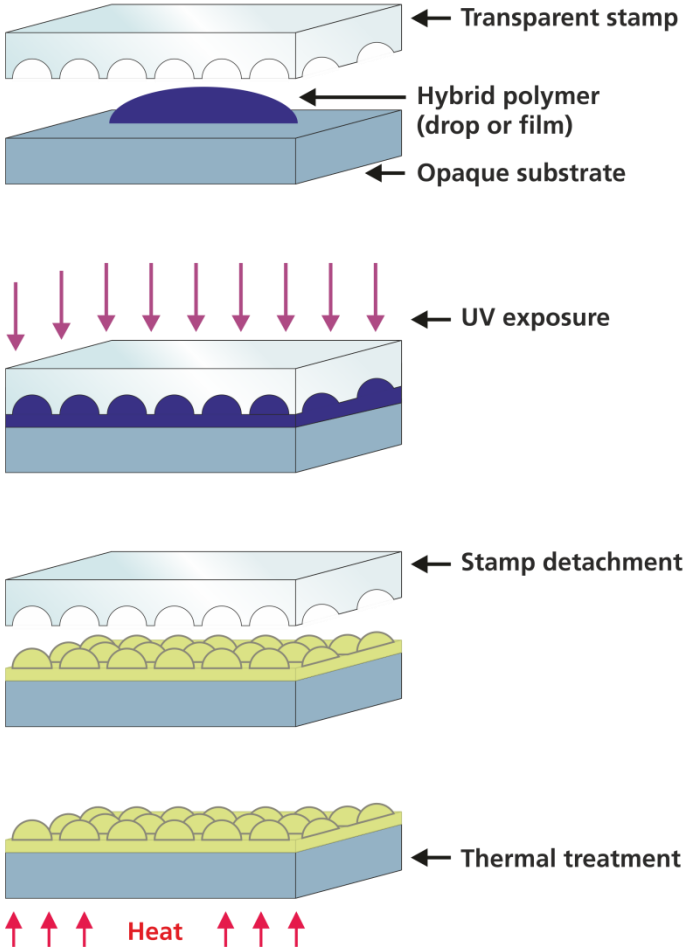
Fraunhofer ISC

Based on ORMOCER® technology licensed from the Fraunhofer Gesellschaft in 2002

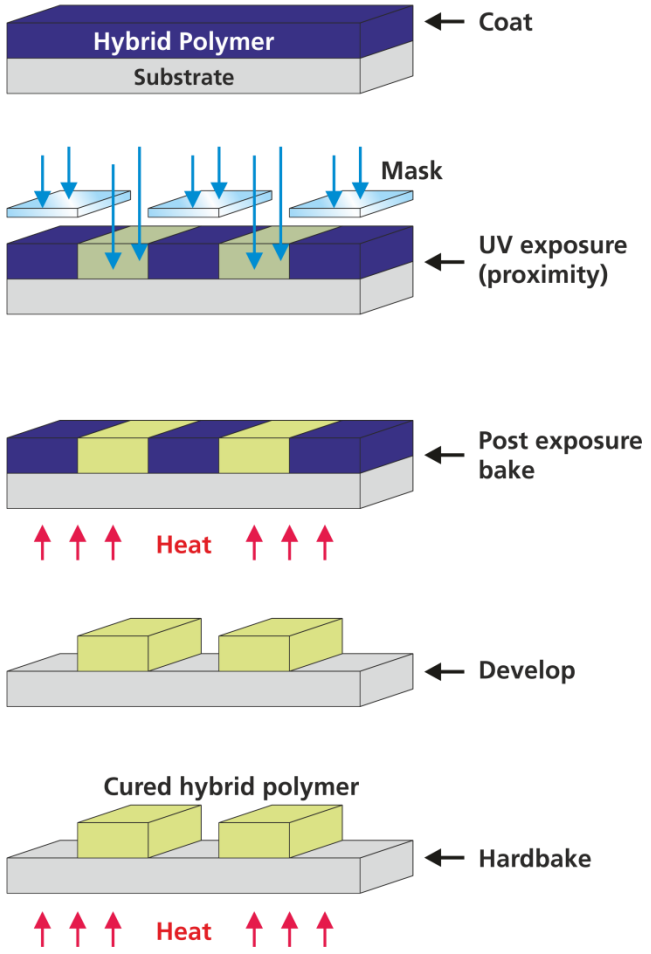
micro resist technology

Hybrid Polymers – General processing schemes

UV molding transparent stamp

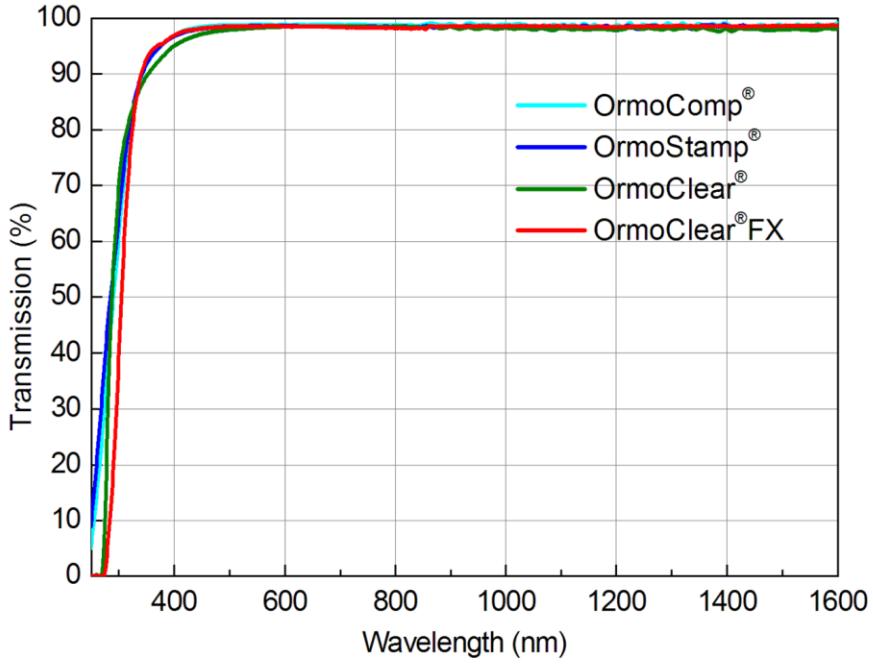


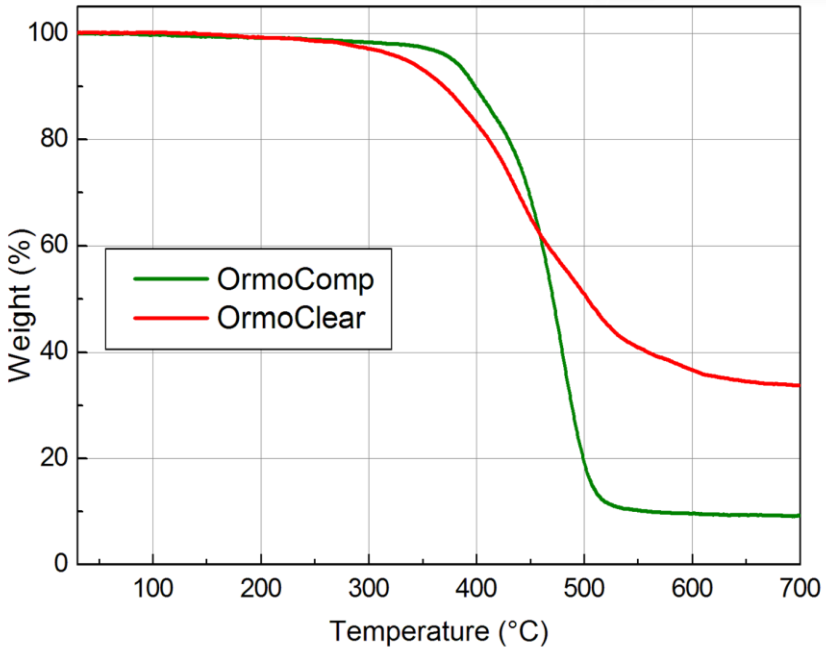
UV lithography



Distinctive features of hybrid polymer products

- Glass-like properties after UV curing
- Highly transparent for near UV, visible light and NIR
- Chemical and mechanical stability
- High thermal stability (up to 270 °C), i.e. non-yellowing
- Refractive index covers 1.52 - 1.56 (prototypes up to 1.65)





Gruetzner et al., Proc. Of SPIE Vol. 8974 897406, 2014

Hybrid Polymers – Optical appearance at macro scale objects

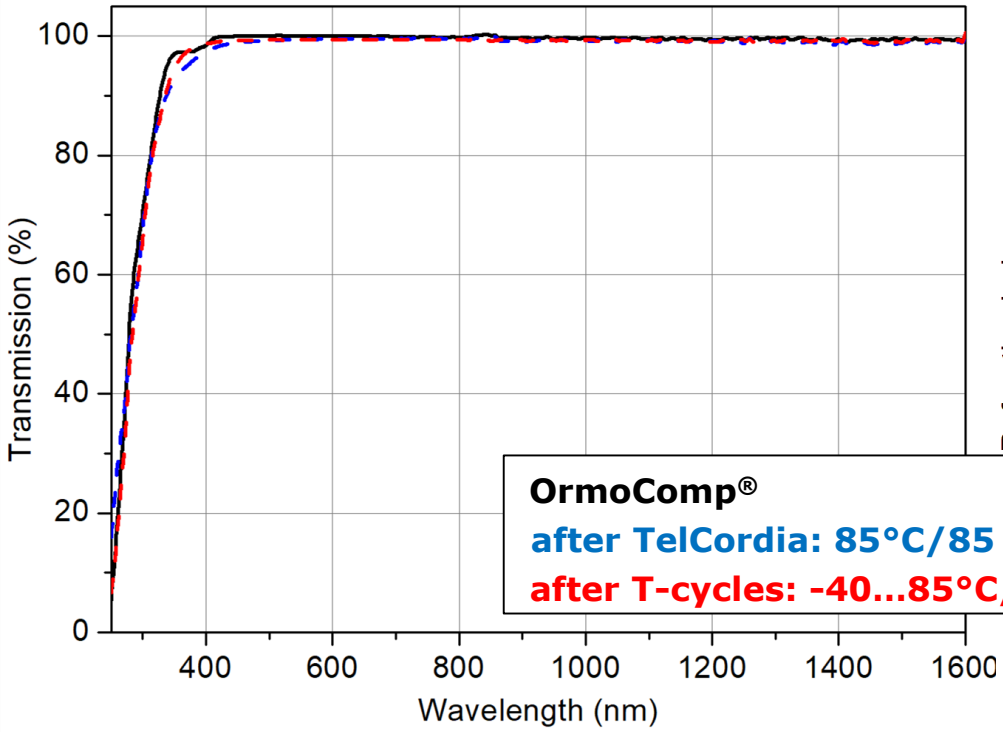
Photography at ambient light (unedited picture)

Benefits for industrial microoptics manufacture

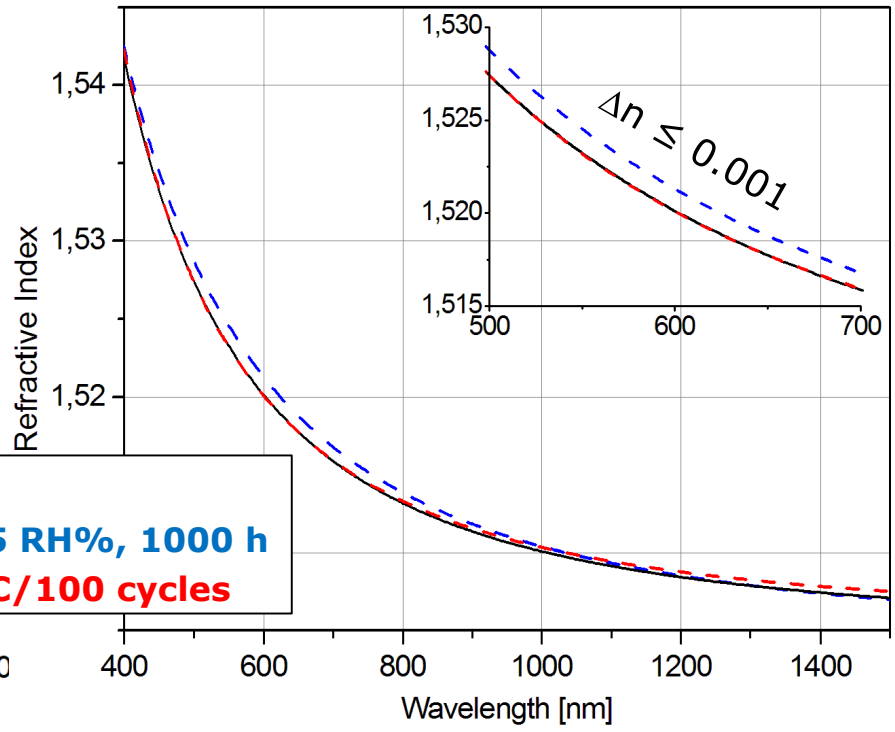
- Fast processing (i.e. instantaneous polymerization and no post-exposure curing)
- Solvent-free and compatible to various stamp materials (e.g. PDMS, PFPE, OrmoStamp)
- Optical integrity: high temperature and climate stability

Fraunhofer IZM

Transmission



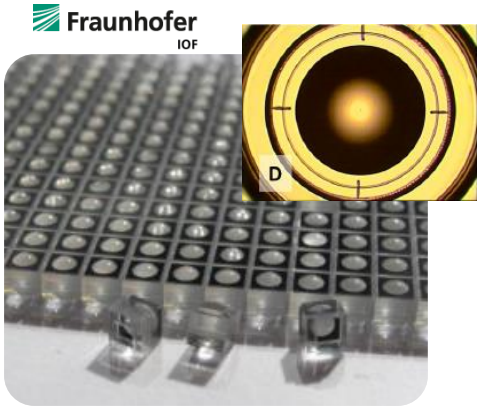
Dispersion



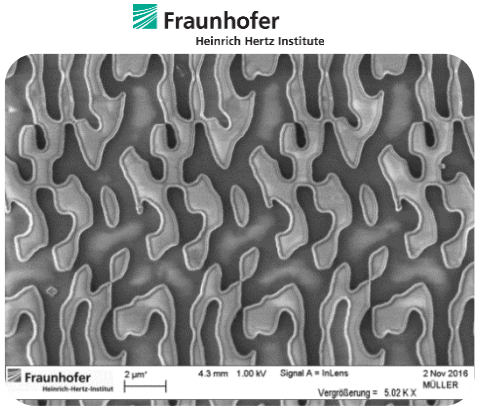
OrmoComp®
after TelCordia: 85°C/85 RH%, 1000 h
after T-cycles: -40…85°C/100 cycles

micro resist technology

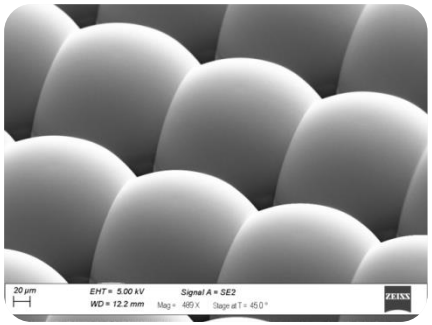
Hybrid Polymers Portfolio - Commercial applications



Micro optics



Diffractive optics



NIL TECHNOLOGY

Micro-lens arrays

- Launch of 9 commercial products (+ availability of **tailored products**)
- By 2019: manufacture of 1500 kg for > 300 customers
- Significant footprint also in global academia and tech start-ups
- Production upscaling and application of stringed quality control (DIN EN ISO 9001)

Technical support – Process guidelines, MSDS, REACH conformity, …


micro resist technology GmbH

Sicherheitsdatenblatt

gemäß Verordnung (EG) Nr. 1907/2006

OrmoComp®

Materialnummer: R413333

Seite 1 von 10

Überarbeitet am: 01.06.2018

ABSCHNITT 1: Bezeichnung des Stoffs beziehungsweise des Gemischs und des Unternehmens

micro resist technology GmbH

化学品安全技术说明书

按照GB/T 16483、GB/T 17519编制

修订日期: 01.04.2019

第1部分 化学品及企业标识

OrmoComp

材料号: CN_OrmoComp

页 1 的 9

micro resist technology GmbH

Koepenicker Str. 325

D-12555 Berlin

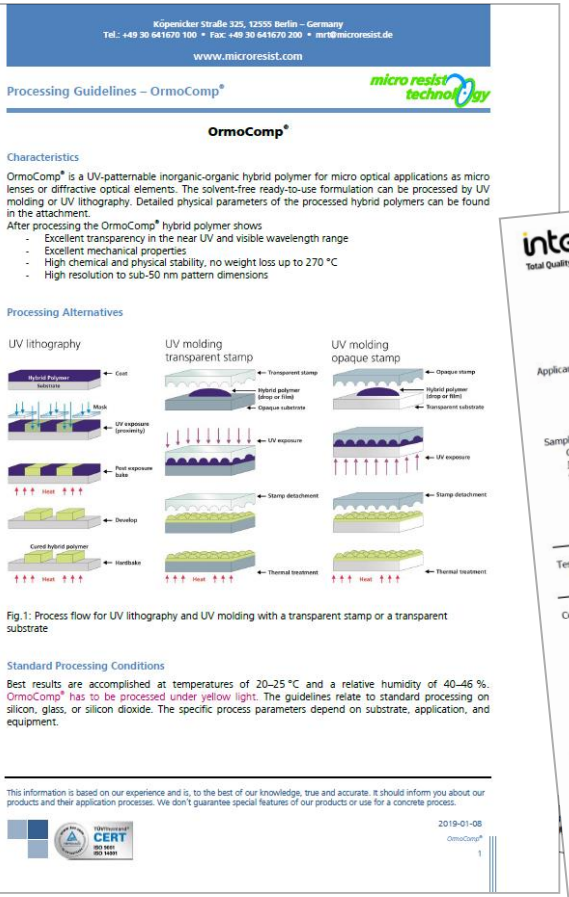
+49 30 641670-100

safety@microresist.de

www.microresist.de

Chemtrec (International - 24 h): +1 703 527 3887

传真: +49 30 641670-200


Köpenicker Straße 325, 12555 Berlin – Germany

Tel.: +49 30 641670 100 • Fax: +49 30 641670 200 • mrt@microresist.de

www.microresist.com

Processing Guidelines – OrmoComp®

micro resist technology

OrmoComp®

Characteristics

OrmoComp® is a UV-patternable inorganic-organic hybrid polymer for micro optical applications as micro lenses or diffractive optical elements. The solvent-free ready-to-use formulation can be processed by UV molding or UV lithography. Detailed physical parameters of the processed hybrid polymers can be found in the attachment.

After processing the OrmoComp® hybrid polymer shows

- Excellent transparency in the near UV and visible wavelength range
- Excellent mechanical properties
- High chemical and physical stability, no weight loss up to 270 °C
- High resolution to sub-50 nm pattern dimensions

Processing Alternatives

UV lithography

UV molding transparent stamp

UV molding opaque stamp

Fig.1: Process flow for UV lithography and UV molding with a transparent stamp or a transparent substrate

Standard Processing Conditions

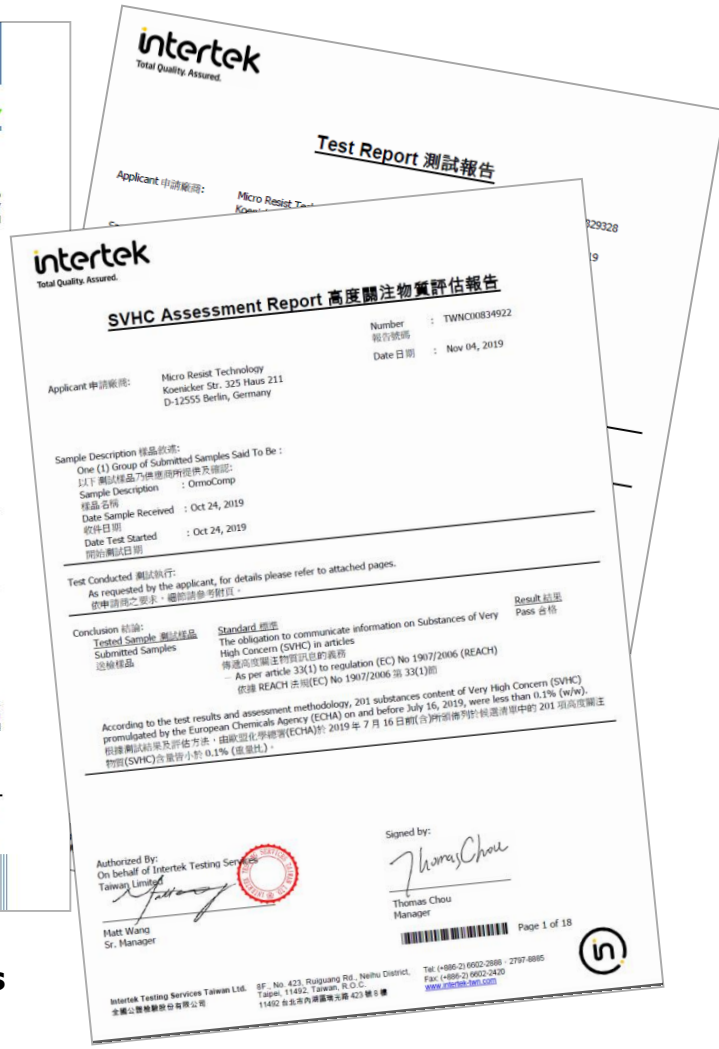
Best results are accomplished at temperatures of 20–25 °C and a relative humidity of 40–46 %. OrmoComp® has to be processed under yellow light. The guidelines relate to standard processing on silicon, glass, or silicon dioxide. The specific process parameters depend on substrate, application, and equipment.

This information is based on our experience and is, to the best of our knowledge, true and accurate. It should inform you about our products and their application processes. We don't guarantee special features of our products or use for a concrete process.

2019-01-08

OrmoComp®

1


intertek

Total Quality. Assured.

Test Report 測試報告

Applicant 申請廠商:

Micro Resist Technology

Koenicker Str. 325 Haus 211

D-12555 Berlin, Germany

intertek

Total Quality. Assured.

SVHC Assessment Report 高度關注物質評估報告

Number : TWNC00834922

報告號碼

Date 日期 : Nov 04, 2019

Applicant 申請廠商:

Micro Resist Technology

Koenicker Str. 325 Haus 211

D-12555 Berlin, Germany

Sample Description 樣品敘述:

One (1) Group of Submitted Samples Said To Be :

以下測試樣品乃供應商所提供及確認:

Sample Description : OrmoComp

樣品名稱

Date Sample Received : Oct 24, 2019

收件日期

Date Test Started : Oct 24, 2019

開始測試日期

Test Conducted 測試執行:

As requested by the applicant, for details please refer to attached pages.

依申請商之要求，細節請參考附頁。

Conclusion 結論:

Tested Sample 測試樣品

Submitted Samples

送檢樣品

Standard 標準

The obligation to communicate information on Substances of Very High Concern (SVHC) in articles

傳遞高度關注物質訊息的義務

As per article 33(1) to regulation (EC) No 1907/2006 (REACH)

依據 REACH 法規(EC) No 1907/2006 第 33(1)節

Result 結果

Pass 合格

According to the test results and assessment methodology, 201 substances content of Very High Concern (SVHC) promulgated by the European Chemicals Agency (ECHA) on and before July 16, 2019, were less than 0.1% (w/w).

根據測試結果及評估方法，由歐盟化學總署(ECHA)於 2019 年 7 月 16 日前(含)所頒佈列於候選清單中的 201 項高度關注物質(SVHC)含量皆小於 0.1% (重量比)。

Authorized By:

On behalf of Intertek Testing Services Taiwan Limited

Matt Wang

Sr. Manager

Signed by:

Thomas Chou

Manager

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Intertek Testing Services Taiwan Ltd.

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Country-specific MSDS

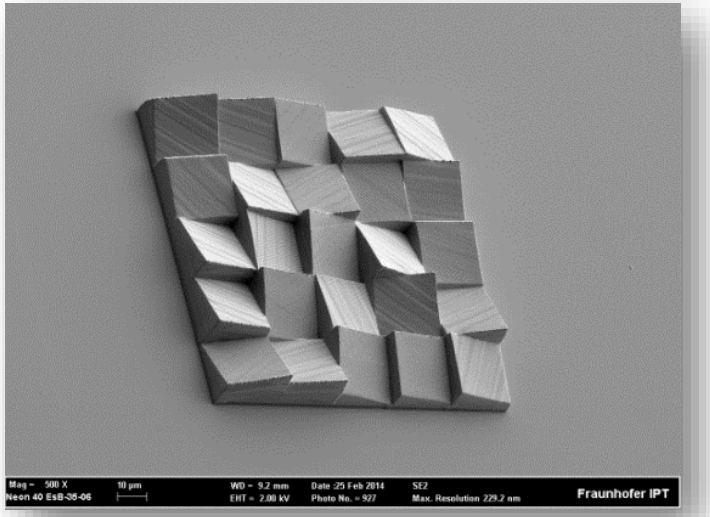
Comprehensive guidelines for advanced process support

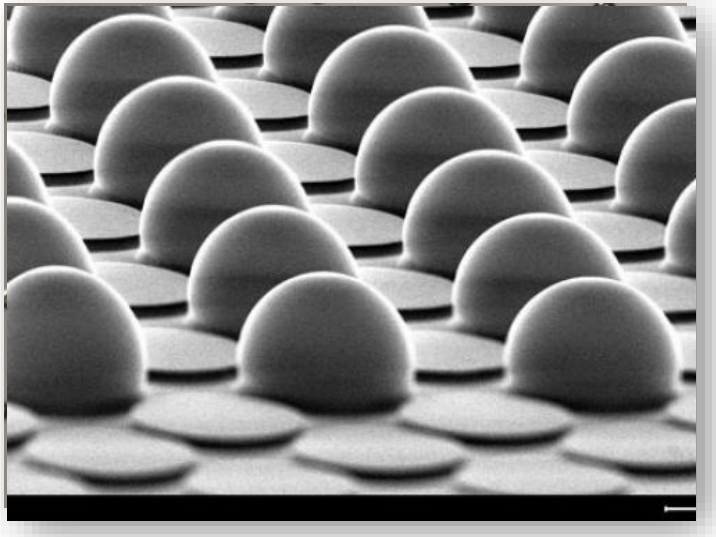
Necessary test and conformity reports (e.g. REACH, SVHC)

micro resist technology

What's next ?– Playing the cross-functionality of hybrid polymers

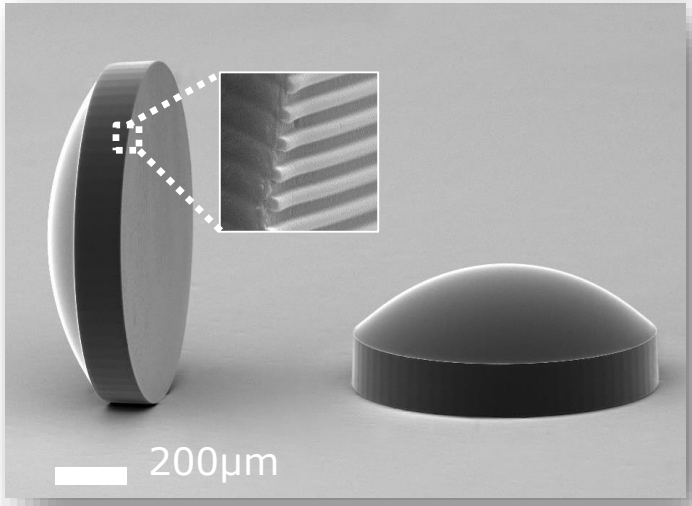
3D printing

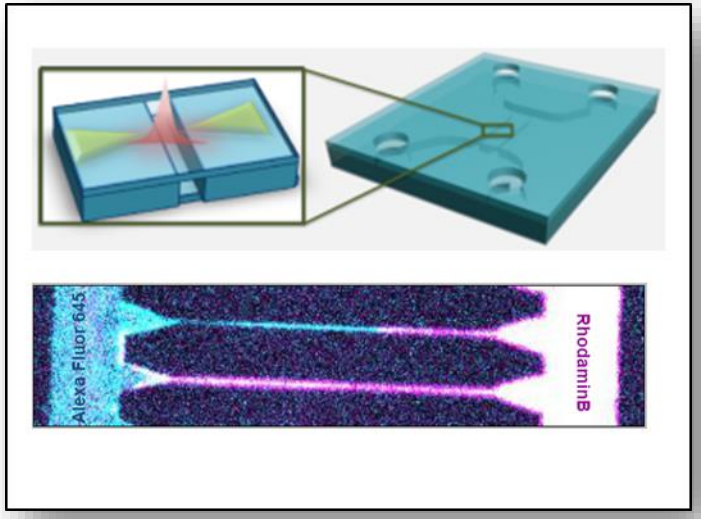




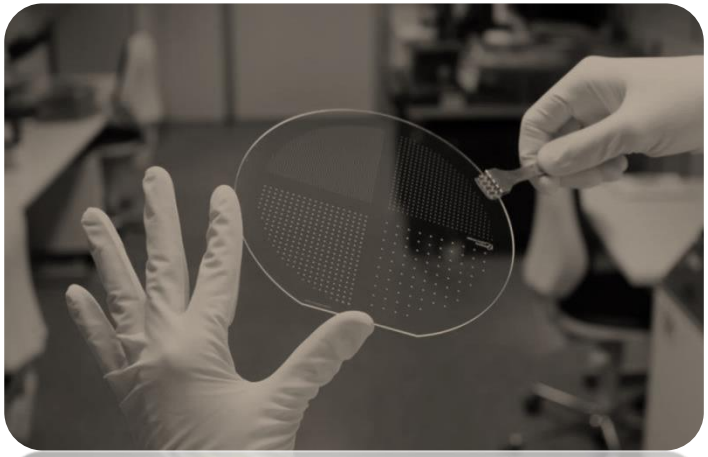
Printed µ-lenes

Mix-and-Match





Opto-fluidics



THANK YOU !

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GERMANY

Please visit our website:
www.microresist.com

Conclusion

What do we offer …

- Innovative (photo)resists, (photo)polymers and ancillaries
  - Advanced photoresists for mastering
  - Working stamp materials
  - UV-curable hybrid polymers
- Complementing process expertise

Hybrid polymers for (additive) manufacturing of microoptical elements

Martin Herder, Jan J. Klein, Marko Vogler, Arne Schleunitz

1 Introduction

Microoptical elements constitute a key enabling technology for consumer electronics, telecommunication, sensing, imaging, lighting as well as virtual and augmented reality applications [1–5]. Their sophisticated design, miniaturization, and integration is crucial for the realization of new devices with high functional complexity and energy efficiency. Current wafer-scale production technology allows for cheap mass-fabrication of elements such as microlens arrays, gratings, diffractive optical elements (DOEs), or waveguides, as well as their integration into complex optoelectronic devices [6].

Modern 3D-printing methods promise to revolutionize the fabrication of microoptics [7]: Rapid prototyping with turn-over times from the optical design to the fabricated part in the range of minutes to few hours as well as the straightforward fabrication of freeform and true 3D parts will allow for completely new concepts in the design and optimization of microoptical elements. Furthermore, fabrication of integrated devices is simplified by direct printing onto sensors, emitters or optical fibers.

Importantly, the emergence of 3D-printing as new fabrication technology goes hand in hand with the development of innovative optical materials with superior performance and processability. While a large number of conventional organic and inorganic optical materials exist, their applicability in 3D-printing requires adaptation or is very challenging as in the case of conventional optical glass [8–10]. Furthermore, from a commercial viewpoint, materials must fulfill stringent quality requirements regarding not only optical performance but also environmental and long-time stability, processability as well as cost-effectiveness.

In this respect, inorganic-organic hybrid polymers constitute a material platform showing unique properties and high performance [11–13]. They are established commercial materials for the wafer-scale fabrication of microoptics and hold great promise for applications realized with additive manufacturing. In this review, we will give an overview of optical materials pointing out the advantages of the hybrid polymer concept. A detailed introduction into the synthesis and properties of hybrid polymers is given and finally their application in the fabrication of microoptical components by conventional wafer-scale fabrication and additive manufacturing technologies will be discussed.

What do we seek …

- Involvement in problem solving rather than solution verification
- Partnerships (along the value chain) for material-related R&D
- Discussions on novel application and specific demands

This presentation was presented at EPIC Meeting on Wafer Level Optics 2019

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