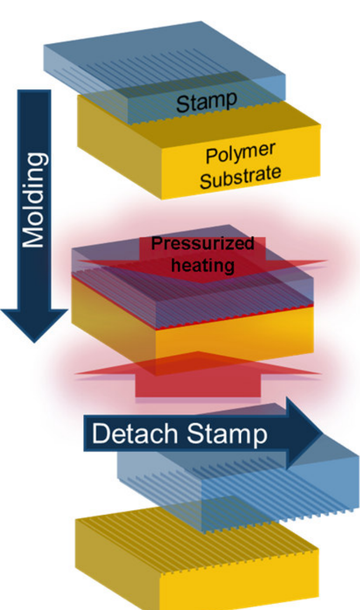
EVG NIL Technology Development

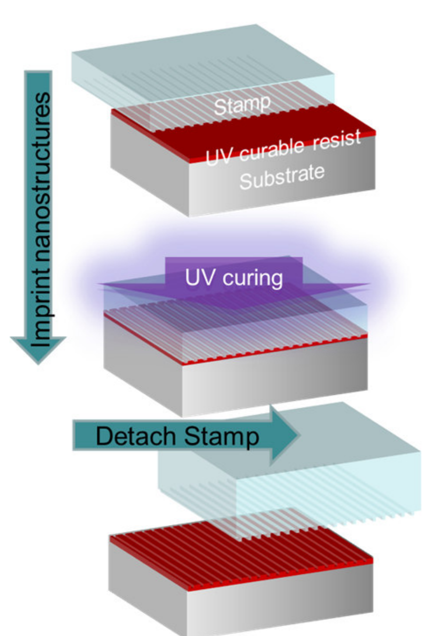
Markus Wimplinger, Corporate Technology Development & IP Director

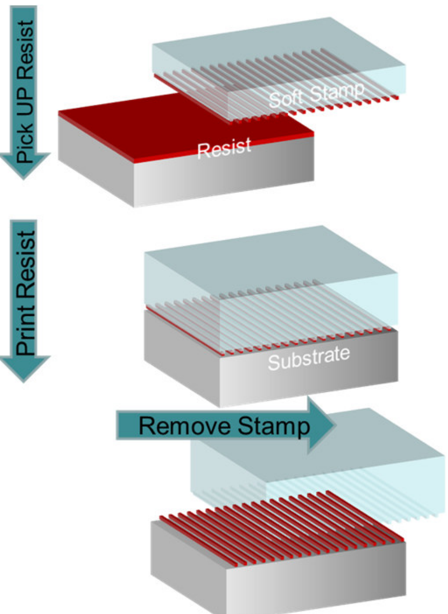
www.EVGroup.com

Nanoimprint Lithography at a Glance

Hot Embossing	UV-Nanoimprint Lithography (UV-NIL)	Micro Contact Printing (µCP) Soft Lithography
Hard Stamp	Transparent Hard Stamp	
Polymer Soft Stamp	Polymer Soft Stamp	Polymer Soft Stamp







Evolution of EVG's Imprint Equipment

EVG® HERCULES®NIL 2015

Fully integrated HVM UV-NIL System

EVG®7200LA 2016

Panel Size Nanoimprint Lithography System

EVG®7200 2014

Fully automated UV-NIL System 200mm

EVG®720 2013

Fully automated UV-NIL System 150 mm

EVG®620 1997

Semi automated UV-NIL / µCP System

EVG®750R2R - HE 2013

Roll-to-Roll System

EVG®750 2007

Automated HE System

EVG®520 HE 2001

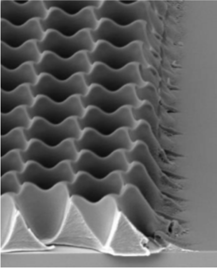
Semi automated HE System

Unique Benefits of Nanoimprint Lithography

Large Area Nanopatterning

- Wafer level processing of nanostructures without stitching
- Scalable technology which is not limited by an optical system

3D Pattering

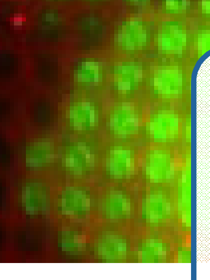


- Replication process is insensitive to shape, size & structure
- Complexity does not add manufacturing costs

Resolution << Alignment

- Enables highest resolution down to 20 nm and less
- No expensive precision alignment optics

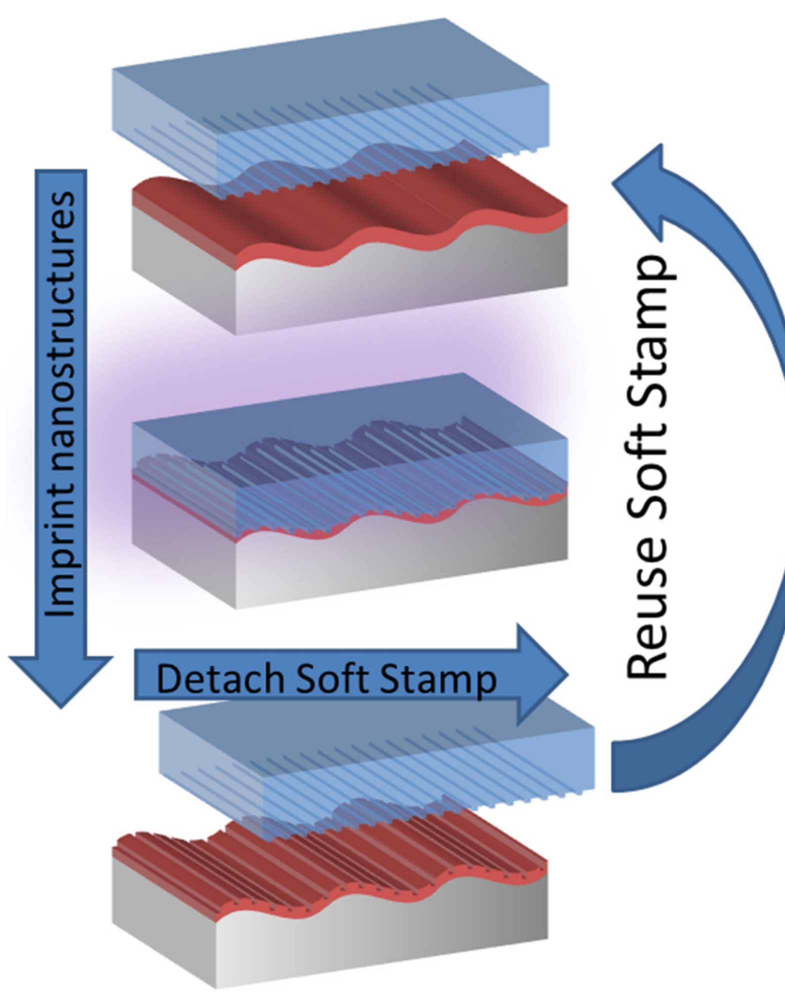
Direct Patterning

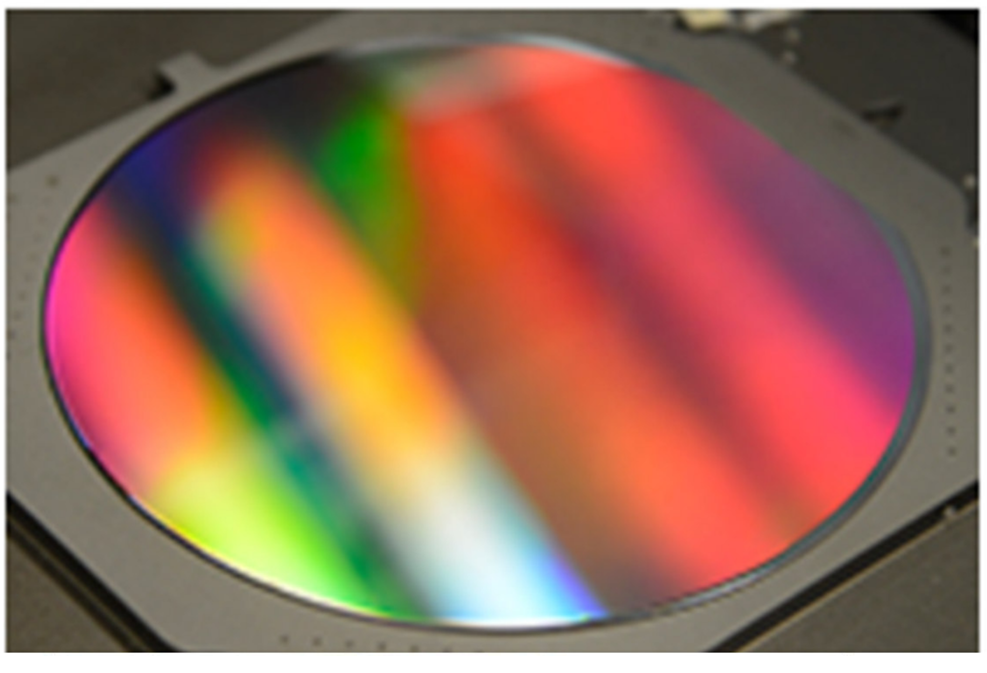


- Imprint materials can be functionalized to needed properties
- Reduces process steps significantly

SmartNIL® – Large Area Imprint

Conformal nanoimprinting





Basic elements of the technique:

Flexible UV-transparent molds
Proprietary imprint tooling → **SmartNIL®**

Allows large area conformal imprints

Working Stamp - Improved Cost of Ownership (CoO)

Master

Made by e-beam-lithography, …

Master stamp

Spin coat working stamp material on master

Curing

Release working stamp from master

Multi replicated working stamps

Spin coat imprint resist

Bring working stamp in contact with substrate

UV exposure

Seperation of working stamp and wafer

Multi imprints per working stamp

UV-NIL/SmartNIL® Resolution

Soft/Hard UV-NIL

SmartNIL

500µm

50µm

5µm

500 nm

50 nm

UV Lens Molding (300 µm)
(Source EVG)

Pyramidal Structures (50 µm)
(Source EVG)

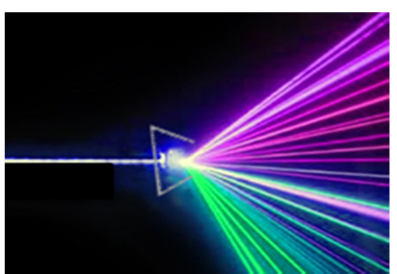
3D Anti reflective Structures (7 µm)
(Courtesy of Fraunhofer ISE)

Photonic Crystal (350 nm)
(Source EVG)

High Resolution Imprinting (12.5 nm)
(Source EVG: Master fabricated by IMS)

Main Markets Today

Photonic Applications



Application Examples

- Wire Grid Polarizer
- DOE Pattern
- Photonic Crystal
- VR / AR

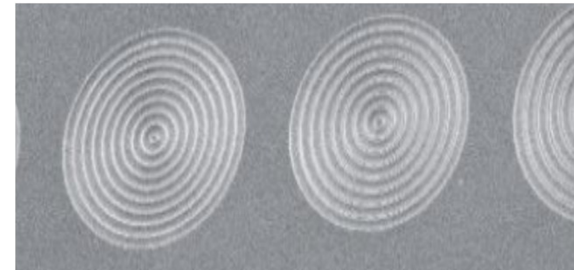
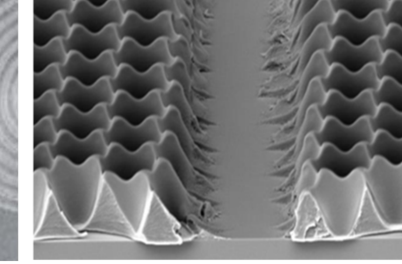
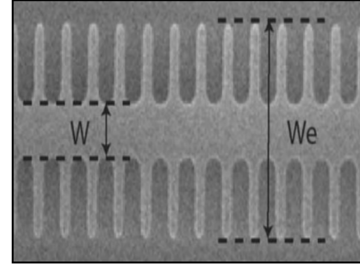
Bio-medical applications

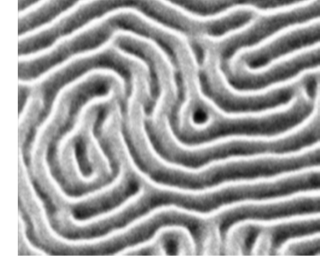
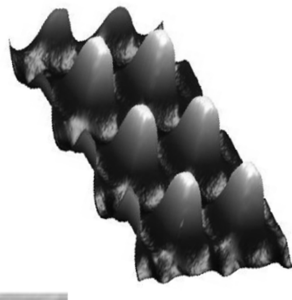
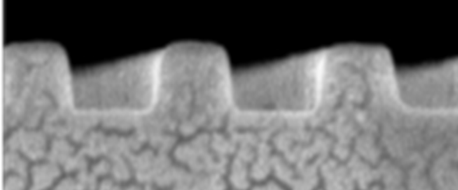
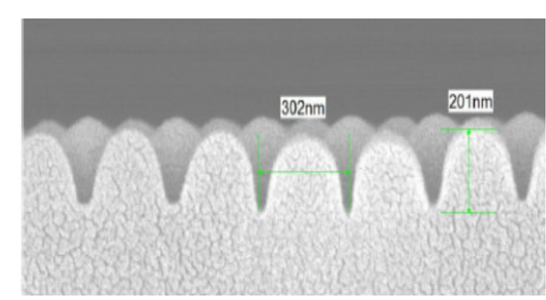
Application Examples

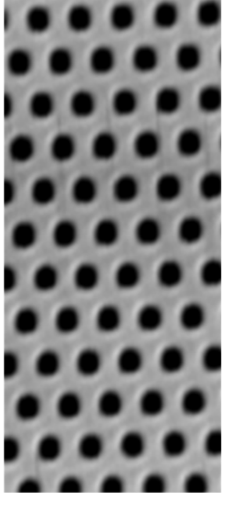
- Lab on a chip
- Organ on a chip
- Chips with photonic structures
- DNA Sequencing

SmartNIL™ – Universal Capabilities

- Diffractive Optical Elements
- Holographic Structures
- Optical Gratings
- Anti Reflective Structures
- Plasmonic Structures



Arbitrary 3D Structure

SEM – Imprint EVG NIL UV/A

m

2.5 µm pitch

Pattern height: 1.70µm

ims chips
INSTITUT FÜR MIKROELEKTRONIK STUTTGART
Allmandring 30a,70569 Stuttgart, Germany
Phone.: +49 711 21855 - 0 • Fax: +49 711 21855 - 111
info@ims-chips.de • www.ims-chips.com

Contact: Mathias Irmscher • Phone: +49 711 21855 - 450 • irmscher@ims-chips.de
Jörg Butschke • Phone: +49 711 21855 - 453 • butschke@ims-chips.de

1µm 2/25/2016 11:00:00 EVG
al=SEI Mode=SEM WD=4.5mm Ie=9.5µA

High Fidelity Patterns | DOE | IMS Structures

SmartNIL™ Template – Regular Pattern

DOE Basics : principle

Example : Conversion Gaussian to Top-Hat profile

Position	#1	#2	#3	average
12:00	1,61	1,623	1,602	1,611667
03:00	1,603	1,616	1,604	1,607667
06:00	1,626	1,653	1,655	1,644667
09:00	1,639	1,662	1,636	1,645667
center	1,638	1,657	1,648	1,647667
				1,631467

Spectral Period 3.30 µm
Spectral Freq 0.303 /µm
Spectral RMS Ampl. 595 nm
Temporal Freq: 0.00 Hz

Pair	Horizontal Dist.	Vertical Dist.	Surface Dist.	Angle	Rmax	Rz	Rz Count	Rms	Ra (Freq cutoff)	Freq cutoff
0	1.884 (µm)	1638.27...	2.665 (µm)	41.0...	1598....	0.000 ...	0.000	603.9...	555.410 (nm)	0.316 ...
1	1.560 (µm)	-1657.4...	2.463 (µm)	-46....	1630....	0.000 ...	0.000	631.0...	583.209 (nm)	0.258 ...
2	1.727 (µm)	1648.26...	2.511 (µm)	43.6...	1720....	0.000 ...	0.000	599.5...	556.706 (nm)	0.303 ...

VR / AR Application

WaveOptics Phlox Waveguide Technology

Light Engine

Input Structure

Output Images to eye

Output Structure

Blue Waveguide

Source: Waveoptics Web Page - http://enhancedworld.com/manufacturing/

VR / AR Application

Production NIL

NANO-IMPRINT TOOLING
Silicon Master Manufacture
Multi-pattern Master Stamp Generation
PRODUCT FLOW
Production NIL
Coating
Finishing

Source: Waveoptics Web Page - <u>http://enhancedworld.com/manufacturing/</u>

First fully integrated NIL track system worldwide

- Combines preprocessing and UV-NIL on a modular platform
- Redeems the long-term promise of nanoimprinting being a cost effective and high-volume alternative lithography technology
- Optimized solution for high throughput and low cost-of-ownership

HERCULES® NIL

Clean Module

Coat Module

Bake Module

Imprint Module

Preprocessing modules

The SmartNIL® module is the heart of the HERCULES® NIL

Gen 2 NIL System

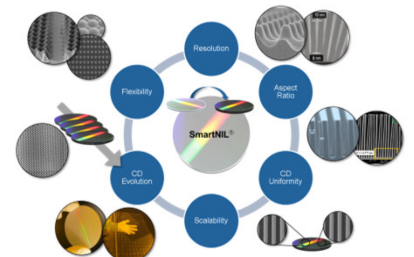
Overview

Key Takeaways

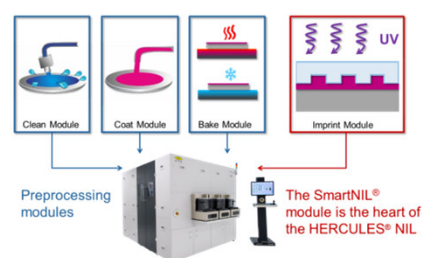
Wafer-level Nanoimprint Lithography

SmartNIL® is established for photonic, bio and non-CMOS manufacturing

Proven Capabilities



Equipment Readiness



Addressing Challenges Beyond

Targets

- Enabling novel devices and applications
- Fully CMOS compatible production line

Goals inspire

- Imprint Technology Improvement
- Platform Improvements
- Process Integration

Addressed Topics inspire

- Overlay, Yield, Material Influence
- Automation, Process Monitoring, Performance
- Etching, Deposition, Mix and match Lithography

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