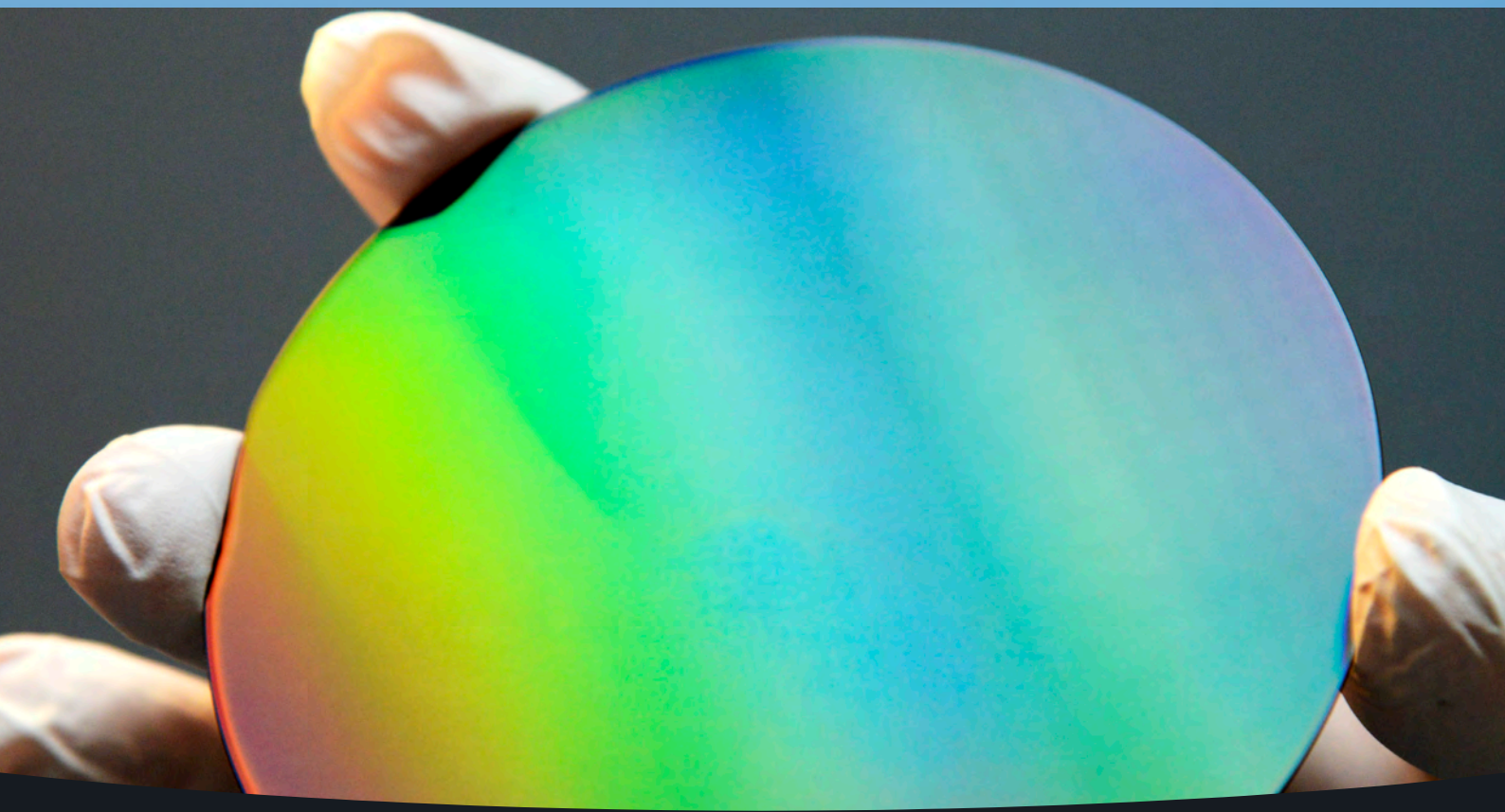
EV Group

Nano & Micro Imprint Technologies



EVG®

Introduction

Since the first Nano Imprint Lithography (NIL) publications, interest in the technology has grown rapidly - starting with the scientific community and then moving to industrial sectors like integrated optics, sensors and micro fluidics.

NIL offers several technical advantages with respect to resolution, overlay accuracy, and tool design. In addition to creating high resolution features in the nanometer range, NIL can also be employed for replicating much larger features. Presently, NIL is utilized in optical applications for the production of optical elements with feature sizes in the sub-millimeter range and for production of microfluidic devices.

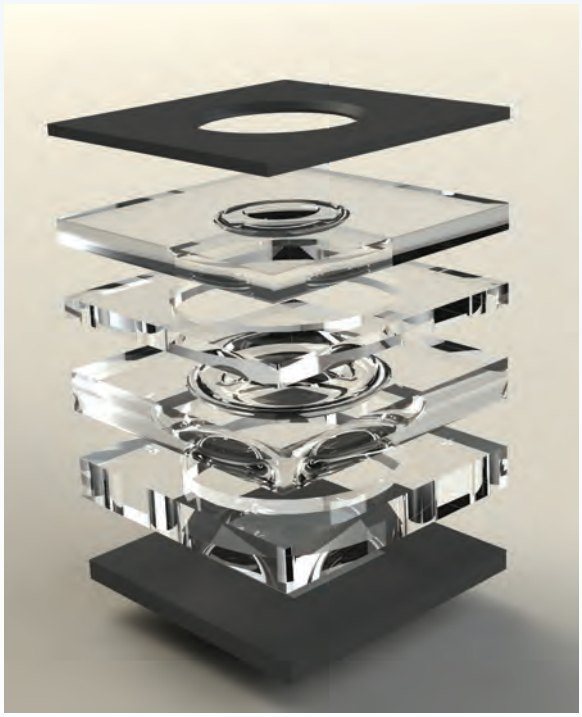
With the ever increasing demand for higher integration of functionality, combined with the need to reduce structure sizes at acceptable costs, traditional lithographic techniques are fast approaching their limits. NIL is a competitive candidate for Next Generation Lithography (NGL) due to its advantages in resolution and cost effectiveness.

The potential of this technology has been acknowledged by leading experts. Subsequently, it has been added to the International Technology Roadmap for Semiconductors (ITRS) as a potential NGL solution for microelectronics at the 22 nm node and beyond.

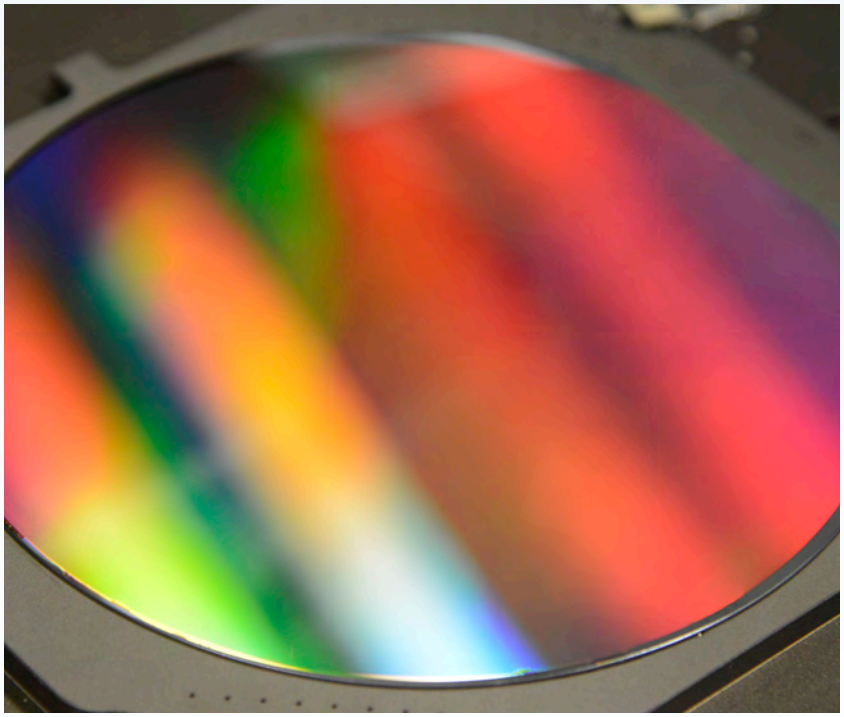
EVG offers solutions within the three main areas of Nanoimprint Lithography (NIL):
- Hot Embossing (HE),
- UV-based Nanoimprint Lithography (UV-NIL) and
- Micro Contact Printing (µ-CP).

EV Group offers systems for flexible, cost effective micro- and nanofabrication and realizes that successful implementation of any technology relies on infrastructure and process expertise.

As a result, through our worldwide alliance NILCom® (www.nilcom.org) and partnerships, EVG can offer total process solutions for NIL including materials, stamps and processes for both R&D and manufacturing applications.



Exploded image of a CMOS Image Sensor stack **Source: EVG**



PSS substrate on a wafer chuck in an EVG®6200 **Source: EVG**

Potential Applications for Nano & Micro Imprint Lithography

- **Hot Embossing**
  - Microfluidics
    - Lab-on-chip Systems
    - Life Sciences
  - Patterned Media (HDD)
  - Rapid Prototyping
- **UV-NIL**
  - Full Field
    - Patterned Media (HDD)
    - Optics
      - LED's
        - Patterned Sapphire Sustrates (PSS)
        - Quasi Photonic Crystals (PC)
      - Image Sensor Optics
      - Displays
      - Communications
      - Sensors
    - Other Low-Cost, High-Tput, Full Field Litho
      - Probe Cards
      - OLED's
      - Organic Photovoltaics
      - SAW-Devices
      - Q-Dots
  - Step and Repeat
    - Sub 32 nm CMOS
    - Stamp Replication/ "Mastering"
      - Displays
      - Diffractive Optical Elements
      - Biosensors
      - Wafer Level Optics
    - Optics
    - Semiconductors
      - Dual-Damascene
      - Contact Holes
- **Micro Contact Printing**
  - R&D Self Assembly
  - Photovoltaics
  - Flexible Electronics
  - Biomedical

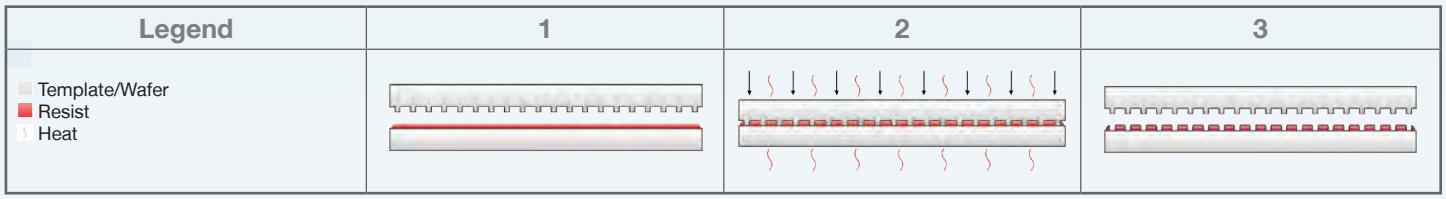
From R&D to HVM - EVG's Equipment Portfolio

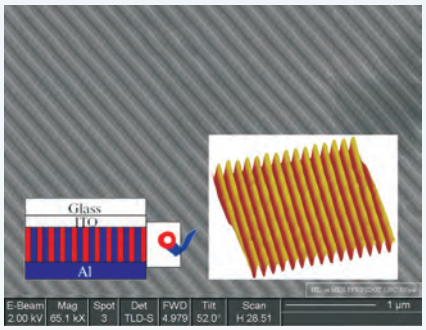
Hot Embossing

The EVG600 Series precision alignment systems support stamp to substrate alignment for subsequent hot embossing. Stamp and substrate are brought in contact inside an EVG500 Series vacuum chamber. A precisely controlled temperature profile (typically up to 250°C, the system supports up to 650°C) and contact force sequence (up to 360 kN) create an imprint of the stamp on the substrate. Imprint areas up to 200 mm in diameter with high resolution features down to 50 nm have been demonstrated on the EVG500 hot embossing systems. Typical stamps are made out of Si, SiO_2 or metals (e.g. Ni). Substrates are typically polymer substrates or coated polymers on semiconductor wafers. The high temperature option enables imprinting into materials where elevated temperatures are needed (e.g. glass substrates).

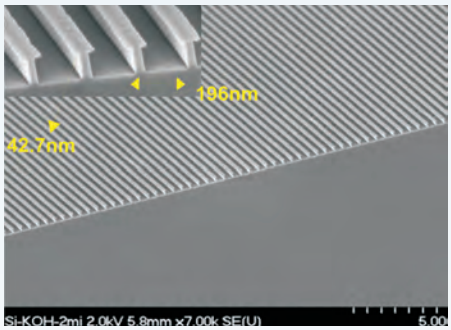
Systems	
■ EVG®610/620 ■ EVG®6200 ■ IQ Aligner®	for optical alignment
■ EVG®501/510HE ■ EVG®520HE ■ EVG®750 ■ EVG®750 R2R	for embossing

Principles

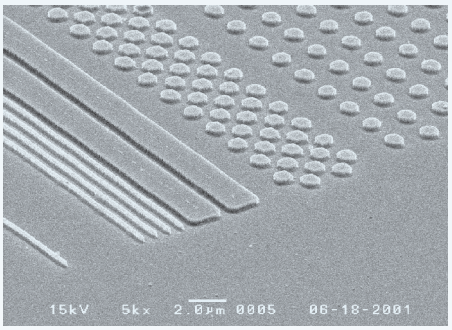




Large area patterning of semiconducting polymers for flexible solar cell applications
Courtesy of IMI-CNRC



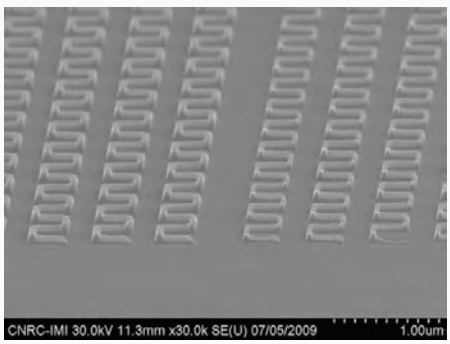
Large area pattern transfer on Si using NIL on the EVG®520HE
Courtesy of IMI-CNRC



Imprinted substrate with submicron lines and spaces. Imprinted on EVG®520HE
Courtesy of Bergische Universität Wuppertal

Working Polymeric Stamps

EVG also offers a technology which uses polymer working stamps instead of hard metal stamps enabling rapid prototyping with much faster turn around time compared to state-of-the-art LIGA (lithography and galvanoforming) processing. Besides that, polymer stamps improve the hot embossing process in regards to imprint uniformity, overlay alignment and process automation.



50 nm and 100 nm meander structures with a height of 100 nm replicated with polymeric working stamps into spin on thermoplastic polymers (Imprinted on EVG®750)
Courtesy of IMI-CNRC

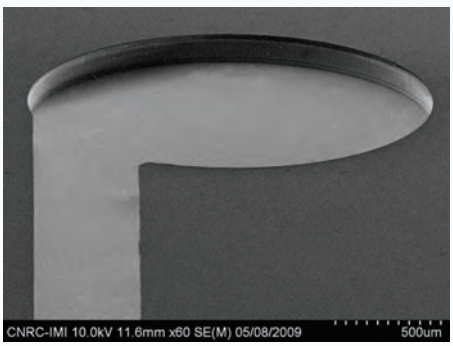


Image of mm large micro channel reservoirs into COC using polymer working stamps imprinted on EVG®750
Courtesy of IMI-CNRC

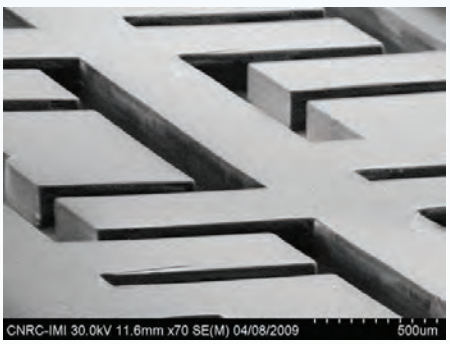


Image of 100 µm wide micro channels into COC using polymer working stamps imprinted on EVG®750
Courtesy of IMI-CNRC

Unique Features / System Configuration

All of EVG's hot embossing systems (except for the EVG®750 R2R) have both imprinting and bonding capabilities.

EVG®501HE/510HE UV-NIL Semi-automated Hot Embossing System

The EVG501HE/510HE can be configured as a manual hot embosser and/or UV-NIL system for R&D processes. The field proven EVG501HE/510HE system architecture provides the best capabilities for high-vacuum and high-contact force applications. With the universal embossing chamber of the EVG501HE/510HE the whole range of thermoplastic polymers can be structured.

EVG®520HE Semi-automated Hot Embossing System

The EVG520HE is designed for both micro and nanoimprinting applications. This production-proven system from EVG accepts substrates up to 200 mm and is compatible with standard semiconductor manufacturing technologies. The hot embossing system is configured with a universal embossing chamber, high-vacuum and high-contact force capabilities and can process the whole range of polymers suitable for hot embossing.

EVG®540HE Semi-automated Hot Embossing System

The EVG540HE is designed for both micro and nanoimprinting applications. This production-proven system from EVG accepts substrates up to 300 mm and is compatible with standard semiconductor manufacturing technologies. The hot embossing system is configured with a universal embossing chamber, high-vacuum and high-contact force capabilities and can process the whole range of polymers suitable for hot embossing.

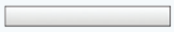
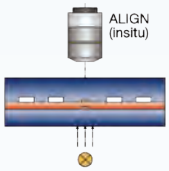
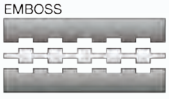
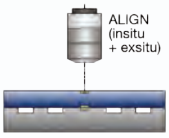
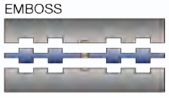
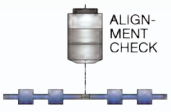
EVG®750 Automated Hot Embossing System

The EVG750 is designed for high volume embossing and nanoimprinting applications for imprinting of spin-on layers and polymer substrates. This high throughput system is the first of its kind in the world and can be used for high volume microfluidic device fabrication. The system has the ability to check the substrate alignment after the embossing process and feed back an offset to the alignment stage to assure that subsequent substrates have proper alignment.

EVG®750 Roll-to-Roll Hot-Embossing system

The EVG750 roll-to-roll hot-embossing system is designed for R&D as well as pilot manufacturing of all-in-plastic flexible substrates for applications ranging from anti-counterfeiting, surface texturing (photovoltaics, displays, sensors) to bio-functional constructs. The system combines an automated foil handling unit for unwinding and rewinding with the core embossing module and accepts 300 mm wide films with thicknesses ranging from 50 µm to 1000 µm. In addition, the EVG750 roll-to-roll hot-embossing system has the ability to handle exotic films which are not available on large rolls and automatically detects the splicing film line through an optical sensor and adjusts the position of the structuring cylinder via encoders to the tape position.

EVG®750 Process Modes

First Imprint				
Aligned Imprint (ex situ)				
Aligned Imprint (in situ)				
Double-Side First Imprint				
Double-Side Aligned Imprint				

UV-NIL

In UV-NIL, a substrate is spin coated or drop dispensed with a UV-curable monomer or oligomer. Imprinting is carried out with a transparent template (quartz glass or soft working stamps) and the imprinted structures are cured by UV-light exposure which cross-links the resist. The template is subsequently released from the imprinted substrate. The use of quartz glass stamps is regarded as hard UV-NIL whereas the use of soft working stamps refers to soft UV-NIL.

Systems

Single Step Imprint Systems
- EVG®610/620
- EVG®6200
- EVG®720
- IQ Aligner®
- EVG®501/510 UV-NIL/HE

Step and Repeat Systems
- EVG®770 NIL Stepper

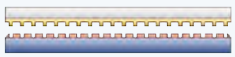
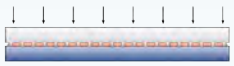
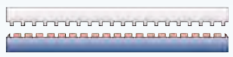
Full Field Large Area UV-Nanoimprinting

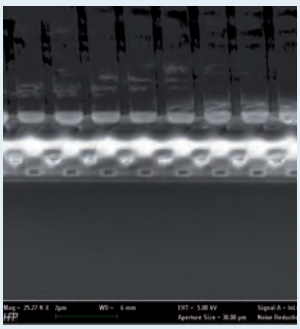
A dispensed UV curable material is imprinted at a pre-programmed contact force with a UV transparent stamp. UV irradiation cures the polymer. Both soft and hard stamps can be used on EVG systems. UV transparent hard stamps are usually made of quartz glass (SiO_2). Soft stamps are similar to those used in micro contact printing (e.g. PDMS) where the stamp is mounted on a thin, conformal or a thick, rigid backplane. Soft stamps are typically used for large area imprinting applications. The release process, after curing, is supported by an anti sticking layer (only with hard stamps) as well as by a non-parallel release mechanism.

Step and Repeat Large Area UV-Nanoimprinting

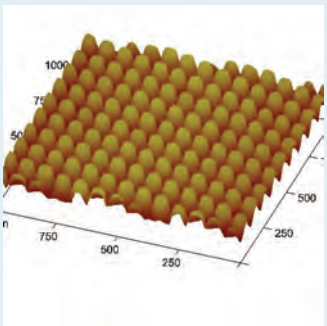
The EVG770 NIL Stepper is designed for step and repeat UV-NIL processes and is compatible for 100 mm to 450 mm wafers. The special features of the EVG770 include a dual-stage alignment approach and the capability to imprint in a lower pressure environment (patented technology), which enables greater pattern fidelity compared to other technical solutions which imprint at ambient pressure. The step and repeat NIL system targets sub-25 nm overlay alignment accuracy and a lithography resolution in the sub-30 nm range.

Principles

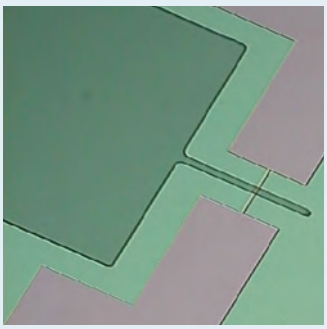
Legend	1	2	3
UV-NIL with soft stamps Backplane Substrate Resist Soft Stamp			
UV-NIL with hard stamps Template Substrate Resist			



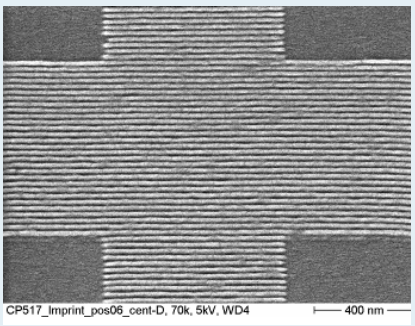
Five layer photonic crystal in Si/SiO_2 utilizing UV-NIL, alignment < 100 nm
Source: EVG



Soft UV-NIL imprinted 50 nm pillars
Source: EVG



NMOSFET on SOI
Courtesy of AMO GmbH



12.5 nm lines/spaces imprinted on EVG®620
Courtesy of NIL Austria

Unique Features / System Configuration

EVG®501/510 UV-NIL/HE Hot Embossing System

The EVG501/510UV-NIL can be configured as a manual UV-NIL and/or hot embossing system for R&D processes. The field proven EVG501/510UV-NIL system architecture provides the best capabilities for large area applications requiring vacuum imprinting.

EVG®610/620 UV-NIL System

The EVG610/620NIL system allows for imprint processes with stamps and substrates from small chip size pieces up to 150 mm in diameter. Configurations for nanotechnology applications can include release mechanisms for stamps in addition to programmable high and low contact force. Uniform contact force for high yield, large area printing is provided by EVG's proprietary chuck design which supports both soft and hard stamps. In addition to that, the EVG610/620 can be configured as a multiple use system, featuring both optical lithography and micro contact printing toolings.

EVG®6200 UV-NIL System

The EVG6200 is the culmination of EVG's aligner technology roadmap and provides the same basic funcionality as the EVG620. A variety of stamps and substrates sizes, from 75 mm to 200 mm, are supported on the EVG6200$^{\infty}$ for nanoimprint lithography applications.

EVG®720/7200 (150/200 mm) Automated UV Nanoimprint Lithography System

Providing full-field imprint lithography (SmartNIL) with an integrated soft stamp fabrication capability, the EVG720/7200 system enables throughputs of more than 40 wafers per hour at lowest cost of ownership (CoO). Capable of printing nanostructures as small as 40 nm over a large area and in high volume, the EVG720/7200 system is ideally suited for volume production of optics, photonics, light emitting diodes (LED), microfluidics and other bioMEMS devices, as well as advanced non-volatile memory production. The EVG720/7200 UV-NIL system, EVG's most advanced dedicated NIL system, provides an unmatched combination of high throughput, ease of use and high resolution—allows customers to create working stamps in a matter of minutes at unprecedented compact footprint on the fab floor.

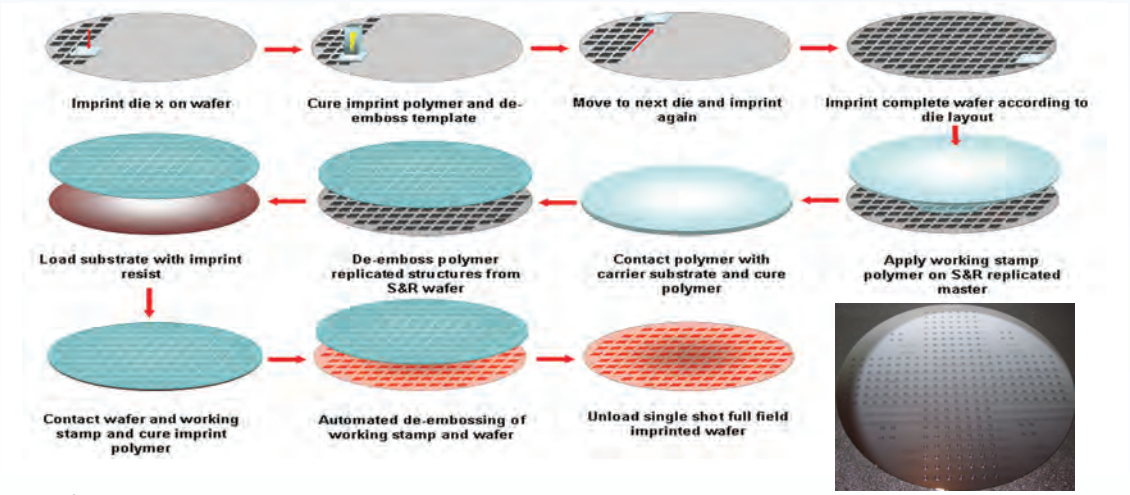
IQ Aligner® UV-NIL System

The IQ Aligner allows for imprint processes with stamps and wafers from 150 mm to 300 mm diameter. The tool's configuration for nanotechnology applications can include stamp release mechanisms and programmable contact force capability. A temperature controlled chuck for large substrates provides unmatched stamp to substrate overlay accuracy. Uniform contact force for high yield large area printing is provided by EVG's proprietary chuck design which supports both soft and hard stamps. The IQ Aligner can be used for micromolding processes for the fabrication of optical elements.

EVG®770 UV-NIL Stepper

The special features of EVG's EVG770 NIL stepper include a dual-stage alignment approach in lower pressure environments. This step and repeat UV-NIL system surpasses competing ambient pressure solutions in terms of pattern transfer fidelity. The EVG770 targets sub-25 nm overlay alignment accuracy and a lithography resolution in the sub-20 nm range. The special features of the EVG770 can be summarized as follows:

- Vacuum imprinting for superior pattern fidelity
- Imprint force control
- Dual stage alignment approach (first print and fine alignment)
- Spun on polymer layer utilizes industry standard coating techniques
- Chuck system with edge handling
- Active optical sensors to bring stamp and wafer into perfect parallelism for contactless wedge compensation and adjustment of the separation gap during alignment



EVG®770 Large Area Master Stamp Fabrication

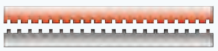
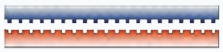
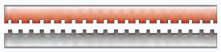
200 mm S&R Lens Master **Source: EVG**

Soft and Working Stamp Fabrication

Due to the thickness variation of standard substrates, the use of a rigid quartz stamp for UV-NIL is limited to an effective patternable area of approximately 25 mm x 25 mm. Therefore, in order to pattern larger areas (e.g. 300 mm wafers), a step and repeat process must be employed. However, EVG, with our NILCom partners, have made recent advances in soft UV-NIL which allow for imprinting of the entire substrate surface in a single step. This method is preferred over hard UV-NIL's step and repeat application where: (1) a continuous pattern without any stitching errors is required (e.g. waveguides); and (2) either relaxed specifications on alignment accuracy are allowable or (3) the imprint is a first-print application. EVG has demonstrated full-field imprints with sub 15 nm resolution using the soft UV-NIL technique. Our soft stamp technology offers reduced cost-of-ownership and processing benefits over competing methods due to the following reasons.

Advantages of UV-NIL Soft Stamp Technology

- Ability to make stamps in-house
  - Same tool for imprinting and stamp replication
  - No need for costly outsourcing
- No anti-stiction layer needed, thus a faster solution by eliminating the need for a separate tool-set or outsourcing
- Ability to make postitive and negative stamps
- No run-out or alignment issues due to thermal expansion in stamp manufacturing and imprinting
- Control of stamp material (Young's modulus, surface energy...)
- CoO advantage
  - 20 times faster than PDMS stamp technology
  - No "swell" during contact with organics (e.g. PDMS)
  - Working stamp can be used several times (>100) before disposal
  - Pattern fidelity (sub 15 nm resolution on 4" wafers demonstrated)
  - Field proven mechanics and process flow
    Same equipment and process flow as in production for µ-lens molding.

	1	2	3	4
Positive Image Replication Master, Positive Imprint, Negative Soft Stamp				
Negative Image Replication Master, Negative Imprint, Positive Soft Stamp				
EVG Sub-Master Replication Master, Positive Imprint, Positive Soft Stamp, Negative Soft Stamp				

Micro Contact Printing (µ-CP)

In a µ-CP process, inked chemicals are transferred from an elastomeric stamp to a novel metal surface to build up a Self Assembling Monolayer (SAM). A SAM can be used as an etching mask or act as a precursor for covalent binding of specific molecules. In most cases thioles are transferred to gold surfaces on silicon wafers. Other common inks are proteins for biological or biotechnological applications.

Systems

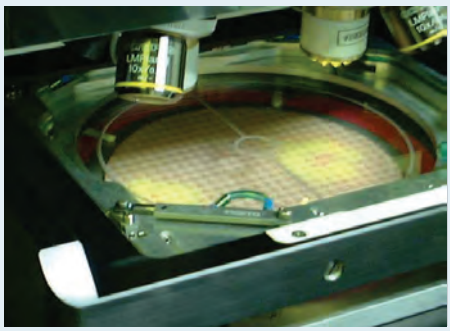
- EVG®610/620
- EVG®6200
- EVG®720

The EVG600 Series configured for µ-CP, applies a uniform contact force to the inked soft stamps. Soft stamps are typically made of elastomer material such as PDMS (polydimethylsiloxane). Alignment is performed through the transparent PDMS stamp.

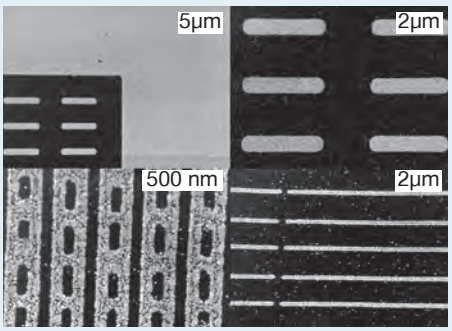
Principles

Legend	1	2	3	4
Backplane Soft Stamp Ink				

EVG®620 Mask aligner for single step UV imprinting



Micro contact printing tool in the **EVG®620**



Contact inking stamps for micro contact printing of alkanethiols on gold **Courtesy of IBM**

Technical Data UV-NIL and µ-CP Systems

	EVG®501/510 UV-NIL/HE	EVG®610/620	EVG®6200	EVG®720 / 7200	IQ Aligner®	EVG®770
						
Max. Wafer Diameter [mm]	150	150	200	150 / 200	300	450
Min. Wafer Diameter (Substrate Diagonal) [mm]	pieces	pieces	75	75	150	100
Exposure Source	150 W Hg	350 W, 500 W, 1000 W Hg	500 W, 1000 W Hg	Hg broadband exposure	1000 W, 5000 W Hg, 3500 W high intensity pulsed lamp	Hg broad band exposure
Automated De-embossing	on external de-embossing station	• / •	•	• / •	•	•
Manual Wafer/Stamp Transfer	• / •	• / •	•	• / •	•	•
Automated Wafer/ Stamp Transfer		- / •	•	• / •	•	•
Resolution	sub-50 nm* (demonstrated sub-10 nm)	sub-50 nm* (demonstrated sub-10 nm)	sub-50 nm* (demonstrated sub-10 nm)	sub-40 nm*	sub-50 nm*	sub-50 nm* (demonstrated sub-10 nm)
Alignment Capabilities	NA	sub-100 nm using Moiré	sub-100 nm using Moiré	sub-3 µm	sub-1 µm	sub-20 nm standard; sub-1 µm for non-CMOS applications
Throughput	**	**	**	> 40 W/h **	> 10 W/h **	10 W/h **
Process	hot embossing hard + soft UV-NIL	hard + soft UV-NIL, µ-CP	hard + soft UV-NIL, µ-CP	SmartNIL™	hard + soft UV-NIL; micro molding	hard + soft UV-NIL
Customer / Application	R&D					
		Pilot Line + Manufacturing				
				High Volume Manufacturing	High Volume Manufacturing	High Volume Manufacturing

* resolution dependent upon template and process
** throughput dependent upon process

NILCom

NILCom® Platform

NILCom® Markets

- Nano Electronics
- Data Storage
- Life Sciences
- Opto Electronics
- Stamp Replication/Mastering

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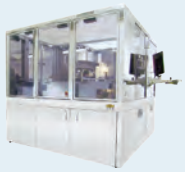
NILCom® Objectives

- Approved Nanoimprint Solutions
- Worldwide Demonstration Labs
- Joint Research Initiatives
- Stimulation of Industrial Utilization
- Accumulation of Expertise
- Service, Material & Know-How Supply

Technical Data Hot Embossing Systems

		EVG®501/510 UV-NIL/HE	EVG®520HE	EVG®540	EVG®750	EVG®750R2R
						
Heater Size = Max. Wafer Diameter [mm]	150	•	•			
	200		•		•	
	300			•		•
Min. Wafer Diameter (Substrate Diagonal) [mm]	150 mm	pieces	pieces			•
	200 mm		100		100	
	300 mm			150		300 mm foil width
Hot Embossing Chuck System / Alignment System	150 mm	EVG620, EVG6200	EVG620, EVG6200			
	200 mm	EVG620, EVG6200	EVG620, EVG6200		alignment integrated	
	300 mm			IQ Aligner Smart View		
Max. Contact Force for HE [kN]		60	100	100	360	10
Cooling System		rapid cooling (bottom side)	rapid cooling (top & bottom side)	rapid cooling (top & bottom side)	rapid cooling (top & bottom side)	air knife cooling
Automated De-embossing			•	•	•	•
Manual Wafer/Stamp Transfer		•	•			
Automated Wafer/Stamp Transfer				•	•	
Film Thickness						50 - 1000 µm
Temperature						200°C
Speed						0,5 - 20 m/min
Customer / Application		R&D				R&D
			Pilot Line + Manufacturing			Pilot Line + Manufacturing
				High Volume Manufacturing		

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