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## A UV-NIL resist developed for a transitional soft mold process and the subsequent dry etch transfer into hard materials

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## 1 Printing with nanonex equipment

**Equipment**  
Use a nano-imprint lithography set-up (NX-2500 equipped with a double membrane system) for the molding of a temporary film on a flexible polymer sheet

**Advantages of the equipment**  
Isostatic pressure  
Homogeneous thickness of residual layer  
Better suited for fragile substrates such as III-V wafers

<http://www.nanonex.com/>

S.Y. Chou et al, Appl. Phys. Lett. 67 (1995) 3114.  
M. Vogler et al, Proc. of SPIE Vol. 6517 651727-1(2007)  
A.Amirsadeghi et al, App. Surf. Sci. 258 (2011) 1272- 1278

Nanonex NX 2500

Air cushion system : the pressure is applied uniformly thanks to nitrogen pressure through the membranes

## 2 Transitional soft mold process

**Advantages of transitional soft mold**  
Less sensitive to dust, less mold degradation  
Replication of the mold without inversion  
Zeonor® : more rigid than flexible PDMS stamps (Young modulus of elasticity over 2000 Mpa instead of 8,2 Mpa for h-PDMS) → no pairing effect

Zeonor® (ZEON corp) 188 μm  
RESIST  
SILICON

I<sub>1</sub> : Imprint 31 bar 145°C 3 min  
I<sub>2</sub> : Imprint 14 bar 3 min UV 2 min  
E<sub>1</sub> : Residual layer etching (O<sub>2</sub>)  
E<sub>2</sub> : Transfert etching in Si (C<sub>4</sub>F<sub>8</sub>-SF<sub>6</sub>-O<sub>2</sub>)

## 3 Issues encountered with our process and commercial resists

**NXR-2010**  
"Bubbles" formation in the resist leading to holes after etching

**mr-UVCur21**  
Dewetting of the resist leading to scattered printed areas

→ Not adapted to our process

## 4 Results with our resist NIL-UV135

SEM image (tilt 45°) of lines and dots of 500 nm, 200 nm and 100 nm imprinted in the resist on Silicon

Gratings imprinted into resist from a silicon mold on a transparent substrate (visible light is decomposed by the gratings)

**No dewetting**  
**No "bubbles"**

SEM image (tilt 45°) of lines of 250 nm with 500 nm period  
- Top : imprinted in the resist  
- Down : dry etch transferred into Si

## 5 Our resist properties

Resist thickness (nm) homogeneity over 7 cm ø after imprint (@ 4 krpm ; 4 krpm/S ; 30 S) by ellipsometry

Resist thickness (nm) after imprint depending on spin speed; dilution

Resist thickness (nm) after imprint depending on % diluent (@ 4 krpm ; 4 krpm/S ; 30 S)

Resist optical index depending on wavelength measured by ellipsometry

## 6 Applications to research projects

- Thermal imprint in zeonor
- UV imprint in NIL-UV135 with zeonor temporary mold
- Dry etch transfer into substrate

Photography of a GMRF (Guided Mode Resonance Filter) pattern on 6" silicon mold made by optical stepper and dry etching. Grating periodicity is 880 nm with an etching factor of 57±3%. Rainbow shapes come from diffraction of light. Insert is an AFM micrograph

Photography of a GMRF (Guided Mode Resonance Filter) pattern transferred on the top layer of a full 4" SiO<sub>2</sub>/a-Si/SiO<sub>2</sub>/a-Si/glass sample (respective thicknesses 61, 49, 120, 74 nm on 500 μm thick glass). Insert is an AFM micrograph. Red and green shapes come from diffraction of light

SEM micrograph of a silicon mold of a CRIGF (Cavity Resonator Integrated Grating Filter, made of a Grating Coupler (GC) and Distributed Bragg Reflectors (DBRs) separated by a Phase Shift (PS)) that was successfully transferred into substrate thanks to the NIL process with NIL-UV 135 resist

SEM micrograph of a GaAs heterostructured CRIGF (Cavity Resonator Integrated Grating Filter, made of a Grating Coupler (GC) and Distributed Bragg Reflectors (DBRs) separated by a Phase Shift (PS)) made by transfer into the substrate thanks to the NIL process with NIL-UV 135 resist

S.Pelloquin et al, Microsys. Technol.(submitted)

## 7 Conclusions /Future work

We designed a new UV nanoimprint resist adapted to the use of a transitional soft COP or COC mold to replicate or transfer submicro or nano features into hard materials such as silicon, silica or gallium arsenide. We have used this resist successfully to transfer submicro or nano features from a silicon mold into silicon, silica or gallium arsenide on small samples or full 4" wafers. This enables for instance the making of optical filters on transparent substrates on which direct stepper lithography can not be done easily. The knowledge of the resist content provides a good reliability of the process and enables adaptation of the resist to new applications (such as final optical index adjustment). Among currently investigated and future works or those implying the use of the resist as an optical layer that will remain on the final device (as it is, or with optical index adaptation) and its use for nanoscale metal deposition by lift-off process.