NILCom® – Commercialization of Nanoimprint Lithography

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ABSTRACT:

NILCom® is a consortium and technology platform for Nanoimprint Lithography (NIL) processes (Fig 1.)[1]. NILCom® focuses on commercially available infrastructure for nanoimprint applications in nano electronics, life sciences, data storage, and opto electronics, whereas previous work in NIL examines specific phenomena of imprint technologies and feasibility studies in feature size resolution and its specific process challenges[2,3]. Today NIL is considered a member of next generation lithography (NGL) and with that, it enjoys its consideration and application in product development and manufacturing if compared to other patterning technologies.

Figure 1 NILCom® Consortium Members

Keywords: NILCom®, nanoimprint lithography (NIL), UV-NIL, μTAS, patterned media, biosensors, commercialization

1 NILCom® IN THE INDUSTRY:

The industry looks at NIL as an enabling technology for novel devices and to replace high-end substrate materials with lower cost polymers [4]. In addition it offers opportunities to apply NIL technology as a promising and cost efficient way for advanced pattern replication amongst which the most prominent and promising is in nano electronics. Although the 65nm node is already destined for high volume manufacturing [5] there are challenges to provide a cost efficient continuing path with current NGL technologies, especially with Extrem UV (EUV).

Status	**NGL (EUV, EPL, ML2)**	**NIL**
Exposure equipment	Feature size depends on wavelength of light source	Existing lithography light source
Resist Material	New resist sensitivity development	Existing polymers available
Mask Making	New resist sensitivity needs	Existing technology can be used (LIGA, E-beam, etc..)
Metrology	Similar Requirements	

Table 1: EUV and NGL status.

Other successful application areas are in data storage with an opportunity and a roadmap to continually increase the data storage capacity for the growing demand on information mobility in consumer electronics. Advances in nanoimprint lithography (NIL) are being employed to introduce new manufacturing processes for next-generation, thin-film disks, which use patterned substrates for land-and-groove structures that magnetically isolate individual data tracks from each other. The concept, called discrete track recording (DTR), promises to significantly increase data storage in hard-disk drives because recording heads will no longer be used to define data tracks. Physical tolerances for recording heads will also be relaxed, and other performance improvements are expected from DTR [6].

Further the broad field of life sciences, its bio-sensors and fluidic devices, as well as in opto electronics are on the roadmap for NIL manufacturing technologies. NIL has been identified to combine multiple process steps in one, such as being promoted by Sematech [7] for dual damascene processes in semiconductor manufacturing. Its capability to generate three-dimensional patterns in a single step make it an ideal process technology for building structures on existing devices in surface or bulk patterning methods. It offers process simplification in particular with multi material systems prone to etch rate differences.

NILCom® serves application developers in the above-mentioned market segments as well as material suppliers alike to develop qualified NIL manufacturing methods. The combination of polymeric material development and availability of multiple centers of excellence provide processing expertise to accelerate prototyping and transfer from R&D to high volume manufacturing.

The goal of NILCom® is to leverage NIL synergies and support market segment acceleration for processes and infrastructure in its main areas of interest: nano electronics, data storage, life science, and opto electronics. In doing so NILCom® promotes process standardization and equipment automation for top down nano patterning technologies. The technology platform offers qualification opportunities for commercially available infrastructure (Fig. 2) such as templates, stamps, resists and substrates, processing equipment and metrology continuously taking advantage of developments along the International Technology Roadmap for Semiconductors in following ongoing scaling requirements in the nanometer regime driven by Moor's Law.

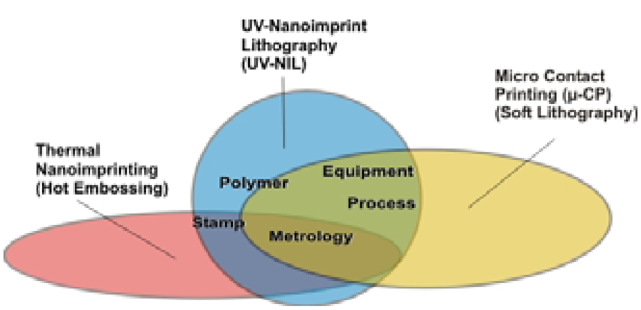

Figure 2 Synergies of NIL Technologies

2 CONNECTION WITH ITRS:

The difference between standard optical photo lithography (OPL), and NIL based pattern replication is that standard OPL depends on the control and range of its emitting wavelength. NIL technology mechanically replicates the pattern from a template (or stamp) either in a printing mode, under UV exposure or via a thermal imprint. As such high-end OPL systems are used today for template manufacturing only. High volume manufacturing can be done on a more cost efficient NIL system (Fig. 3) with reduced process steps due its intrinsic 3D capability [8].

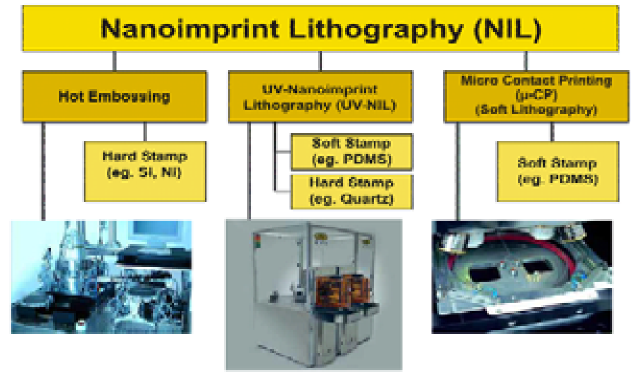

Figure 3 NIL Manufacturing Systems

Applications and components developed with NILCom® consortium partner's technology can take full advantage of the most advanced and cost efficient pattern replication methods promoting an accelerated product commercialization path. This becomes apparent when combining the high yield and high volume manufacturing specifications for semiconductors with low cost application requirements in life sciences for consumable products.

An area of particular interest is in the broad field of life sciences. Since NIL technology offers the possibility to work with biocompatible materials at room temperature it can take full advantage of critical processing environments and process time constraints. An example for such an application can be a cell culture platform that employs thermal imprinting for replicating larger patterns in sheet polymer (Polycarbonate (PC), Polymethylmethacrylate (PMMA)). Further it may use UV-NIL for nano structuring dedicated areas and finally applies solutions in dedicated zone providing functionality, fully automated and precision aligned. The same approach can be employed for manufacturing flexible displays or solar cells.

Of particular interest is the demonstration of nanoimprint technologies as contenders to 193nm optical lithography [9] with detailed results and demonstrations in defect control (Fig. 4). Since in all cases the template is in contact with the substrate, success of nanoimprint is strongly coupled to the absence of particles between the template and the substrate. While particles on a photomask in OPL lead to a local defect in the feature, a particle on the template acts as a bumper between template and substrate during the imprint procedure. Depending on its size areas up to the whole imprint area can be affected due to the non-parallelism between both surfaces.

NSTI-Nanotech 2005, www.nsti.org, ISBN 0-9767985-1-4 Vol. 2, 2005

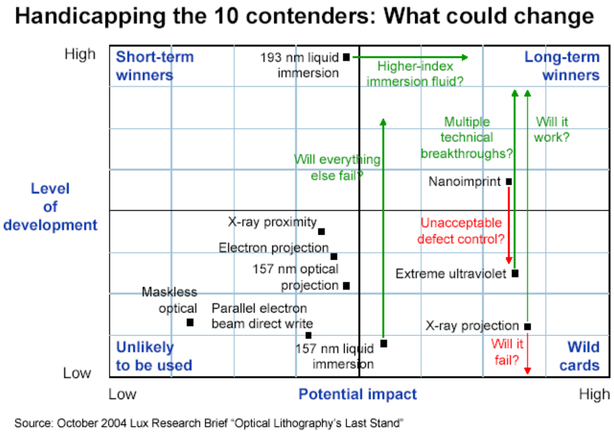

Figure 4 Nanoimprint Opportunities

However reapplying the same template in several consecutive imprint cycles can minimize the effect of small particles inside a template feature. It has been observed that particles tend to stick rather to the imprint resist than to the template resulting in some kind of "self-cleaning" effect of the template. This phenomena is observed were a defect caused by a particle on a template after 10 consecutive imprint steps. It can clearly be seen, that the defect size is dramatically reduced during the first five imprint cycles and nearly disappears after ten cycles [10].

Special nano-scale coatings can be used as "anti-stiction" or "release" layers in nano-imprint lithography. The MVD™ coatings can be applied to virtually any material using special adhesion layers [11]. Studies with release promoters are currently ongoing to satisfy the industry's demand for high repeatability and pattern fidelity.

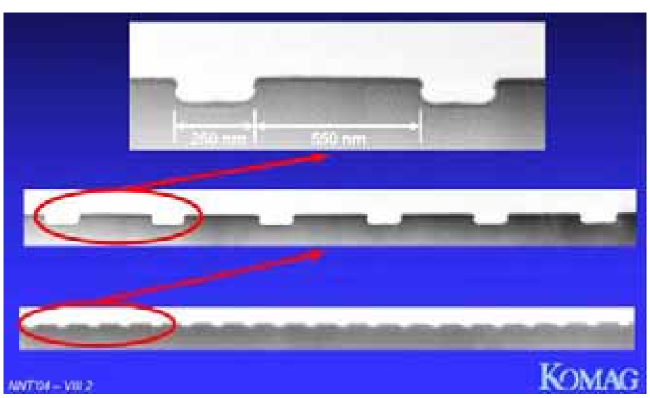

Figure 5 NIL on 95mm patterned media

Applied NIL technology in hard disk manufacturing for data storage aims at zero defect to avoid contact between the read and write head and the disc platter. Since the glide height over the platter during operation is in the range of 200nm, any contact between the head and the platter may cause a fatal error. Joint collaboration with individual NILCom® members and Komag, Inc. a hard disk manufacturer headquartered in California, USA, demonstrated the current state of the art in discrete track recording (DTR), where NIL is used as a cost efficient technology to create a land and grove structure on the platter to mechanically isolate the magnetic information on the disc and hence increase the data storage capability (Fig. 5).

The progress report (fig. 6) illustrates the developments in defect control on the final platter caused by the imprint process as well as subsequent processing steps. The current status lists 120wph throughput for this type of application and additional challenges remain to transfer this product successfully to commercialization [12].

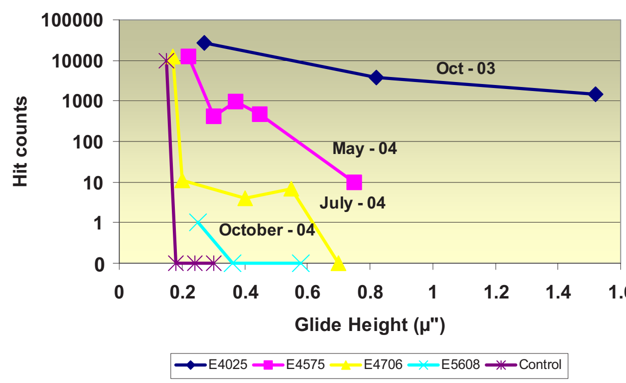

Figure 6 Defect Control

3 SUMMARY:

The NILCom® consortium has access to three centers of excellence located in Europe, Japan and North America for NIL infrastructure qualification and process development in nanoelectronics, data storage, life sciences and opto electronics. The qualified processes build upon results in large scale ultraviolet based nanoimprint lithography and hot embossing developments aiming to provide an off-the-shelf manufacturing platform for top-down nano patterning.

Main industrial opportunities for NIL relate to:

1) Enabling technology for novel devices
2) Manufacturing on low cost materials
3) Low cost manufacturing through process simplification
4) ITRS: 32nm node for nano electronics

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