NIL Masters and Surface Modification

Masters and Silicon Passivation Coating Technical Note

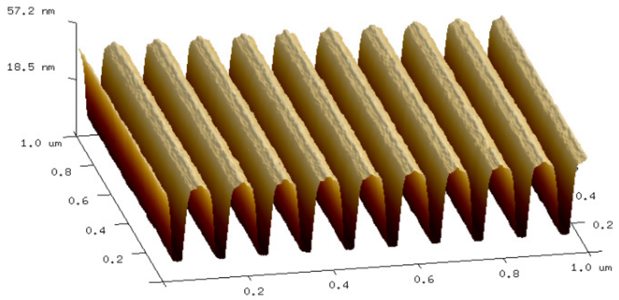

Figure 1 AFM image of a typical 300mm high precision master

Introduction

Nanoimprint Lithography (NIL) has demonstrated its value in manufacturing nanostructures with extremely tight tolerances for the optics industry. A key component of NIL consists of obtaining precision masters to use in producing stamps for mass replication. Silicon wafers are an ideal base material for these masters due to their considerable use in standard semiconductor processes. However, access to high quality masters has been limited due to significant equipment costs, thus limiting rapid prototyping using NIL. To address this need, Moxtek offers a collection of masters making capabilities at different cost and quality targets. Specifically, we offer high precision masters up to 300mm in diameter made with state of the art tools; NIL replica of high precision masters up to 200mm in diameter using a Substrate Conformal Imprinting Lithography (SCIL) process; and Laser Interference Lithography (LIL) based masters up to 200mm in diameter. These masters in conjunction with NIL processes can help to break the ultra-high price barrier to nanoscale feature printing on the latest lithography scanners; therefore achieving fast DOE cycles at reasonable costs. We offer custom design options for high precision and LIL-based masters. NIL replica offers an economical solution to access masters patterns that are already available in house.

AFM Data for 300mm High Precision Master (Measurements in nm)

Site	Height Mean	Height STDev	Width Top Mean	Width Top STDev	Width Middle Mean	Width Middle STDev	Width Bottom Mean	Width Bottom STDev	Pitch	Max Pitch Dev
1	50.82	0.33	43.31	1.27	53.50	1.09	61.19	0.71	101.56	6.86
2	48.43	3.36	43.27	1.49	53.58	1.36	61.24	1.44	101.56	2.93
3	50.93	0.38	44.12	1.69	54.17	0.82	61.45	0.79	101.56	2.93
4	50.37	0.43	42.62	1.92	53.23	0.79	60.70	0.60	101.56	2.93
5	48.41	0.23	43.32	1.45	52.86	1.06	59.97	1.12	101.56	2.93
6	51.01	0.30	43.77	1.62	53.58	1.03	61.12	0.95	101.56	2.93
7	50.78	0.32	43.79	1.40	53.23	0.90	60.67	0.86	101.56	2.93
8	51.04	0.29	45.38	1.02	54.92	0.79	62.24	0.83	101.56	2.93
9	50.72	0.35	44.54	1.22	53.58	0.92	60.78	0.81	101.56	3.91
10	48.91	0.28	46.16	1.38	55.27	0.97	62.49	0.94	101.56	2.93
11	48.35	0.31	46.43	1.42	55.23	1.15	62.10	1.08	101.56	2.93
12	49.13	0.25	46.61	1.26	55.70	0.98	62.76	0.91	100.59	2.93
13	49.18	0.20	46.63	1.33	55.67	0.88	62.73	0.82	101.56	2.93
Overall Average	49.85	0.54	44.61	1.42	54.19	0.98	61.49	0.91	101.49	3.31
Average STDev	1.116		1.445		1.018		0.889		0.269	

Table 1 AFM data of a typical 300mm high precision master

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In addition to high precision masters, Moxtek has been using its own proprietary LIL processes to produce patterns for Wire Grid Polarizers (WGPs) on 200mm wafers for over two decades. These processes can also produce patterns on the tens of nanometers scale and then be used to etch underlying layers. Using our lithography process we have been able to produce Silicon masters for NIL specifically with Line/Space, periodic pillar and hole structures (Figure 2) as well as pixelated polarizer arrays.

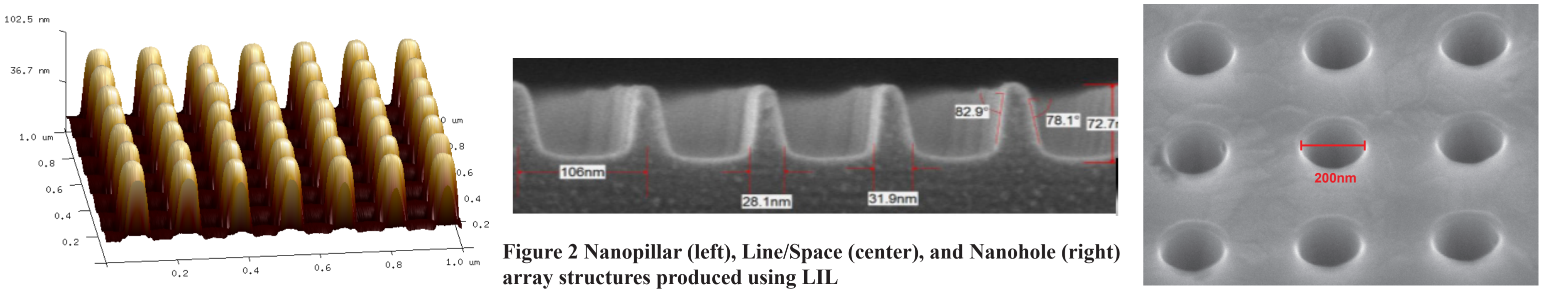


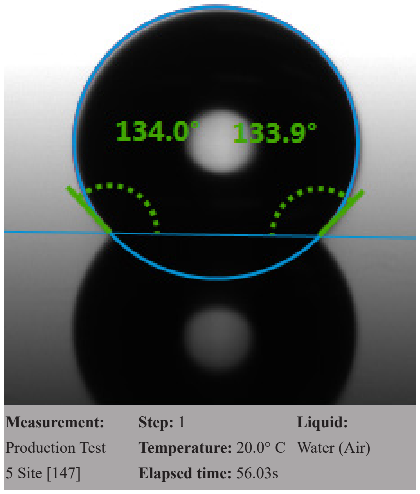
Figure 2 Nanopillar (left), Line/Space (center), and Nanohole (right) array structures produced using LIL

High Precision Master						
Size	**Type**	**Pitch**	**Line CD**	**Depth**	**Tolerance**	**Materials**
300mm	Line/Space	100nm	28-50nm	Up to 3:1 aspect ratio	+/-10% CD	Si
300mm	Line/Space	130nm	32-65nm	Up to 3:1 aspect ratio	+/-10% CD	Si
300mm	Nanohole	80nm	50nm Hole	Up to 3:1 aspect ratio	+/-10% CD	Si
300mm	Line/Space	112nm	32-56nm	Up to 3:1 aspect ratio	+/-10% CD	Si
300mm	Custom Design	Custom Design	Custom	Up to 3:1 aspect ratio	+/-10% CD	Si

NIL replica of High Precision Master						
Size	**Type**	**Pitch**	**Line CD**	**Depth**	**Tolerance**	**Materials**
200mm	Line/Space	100nm	28-50nm	Up to 3:1 aspect ratio	+/-10% CD	Si/Glass
200mm	Line/Space	130nm	32-65nm	Up to 3:1 aspect ratio	+/-10% CD	Si/Glass
200mm	Line/Space	80nm	30nm	Up to 3:1 aspect ratio	+/-10% CD	Si/Glass
200mm	Line/Space	112nm	32-56nm	Up to 3:1 aspect ratio	+/-10% CD	Si/Glass
200mm	Custom Design	Custom Design	Custom	Up to 3:1 aspect ratio	+/-10% CD	Si

LIL-Based Master						
Size	**Type**	**Pitch**	**Line CD**	**Depth**	**Tolerance**	**Materials**
200mm	Nanohole	180-700nm	70-300nm	20-250nm	+/-10% Pitch	Si/Glass
200mm	Line/Space	144 & 180-700nm	43-79 & 70-300nm	20-250nm	+/-10% Pitch	Si/Glass
200mm	Nanopillar	180-700nm	70-300nm	35-250nm	+/-10% Pitch	Si/Glass

Table 2 High precision, NIL, and LIL master characteristics



Measurement: Production Test 5 Site [147]
Step: 1
Temperature: 20.0° C
Elapsed time: 56.03s
Liquid: Water (Air)

Release Layer Coating

In addition to master making, we have successfully developed a passivation coating for Si masters, enabling low adhesion of a PDMS stamp to silicon and with that a water contact angle in the range of 90-140° (Figure 3). The exact angle depends on the surface structure of the master. Specifically, the surface of master is made non-reactive towards PDMS with an active Fluorosilane coating to passivate Si-OH and Si-H groups on the master.

Figure 3 Contact angle of water as measured on a silicon wafer with the Fluorosilane surface modification

Benefits of Coating

Master defects can be an issue with this type of surface modification, thereby leading to lower yielding stamped products as Fluorosilane molecules tend to adhere to themselves and create large areas of self-nucleated agglomerations in the coating process. These defects will be replicated into the stamp and from there to the final product. The innovative solution developed at Moxtek has successfully eliminated these defects through a proprietary process, enabling tight defect control for volume manufacturing from this critical master preparation step.

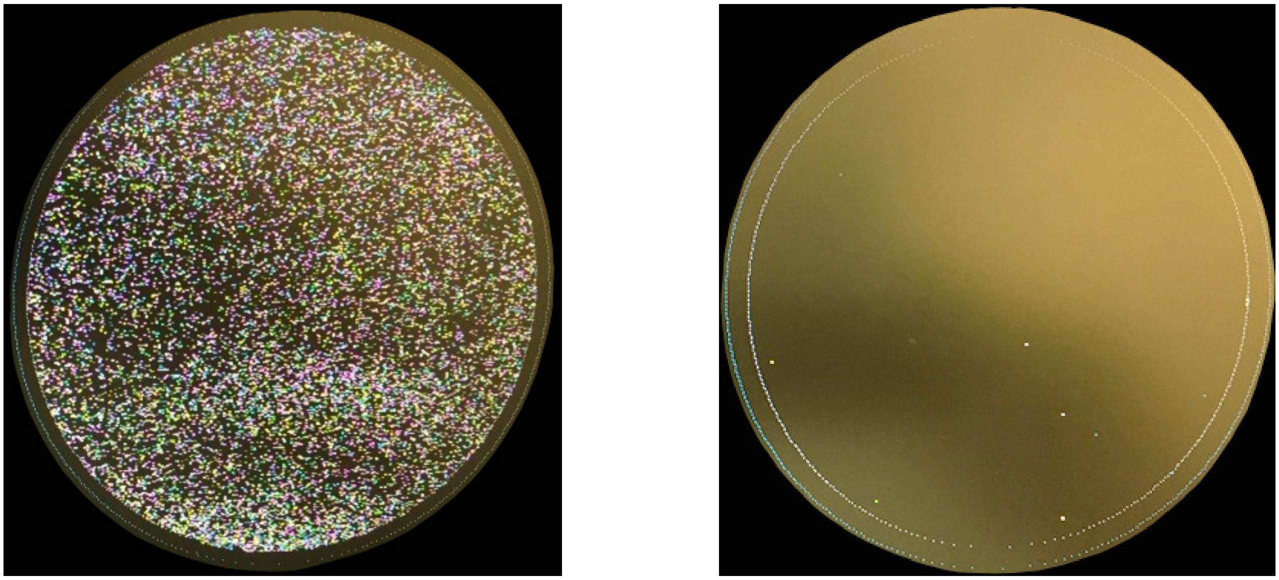


Figure 4 The Left picture shows a Surfscan 6220 defect scan of an 8-inch silicon wafer receiving a Fluorosilane treatment without using Moxtek process. ~22,000 defects >0.3um are added. The right picture showing a Surfscan 6220 defect scan of a silicon wafer with the proprietary defect reducing Fluorosilane treatment process with only 16 defects >0.3um added. Different color dots correlate to particle size bins between 0.3um diameter up to the largest bin of 1.6um diameter and greater.