Technical Report
TR-1278

Development of High-Density Wafer-to-Wafer Interconnects to Enable Next-Generation Scientific Instruments for HEP and BES: Program 10089 Final Report

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6 March 2023

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LEXINGTON, MASSACHUSETTS

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Massachusetts Institute of Technology
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Lexington Massachusetts

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1. INTRODUCTION

Advances in fundamental scientific research across many disciplines, ranging from nanotechnology to astrophysics, are reliant upon ever-increasing detector capabilities, particularly in pixel-array detectors. These devices must provide the necessary spatial and temporal resolution to characterize phenomena of interest for wide-ranging applications such as reconstructing elementary particle tracks, performing precision photometry for astronomical imaging, time-stamping X-ray photon arrivals, or serving as eyes for autonomous systems. Increasingly, these demands require detectors with processing at or near the focal plane—in some cases, even within the pixel—to provide the necessary functionality with minimal latency. Since these capabilities need to be added without sacrificing sensitivity or resolution, simply reducing fill-factor to provide the requisite real estate for processing capabilities is usually not a viable option. 3D integration via hybrid (via-first) bonding, such as the DBI® process developed by Ziptronix, helps ensure these need can be met simultaneously, connecting a detector layer with 100% fill factor on one level to readout circuitry on another level (which can itself be divided into multiple tiers to enable integration of different capabilities such as memory and compute). This approach allows each tier to be optimized separately before being 3D-integrated, and can be done with few or no changes to underlying layers in each wafer.

Over the past few years, manufacturers of commercial CMOS imager sensors has begun to utilize 3D integration via hybrid bonding, largely for the reasons enumerated above. Those processes, however, are generally captive to the manufacturer and not available as a foundry service. While a small number of foundry services for 3D integration do exist, they often struggle to meet the challenges of prototyping low volumes of high-performance, specialized scientific detectors.

MIT Lincoln Laboratory (MIT LL) offers several advantages for 3D integration of scientific imaging devices. First, MIT LL has a long history of prototyping advanced imaging devices, built in their Microelectronics Laboratory (ML), for scientific or DoD applications. Imagers require strict attention be paid to metallic contamination to ensure high performance; trace levels of metal contamination can have negative consequences for device operation, leading to orders-of-magnitude increases in dark current. The sensitivity to device contamination often does not exist at commercial foundries. Second, MIT LL routinely fabricates high-performance backside-illuminated imaging devices, with custom backside treatments to ensure high sensitivity and low dark current. Imagers 3D-integrated at MIT LL can readily take advantage of this capability. Next, MIT LL has a long history in 3D device integration, concurrently developing a 3D integration (via-last) process broadly similar to the hybrid bonding processes utilized commercially in terms of complexity and capability, but forming electrical interconnects after bonding rather than before bonding as is the case for hybrid bonding. Finally, as an FFRDC, MIT LL's focus is on prototype demonstrations rather than high-volume production, and the Laboratory remains dedicated to continuing to provide custom imagers for the government community.

Given this background, Program 10089 was initiated to demonstrate the capability for 3D integration via hybrid bonding, at 10 μm interconnect pitch. The overall goal was to design a new mask set dedicated to 3D integration via hybrid bonding, and to use that mask set to establish initial 90% interconnect yield on metal monitors, eventually increasing to 99% with further fabrication iterations. The bulk of the work for this program began in early 2020 and ended in mid-2021. Though the program has ended, MIT LL plans to continue to refine its 3D integration processes over the coming months as it represents a strategic capability.

2. TECHNOLOGY STATUS AT PROGRAM START

In this section, we briefly outline the status of 3D integration via hybrid bonding at MIT LL prior to the start of Program 10089. We previously prepared and shared briefings on our progress, so this section will only provide a short summary of status leading up to the start this program.

In 2016, MIT LL licensed the DBI® process from Ziptronix and began fabricating metal monitors using a layout previously used for demonstration of 3D-integrated APDs (256 × 256 arrays with 25 µm pitch, with 3D integration done at the Ziptronix foundry). Because the ML is largely a copper-free foundry, MIT LL focused on demonstrating a nickel-based hybrid bonding process (hereafter called HBI), detailed in Figure 1, and we subsequently introduced our own process modifications to suit our requirements and tool set.

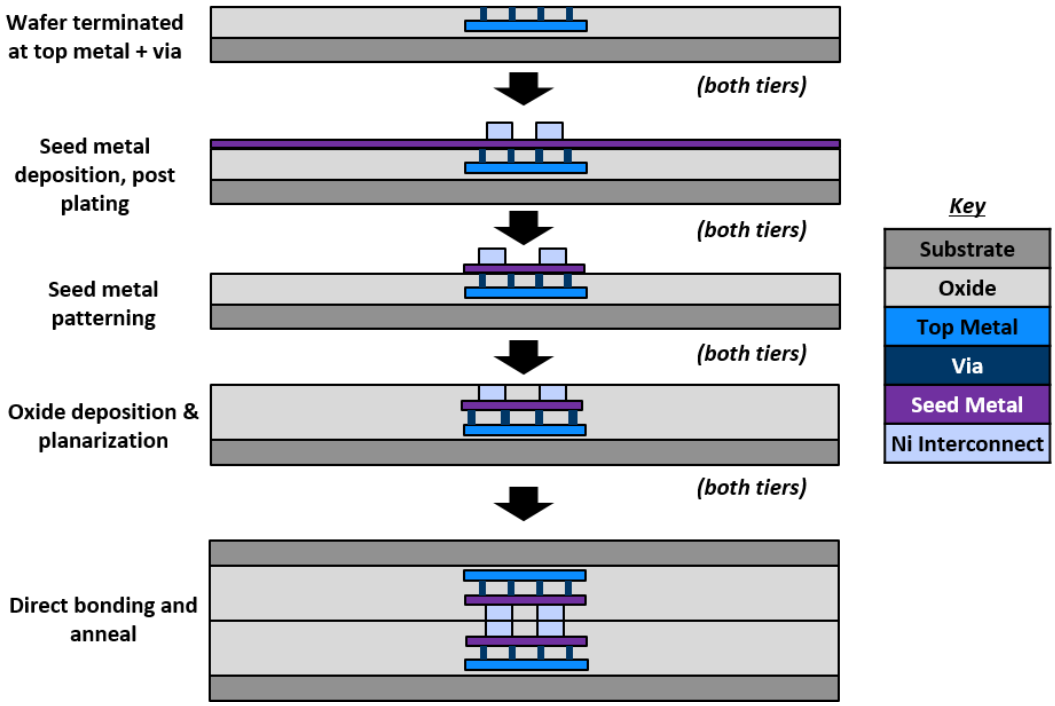

Figure 1. Overview of Ni hybrid bonding process.

In total, MIT LL completed two bonded pairs using this process, using internal R&D funding, in the 2018-2019 timeframe. These wafers are pictured in Figure 2. The first wafer completed (811) had poor bonding yield due to particles and wafer bow. The hybrid interconnects on this wafer were 3 μm diameter posts. Within transferred regions, we demonstrated successful interconnection of short (6 series-connected interconnect) chains after a 350°C post-bond anneal. The second wafer (818) featured much better bonding yield, and also utilized a different hybrid interconnect geometry (2 × 6 μm slots, orthogonal on each tier). A few regions on this wafer showed functioning chains of up to 960 series-connected hybrid interconnects after a 350°C post-bond anneal, indicating very high yield in these areas. For both cases, the hybrid interconnect yield broadly tracked the wafer-to-wafer misalignment, suggesting that the basic HBI process employed was robust and that even higher yields could be expected with improved alignment accuracy. Also, we tested both wafers after 250, 300, and 350°C post-bond anneals and observed steadily improving interconnect yield as we continued to anneal.

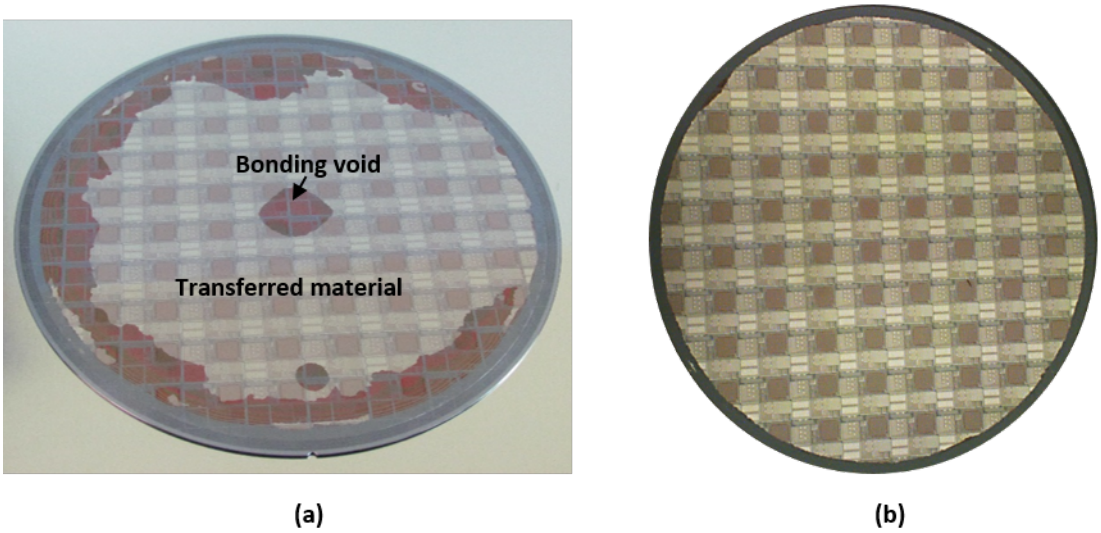

Figure 2. Images of completed hybrid-bonded wafers. (a) Wafer 811, the first wafer completed. (b) Wafer 818, the second wafer completed.

The mask set used in these demonstrations suffered from some limitations, the most significant of which was the presence of metal fill that interfered with alignment of all 3D-specific layers. A secondary issue was that the hybrid interconnect chains on these wafers were solely terminated at the seed metal level, as these metal monitors lacked any other metal layers. Finally, the test structures were fairly limited and not amenable to automated probing. These limitations motivated creation of a new reticle set for this program, designed from the start with 3D integration in mind and reflecting a more aggressive (and relevant) 10 μm pixel pitch.

3. PROGRAM ACCOMPLISHMENTS

3.1 DESIGN OF 3DFBL RETICLE SET

Layout for the new reticle set, named 3DFBL, started in earnest in January of 2020 and was completed in August. The design was documented in a thorough design guide (included here as an appendix) and is summarized here. The most significant features of the 3DFBL reticle set are:

20 physical layers, including for each of the two tiers: top metal, top via, 3D target, hybrid seed and hybrid interconnect. Note that the term “top via” refers to conventional within-wafer vias formed at MIT LL by a W damascene process, while the term “hybrid interconnect” refers to the 3D (Ni) via formed by plating.

10 μm hybrid interconnect pitch with 4 μm diameter seed metal islands.

Four types of hybrid interconnect geometries: 3 μm diameter posts (type A); 3.5 μm diameter posts (type B); 1.5 × 3 μm slots, orthogonal on each tier (type C); and 1.0 × 3 μm double slots, separated by 1 μm and orthogonal on each tier (type D).

Test structures where the 3D connections terminate at either top metal (TM) or hybrid seed (HS) to separate out the influence of via yield on overall 3D yield.

Chains of series-connected hybrid interconnects ranging in length from 1 to 13,800, some of which were intentionally misaligned to enable electrical measurements of overlay accuracy. Some chains were also placed along the edges of features to test the impact of dicing.

Pad layouts amenable to automated probing.

Examples of chains terminated at different metal levels are illustrated in Figure 3.

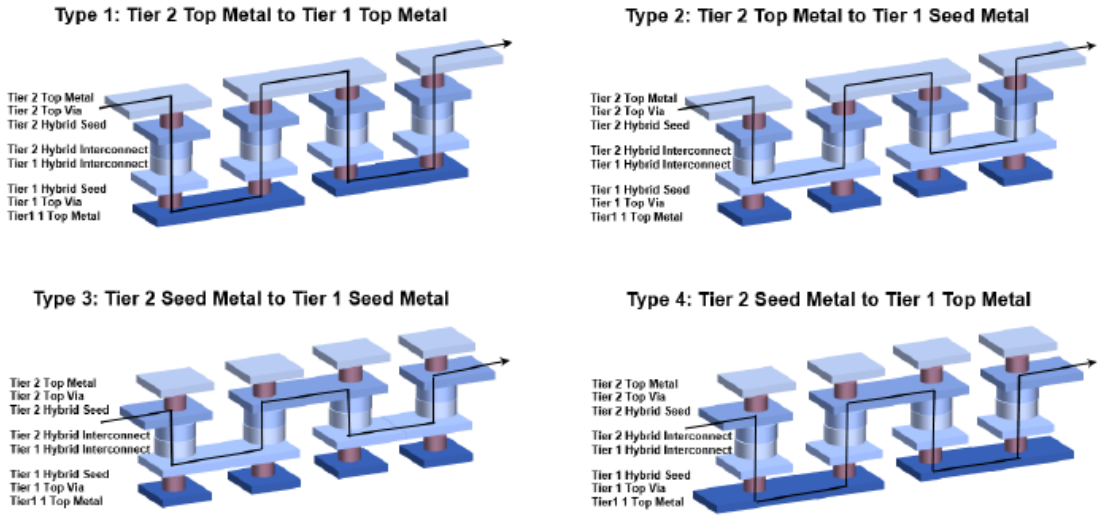

Figure 3. Different interconnect types in 3DFBL reticle set, where chains terminate either at the top metal or hybrid seed layers.

A cross-section of the final structure of bonded pairs is shown in Figure 4. In this figure and on the processed wafers, the tier-2 handle wafer is completely removed to facilitate probing of chains at tier-2 top metal (T2TM). The particular chain shown in Figure 4 terminates at the two top metal layers (T1TM and T2TM).

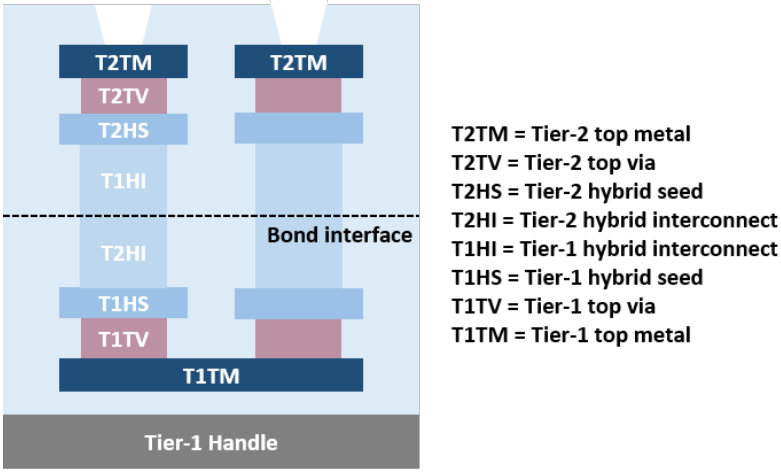

Figure 4. Cross-section (not to scale) of bonded pairs of 3DFBL wafers.

3.2 WAFER PROCESSING

With the 3DFBL layout finalized, wafer processing began in late August of 2020 with two wafer lots: 3DFBL_lot1 and 3DFBL_lot2, dedicated, respectively, to tier-1 and tier-2 processing. After processing these lots for several months, we decided to split these further into four child lots dedicated to each interconnect geometry: 3DFBL_lot2a, 3DFBL_lot2b, 3DFBL_lot2c, and 3DFBL_lot2d (reflecting each of the post geometries described above). Each child lot had five wafer pairs in them, while an additional 10 wafer pairs were held in reserve after oxide deposition over seed metal (referring to Figure 5 below, in the hybrid post module). This strategy was employed to simplify and accelerate wafer processing, as well as leave some wafers further back in the process if we encountered unexpected issues in the child lots.

The overall process flow is described in Figure 5, where 3D-specific processes are separated from the initial processing used to create metal monitors (top metal definition and top via).

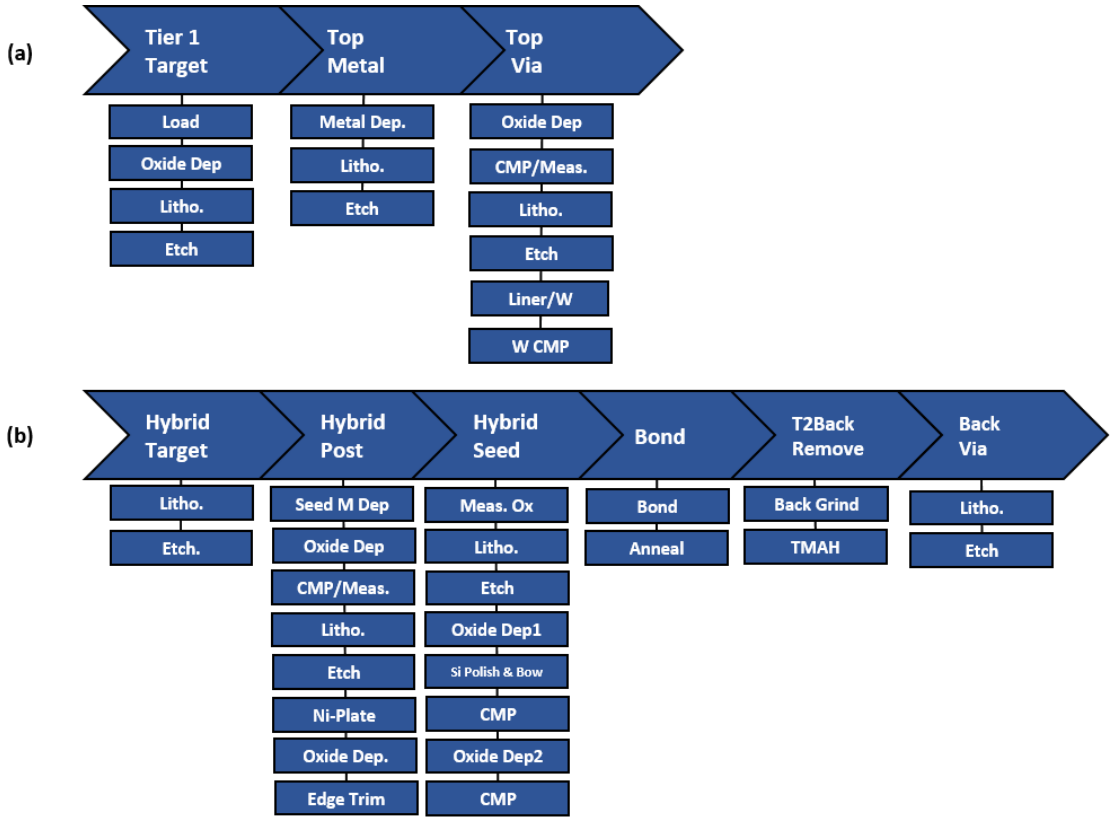

Figure 5. Process flow used for 3DFBL wafers. (a) General metal monitor preparation through top (W) via. (b) 3D-specific processing.

Note that for these metal monitors, wafer processing after bonding includes removal of the entire tier-2 handle wafer. For most applications, the tier-2 wafer will be a detector and will therefore have a finite thickness of silicon. The simplification of removing the entire tier-2 wafer was performed to avoid more time-consuming processing where the tier-2 wafer is preserved, such as the need for IR alignment to register to the buried metal features proximate to the bond interface, or deep silicon RIE etches to expose bond pads in the streets.

The progress of each lot is shown in Figure 6. The largest delay in wafer processing, of about two months, was due to a metallization tool being down. We also encountered other minor delays, mainly due to coordination required for polishing and bonding. 3D-specific wafer processing started in early 2021 and took approximately six months to complete, gated largely by the use of a new reticle set and relative immaturity of the HBI process at MIT LL. We expect that the HBI process developed for this work can be completed significantly more quickly when mature.

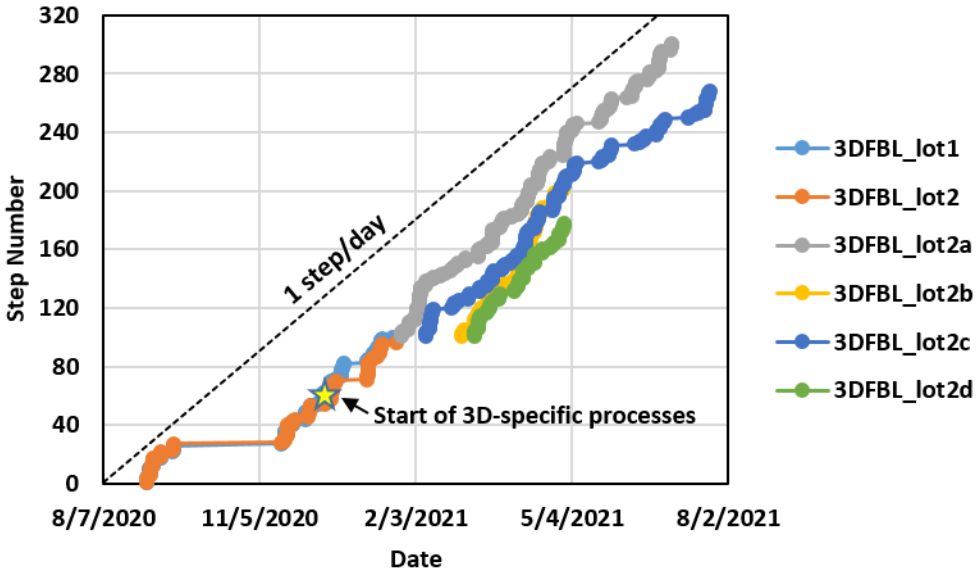

Figure 6. Progress of wafer processing. The trend line indicates 1 process step per day. The 3D-specific portions of the HBI process include about 180 process steps.

Prior to planarization (in the hybrid seed module), 3DFBL_lot2b and 3DFBL_lot2d were held in favor of advancing wafers from 3DFBL_lot2a and 3DFBL_lot2c. For risk mitigation, only two pairs from each of these lots proceeded through the entire process, to ensure that corrective action could be taken if yield on these wafers was low. To date, three bonded pairs have been completed, two from 3DFBL_lot2a and one from 3DFBL_lot2c. A fourth bonded pair from 3DFBL_lot2c was dropped from further processing after sustaining mechanical damage, described further below.

There were a few issues encountered during wafer processing, not unexpected for a relatively immature process flow. These are summarized below.

The most significant issue was an incomplete seed metal etch, affecting 3DFBL_lot2a and 3DFBL_lot2c. During the course of root cause investigation, we found that the CF_4 mass flow controller on the etch tool had drifted out of specification. Since an incomplete seed metal etch could result in shorted islands and ultimately a false indication of 3D connectivity, the affected wafers were reworked. The rework process was successful.

We encountered challenges in measuring the planarity of surfaces immediately prior to bonding via atomic force microscopy (AFM), due to the underlying metal layers interfering with the laser signal used to measure tip height. We were able to take sufficient metrology despite this problem, and can switch to a different tip in the future to avoid this phenomenon.

Earlier in the process flow, the AFM was down, which affected the speed and accuracy of the Ni thickness measurements after plating. We were forced to rely on tilted SEM images for Ni thickness estimation, examining the difference in Ni height against the surrounding SiO_2 film (of known thickness).

3DFBL_lot2c wafer 11 was scrapped late in the process flow. The wafer became wedged in a boat during post-bond anneal, which resulted in a small crack that grew into a larger chip after back grind (part of tier-2 substrate removal). We considered options to complete this wafer, but ultimately decided not to proceed given the extra difficulty involved, as well as the potential risk to fabrication tools.

Finally, we note that successful 3D interconnection via HBI requires nearly perfect co-planarity of the Ni with the surrounding oxide film – the specification given by Ziptronix is that the Ni must be recessed less than 10 nm – as well as the usual stringent cleanliness and planarity requirements of direct (oxide) bonding. A post-bond anneal is employed to allow the Ni hybrid interconnects to expand and make permanent electrical connection via cold welding, as well as to form and strengthen a permanent covalent SiO_2-SiO_2 bond in the field. The baseline post-bond anneal recommended by Ziptronix is done at 350°C. Considering only linear expansion of Ni, we would expect 1300 nm-thick hybrid interconnects to expand by about 5 nm during this anneal. However, since the hybrid interconnect is at least partially constrained against expansion in the other two dimensions by the surrounding SiO_2, we would expect even more elongation normal to the bond interface. In this work, we were interested in determining the minimum thermal budget required for achieving 3D interconnection. We therefore tested wafers after an initial 250°C post-bond anneal and then repeated testing after anneals at higher temperature. However, we point out that the standard MIT LL back-end-of-line processing includes oxide deposition at 400°C and tungsten deposition at 430°C. For wafers being introduced from another foundry and terminated at top via, the latter step would not be needed. As for oxide deposition, we can deposit bonding oxides at temperatures as low as 150°C, though the large amount of trapped hydrogen in those oxides typically constrains post-bond anneal temperatures to about 175-200°C. After we establish a strong baseline HBI flow using 400°C-deposited oxides, we could consider developing a low-temperature variant of HBI, though the co-planarity requirements will be even more stringent.

Acoustic microscope images (Sonoscan) on all three completed wafers, taken after the 250°C post-bond anneal, are shown in Figure 7.

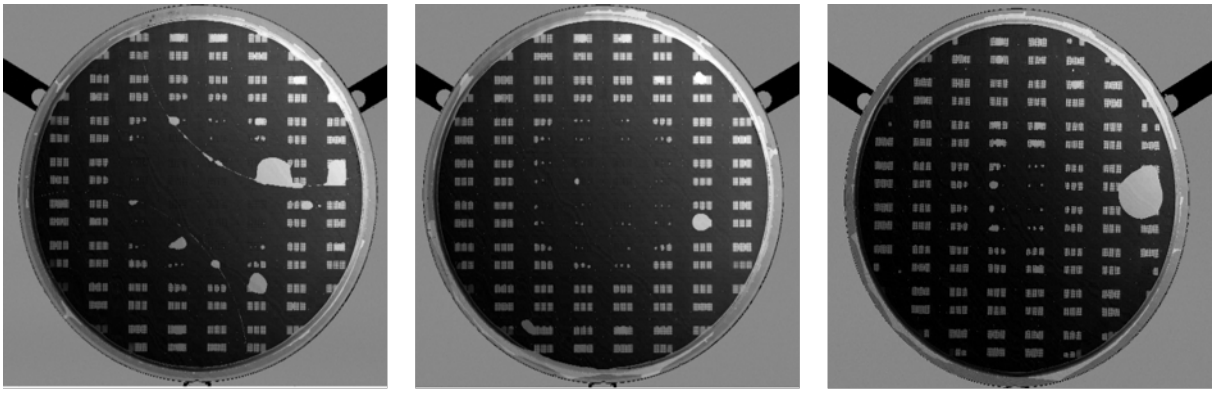

Figure 7. Acoustic micrographs of the three completed wafers.

These images show a few small voids, as well as what appear to be pattern-dependent features that are absent at the wafer center. These features occur in the region of the reticle that houses short interconnect chains (referring to the design guide, Small Chain Type 1 and Type 2). At this time, it is uncertain if these features are artifacts of the measurement technique, or if they represent pattern-dependent micro-voids. Note that the lateral resolution of the acoustic microscope is only on the order of 100 μm—much larger than the scale of metal fill features in these regions.

Photographs of completed wafers are shown in Figure 8. The transfer yield was fairly high for all three wafers, considering the maturity of the process and use of a completely new reticle set.

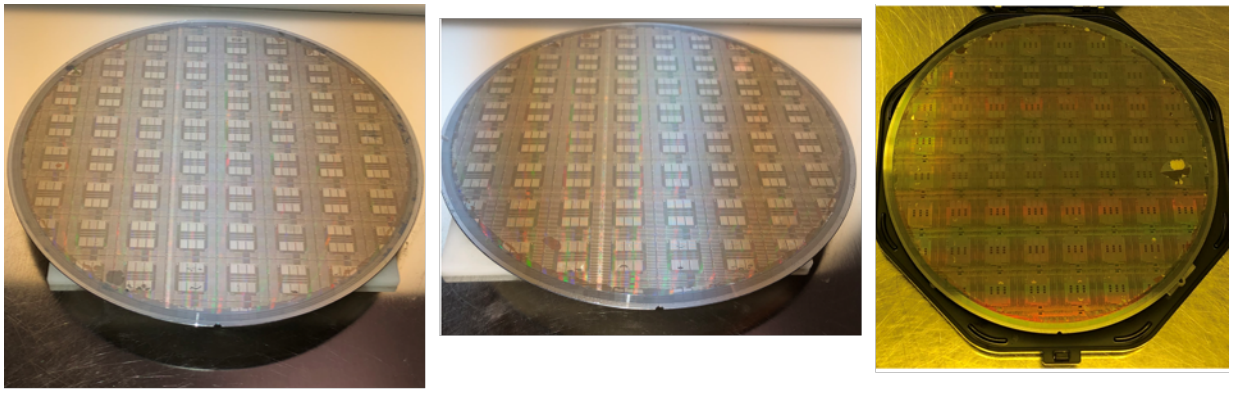

Figure 8. Completed wafer photos.

We were able to use 3DFBL_lot2c wafer 11 (chipped during processing) for cross-sectional SEM analysis. Two representative micrographs, of structures connected through seed (Type 3) or top metal (Type 1), are shown in Figure 9. The SEM did not reveal any major issues besides misalignment at the bond interface; the apparent cracking of some metal and dielectric layers in these images is due to the manual cleave of the specimen.

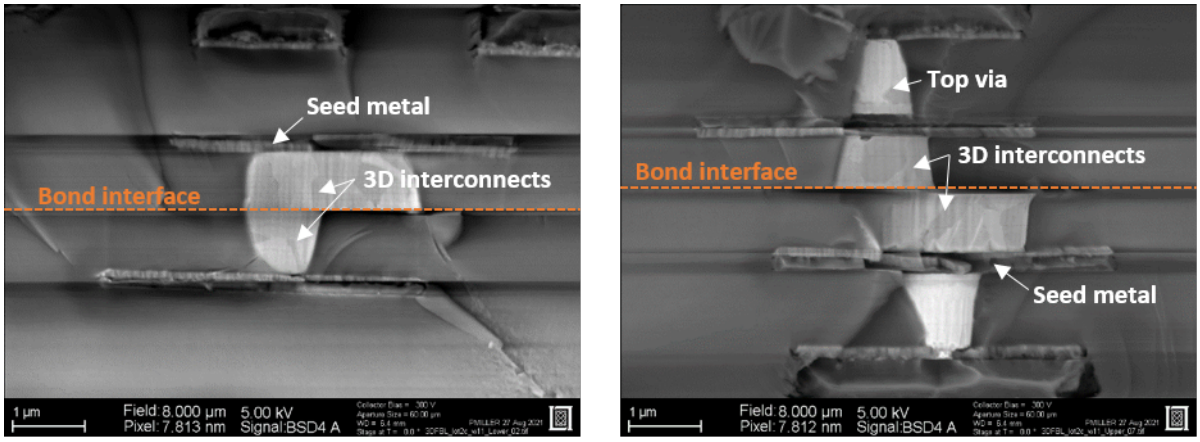

Figure 9. Cross-sectional SEM images of 3DFBL_lot2c wafer 11.

3.3 WAFER TESTING

3DFBL_lot2a wafers 1–2 were completed first, at the end of June 2021. In an effort to quickly assess the yield, we decided to manually probe short chains (up to 20 interconnects; denoted Small Chain Type 2 in the design guide) starting at a chain with only one 3D interconnect and focused on top metal–top metal (referring to Figure 3, Type 1) chains. This initial manual probing did not uncover any working 3D interconnections on either of these wafers (24 die tested on wafer 1, 11 die tested on wafer 2, looking mostly in die near the wafer center). This result was not considered surprising, given that the wafers had only received a 250°C post-bond anneal at that point; we had previously seen few yielding interconnects at that temperature in previous HBI wafers processed and generally observed higher yields as wafers were annealed.

We therefore subjected 3DFBL_lot2a wafers 1–2 to a 300°C anneal and retested. In these tests, 16 die were manually probed, with one connection found on wafer 1 and five connections found on wafer 2. Given that yield was still quite low, we then proceeded to a 350°C anneal, with the expectation that yield would continue to improve, perhaps dramatically given our past experience. Upon retest of the same 16 die, we observed a confusing result: some additional die showed connectivity but some previously connected die were now open. This trend is detailed in Figure 10. Note that some die were connected but quite resistive after the 350°C anneal, adding an intermediate point to the binary pass/fail criteria seen at lower anneal temperatures.

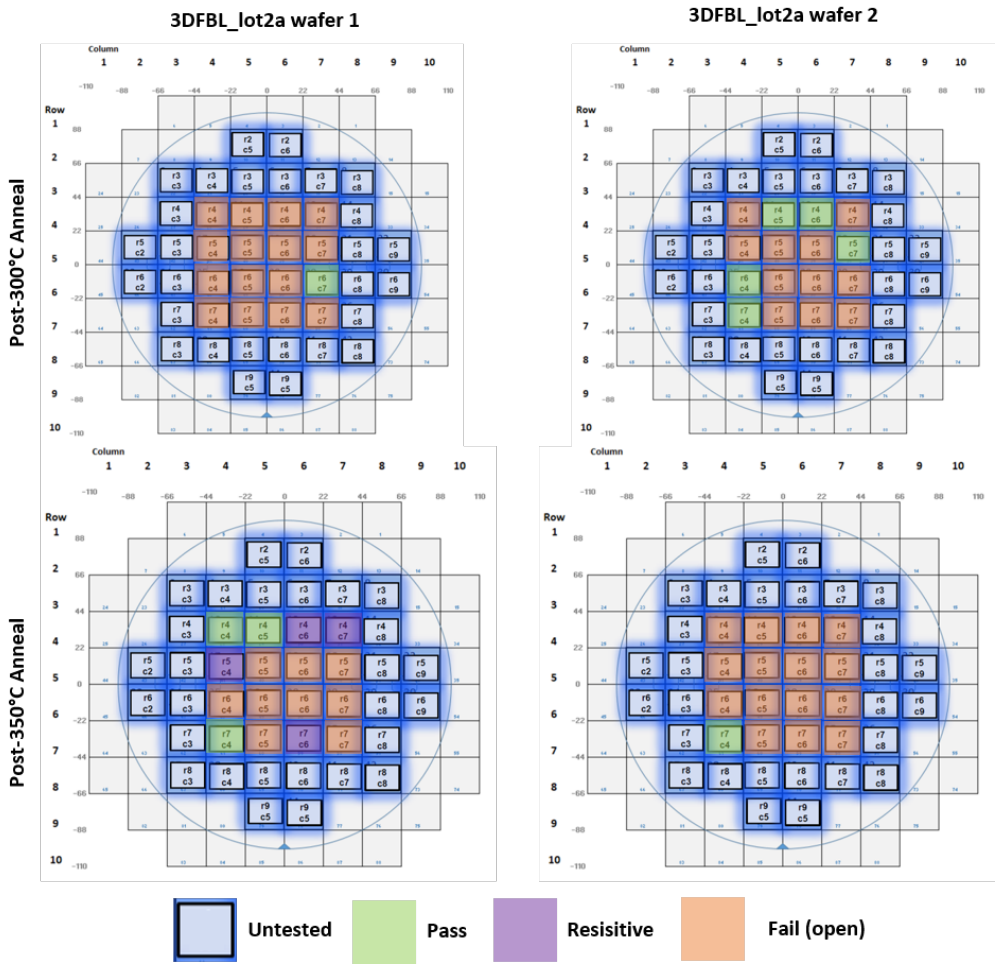

Figure 10. Initial yield assessment, established via manual probing of Small Chain Type 2 structures, on 3DFBL_lot2a wafers 1 and 2.

These results were perplexing in light of our previous experience. In an effort to shed light on this behavior, we expanded the scope of manual testing. In doing so, we found instances of short chains of a few interconnects being disconnected, while longer versions within the same die were connected. We also found that chains terminated at hybrid seed were far likelier to be connected than chains terminated at top metal. Though a full accounting of the extensive manual testing undertaken would lengthen this report considerably without providing further clarity, we show one example of test results below, detailing 60 individual tests on Small Chain Type 1 structures on a single die from 3DFBL_lot2a wafer 1. These results

indicate better yield for Type 3 chains (terminated at hybrid seed) over the other variants, as well as an apparently higher yield for chains with a 1 µm compass shift towards the northeast.

# Interconnects -->														
#	T2	T1	SHIFT		5	10	15	20	25	30	35	40	45	50
1	TM	TM	NS		✗	✗								
2	TM	HS	NS		✗	✗								
3	HS	HS	NS		✓	✗	✗							
4	HS	TM	NS		✗	✗								
5	TM	TM	N	1um	✗	✗								
6	TM	HS	N	1um	✗	✗								
7	HS	HS	N	1um	✓	✗	✗							
8	HS	TM	N	1um	✗	✗								
9	TM	TM	NE	1um	✓	✗	✓	✗	✗	✓	✗	✗	✗	✗
10	TM	HS	NE	1um	✗	✗	✗	✗	✗	✗				
11	HS	HS	NE	1um	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗
12	HS	TM	NE	1um	✗	✗								
13	TM	TM	E	1um	✓	✓	✓	✗	✗					
14	TM	HS	E	1um	✗	✗								
15	HS	HS	E	1um	✓	✓	✓	✗	✗					
16	HS	TM	E	1um	✗	✗								

Figure 11. Results of manual probing of row 5, column 2 of Small Chain Type 1 structures on 3DFBL_lot2b wafer 11."NS" indicates no compass shift on the chain.

We subsequently decided that automated probing would be necessary to fully characterize these wafers. To manage the initial scope, we decided to focus on two structures: single-interconnect 3D Kelvins, with all four types of connections (Types 1–4; T1TM – T2TM / T1TM – T2HS / T1HS – T2TM / T1HS – T2HS) and large chains composed of 19 segments of 600 series-connected hybrid interconnects (13,800 total), terminated at top metal, on 44 total die. The former was chosen in an effort to isolate single hybrid interconnect yields for all four different Kelvin structures. We decided to probe the long chains because they most closely resembled the uniform layout that would be characteristic of a pixel array; the smaller

chains which we had been manually probing have a less homogeneous fill pattern that varies with chain length.

In parallel, 3DFBL_lot2c wafer 12 was completed in mid-July 2021. Rather than spending significant additional time on manual probing on this wafer, we decided to focus our efforts on automated probing here as well. We conducted a round of automated probing after the 250°C anneal, as well as another round of probing after a 275°C anneal (based on our experience with wafers from 3DFBL_lot2a, we decided to take finer temperature steps with this wafer).

The measured yields on 3D Kelvin structures are shown in Table 1. While we found a few long chain segments that appeared to connect, when considered in light of the 3D Kelvin results shown in Table 1 below, their sporadic yield is likely due to a defect in the metal layers rather than a reflection of a functioning long chain.

Table 1. Compiled 3D Kelvin Yields

		3D Kelvin Type			
Wafer	**Highest anneal temp. (°C)**	**1 (T1TM–T2TM)**	**2 (T1TM–T2HS)**	**3 (T1HS–T2HS)**	**4 (T1HS–T2TM)**
3DFBL_lot2a wafer 1	350	10.5%	38.6%	91.8%	35.2%
3DFBL_lot2a wafer 2	350	0.3%	2.3%	19.3%	4.0%
3DFBL_lot2c wafer 12	250	39.2%	65.3%	63.4%	48.9%
3DFBL_lot2c wafer 12	275	66.8%	94.5%	95.2%	94.3%

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4. DISCUSSION

Referring to Table 1, we have several observations:

The yield on Type 3 Kelvins, which terminate at hybrid seed, is higher in all cases than other Kelvin variants. The Type 1, 2, and 4 Kelvins rely on a single top via located directly over or under the hybrid interconnect, while the Type 3 Kelvins connect to the tier-2 top metal (where the bond pads lie) through many parallel top vias. This clearly indicates that the top via yield is substantially less than 100% on these wafers. The top via yield also appears to be higher on 3DFBL_lot2c wafer 12 than on the other two wafers, as the yield drop-off from Type 3 to Type 2 or 4 is smaller.

The overall yield on 3DFBL_lot2c wafer 12 is higher than on the other wafers, especially considering the other wafers exhibited no observed connectivity at 250°C.

3DFBL_lot2a wafers 1 and 2 have markedly different yields despite being nominally identical. We speculate on possible causes below.

There is no obvious pattern to yielding structures (e.g. radial, top-to-bottom).

Finally, considering Type 3 Kelvins as a baseline for 3D interconnect yield (assuming we can improve top via yield, which should be straightforward), we achieved 95.2% yield on 3DFBL_lot2c wafer 12 after a 275°C anneal. This is intermediate between the initial 90% threshold and final 99% threshold established for this program.

Considering these observations in total, we offer some hypotheses to explain the observed behavior:

The observed behavior in 3DFBL_lot2a wafers 1 and 2 after annealing, with some previously connected portions of the wafer becoming disconnected, could be attributable to one or both of pattern-dependent voids around small chains growing with anneals, or the expanding Ni interconnects exerting sufficient pressure to cause micro-fractures.

The local yield variations observed on Small Chain Type 2 structures in a single die could be attributable to pattern-dependent voids, or to lower-than-expected top via yields.

The higher overall yields seen on 3DFBL_lot2c wafer 12 may indicate that the slot geometry is more tolerant to misalignment than the post geometry, or that the different interconnect geometry results in less of a recess of the nickel relative to the bonding surface during CMP.

We do not currently have a good working theory to explain the yield differences between 3DFBL_lot2a wafers 1 and 2.

We offer one final observation. Our experience with 3D integration suggests that establishing *any* yielding hybrid interconnects is quite challenging, so these initial results are quite encouraging. We believe that additional experience will result in dramatic improvements in yield. Unless we consider only Type 3 chains (terminated at seed metal) in all of the wafers for this lot, however, our top via yield will likely inhibit our overall 3D yield.

5. FUTURE WORK

We plan to continue both evaluating already-completed wafers, as well as continuing to process additional wafers from these lots through 3D integration.

Regarding the former, our immediate plans are to run automated testing on the Small Chain Type 1 (chains in increments of 5 hybrid interconnects up to 50 total) and Type 2 (chains in increments of 1 hybrid interconnect up to 20 total) on 3DFBL_lot2c wafer 12. This will provide useful information, such as whether the yield of small chains can be extrapolated from 3D Kelvin yields, or whether the hybrid interconnect yield in these regions is markedly different than around the 3D Kelvins. These chains also include compass shift variants, potentially shedding light on the impact of misalignment on hybrid interconnect yield. Once that larger suite of automated probing is completed (projected for the week of 10/4/21), we plan to anneal this wafer at 300°C and repeat all automated tests. We will also conduct these same automated tests on the two wafers from 3DFBL_lot2a.

In parallel, we plan to restart 3DFBL_lot2b and 3DFBL_lot2d, moving two pairs from each lot through the entire 3D process. This will facilitate comparison of different hybrid interconnect geometries. While we expect that these wafers also suffer from issues with top via yield, the different Kelvin types will allow us to determine the impact of that issue. Wafer processing will restart the week of 10/4/21 with results expected in January.

Finally, because the unexpected top via problems arose so early in the process, we are considering starting a second set of wafers from the very beginning of processing, with the hopes of achieving high yield across all chain variants.

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APPENDIX A
DESIGN RULE CATALOGUE

The following is a summary of the Hybrid Bond Integration (HBI) design rules that have been written for the 3DFBL reticle set. These rules have been included for information only. A working version of the design rules will be furnished upon request.

Taken From:
HBI Canon FPA-3000 iW Design Checks

General Checks

RULE: flag_offgrid_check {DRAWN OFFGRID}

PURPOSE: Finds all off-grid features

RESOLVED VARIABLE: Design Grid 50 nm

LAYER 000 ZERO - GRID SETTING Canon alignment marks placed by ASML

RULE: 000.001__ZERO_width { @ ZERO width < ^zero_min_width um

INTERNAL ZERO1 < zero_min_width ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum width allowable for layer ZERO

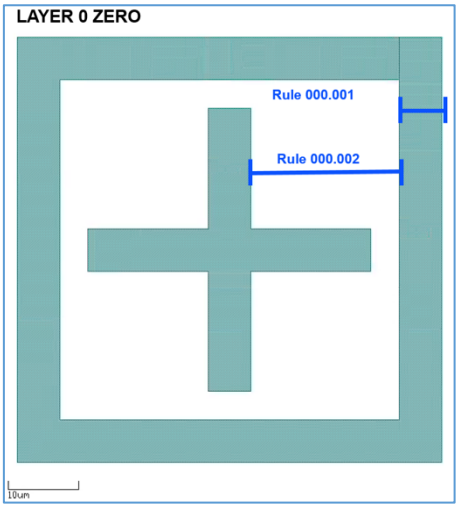
RESOLVED VARIABLE: 2.0um

RULE: 000.002__ZERO_spacing { @ ZERO spacing < ^zero_to_zero um

EXTERNAL ZERO1 < zero_to_zero ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum allowable space between adjacent layer ZERO features

RESOLVED VARIABLE: 1.95 um



LAYER 200 T1HT - Tier 1 Hybrid Target Canon alignment marks placed by Canon

RULE: 200.001__T1HT_width {@ T1HT width < ^t1ht_min_width um

INTERNAL T1HT1 < t1ht_min_width ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum allowable width of each T1HT feature

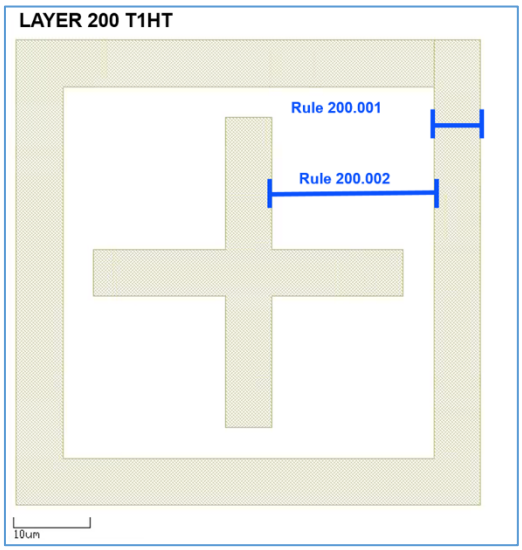
RESOLVED VARIABLE: 2.0 um

RULE: 200.002__T1HT_spacing {@ T1HT spacing < ^t1ht_to_t1ht um

EXTERNAL T1HT1 < t1ht_to_t1ht ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum allowable space between adjacent layer T1HT features

RESOLVED VARIABLE: 1.95 um



LAYER 300 T2HT - Tier 2 Hybrid Target Canon alignment marks placed by Canon

RULE: 300.001__T2HT_width {@ T2HT width < ^t2ht_min_width um

INTERNAL T2HT1 < t2ht_min_width ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum allowable width of each T2HT feature

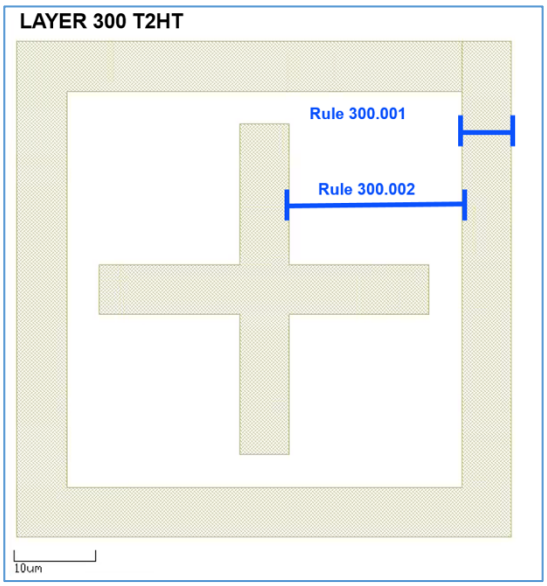
RESOLVED VARIABLE: 2.0 um

RULE: 300.002__T2HT_spacing {@ T2HT spacing < ^t2ht_to_t2ht um

EXTERNAL T2HT1 < t2ht_to_t2ht ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum allowable space between adjacent layer T2HT features

RESOLVED VARIABLE: 1.95 um



LAYER 201 T1TM – Tier 1 Top Metal

RULE: 201.001__T1TM_width {@ T1TM width < ^t1tm_min_width um

INTERNAL T1TM1 < t1tm_min_width ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum allowable width of each T1TM feature

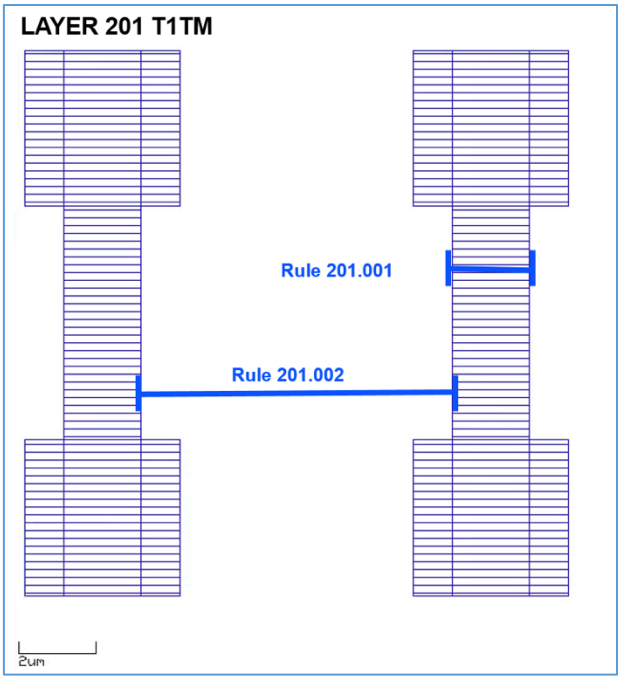
RESOLVED VARIABLE: 1.0 um

RULE: 201.002__T1TM_spacing {@ T1TM spacing < ^t1tm_to_t1tm um

EXTERNAL T1TM1 < t1tm_to_t1tm ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum allowable space between adjacent layer T1TM features

RESOLVED VARIABLE: 1.0 um



LAYER 301 T2TM – Tier 2 Top Metal

RULE: 301.001__T2TM_width {@ T2TM width < ^t2tm_min_width um

INTERNAL T2TM1 < t2tm_min_width ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum allowable width of each T2TM feature

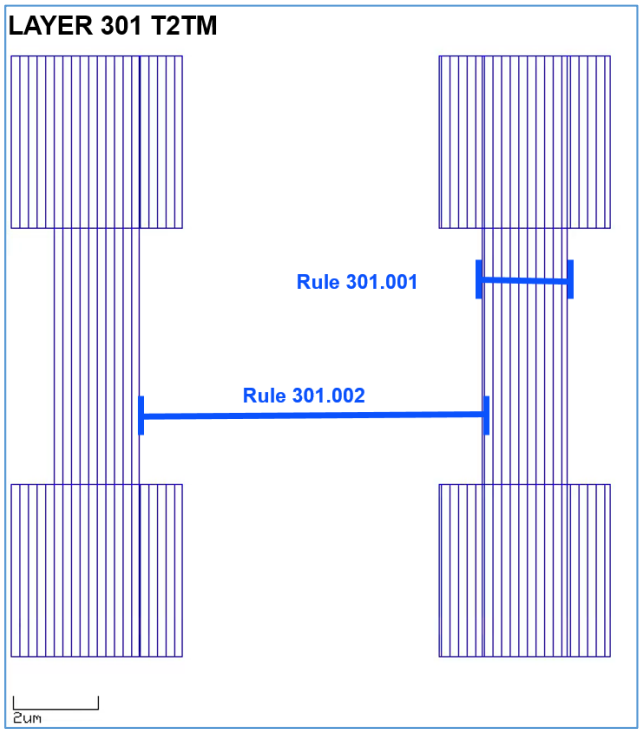
RESOLVED VARIABLE: 1.0 um

RULE: 301.002__T2TM_spacing {@ T2TM spacing < ^t2tm_to_t2tm um

EXTERNAL T2TM1 < t2tm_to_t2tm ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum allowable space between adjacent layer T2TM features

RESOLVED VARIABLE: 1.0 um


LAYER 301 T2TM
Rule 301.001
Rule 301.002
2um

LAYER 202 T1TV - Tier 1 Top Via

RULE: 202.001__T1TV_size_rule {@ T1TVs must be ^t1tv_exact_size_x x

^t1tv_exact_size_y um not rectangle T1TV1 == t1tv_exact_size_x by ==

t1tv_exact_size_y orthogonal only}

PURPOSE: Defines the T1TV as a rectangle with exact x and y dimensions

RESOLVED VARIABLE: 1.0 um (both axis)

RULE: 202.002__T1TV_Spacing {@ T1TV spacing < ^t1tv_to_t1tv um.

EXTERNAL T1TV1 < t1tv_to_t1tv ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum allowable space between adjacent layer T1TV features

RESOLVED VARIABLE: 1.0 um

RULE: 202.003__T1TV_inside_T1TM {@ T1TM overlap of T1TV < ^t1tv_in_t1tm um
T1TV1 NOT T1TM1 // finds all T1TVs not in t1tm
ENCLOSURE T1TV1 T1TM1 < t1tv_in_t1tm ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum enclosure of T1TV inside T1TM

RESOLVED VARIABLE: 1.0 um

RULE: 202.004__T1TV_inside_T1HS {@ T1HS overlap of T1TV < ^t1tv_in_t1hs um

T1TV1 NOT T1HS1 // finds all T1TVs not in t1hs metal

ENCLOSURE T1TV1 T1HS1 < t1tv_in_t1hs ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum enclosure of T1TV inside T1HS

RESOLVED VARIABLE: 1.0 um

RULE: 202.005__T1TV_not_interact_T1TM {@ T1TV must interact with T1TM

NOT INTERACT T1TV1 T1TM1}

PURPOSE: Flags all T1TV that does not touch T1TM.

This rule has been used as a safety net to ensure that all via are connected, included those in shifted cells which may not meet other design rules.

RESOLVED VARIABLE: Tier 1 Top Via must touch Tier 1 Top Metal

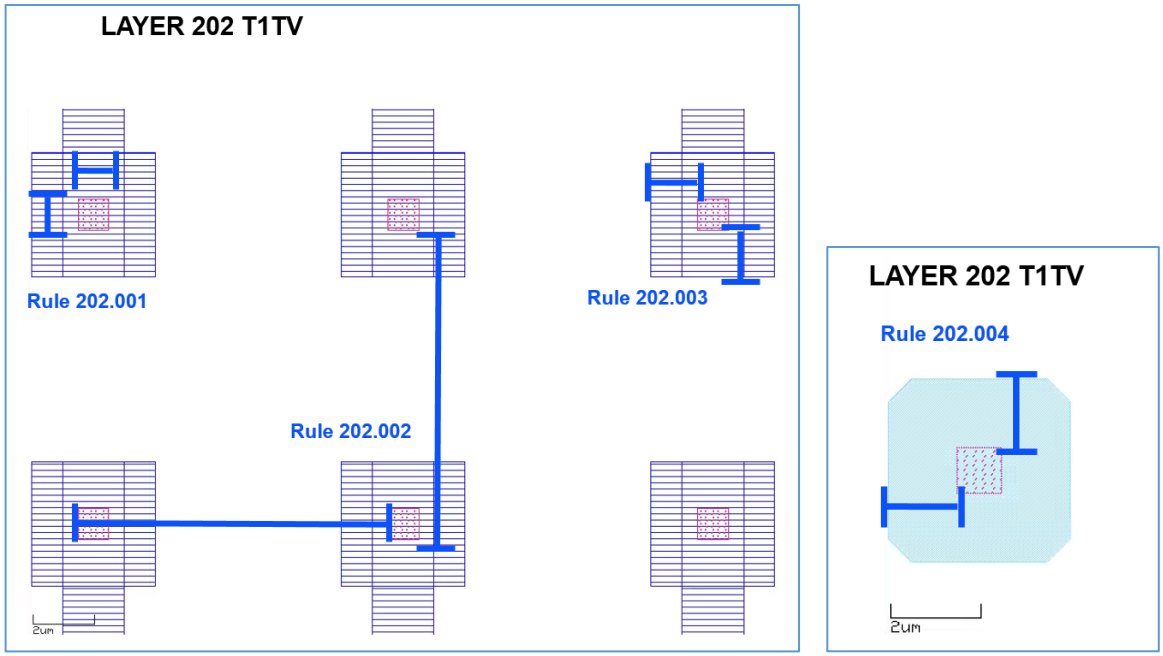
RULE: 202.006__T1TV_not_interact_T1HS {@ T1TV must interact with T1HS

NOT INTERACT T1TV1 T1HS1}

PURPOSE: Flags all T1TV that does not touch T1HS.

This rule has been used as a safety net to ensure that all via are connected, included those in shifted cells which may not meet other design rules.

RESOLVED VARIABLE: Tier 1 Top Via must touch Tier 1 Hybrid Seed



LAYER 302 T2TV – Tier 2 Top Via

RULE: 302.001__T2TV_size_rule {@ T2TVs must be ^t2tv_exact_size_x x ^t2tv_exact_size_yum not rectangle T2TV1 == t2tv_exact_size_x by == t2tv_exact_size_y orthogonal only}

PURPOSE: Defines the T2TV as a rectangle with exact x and y dimensions

RESOLVED VARIABLE: 1.0 um (both axis)

RULE: 302.002__T2TV_Spacing {@ T2TV spacing < ^t2tv_to_t2tv um EXTERNAL T2TV1 < t2tv_to_t2tv ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum allowable space between adjacent layer T2TV features

RESOLVED VARIABLE: 1.0 um

RULE: 302.003__T2TV_inside_T2TM {@ T2TM overlap of T2TV < ^t2tv_in_t2tm um T2TV1 NOT T2TM1 // finds all T2TVs not in t2tm
ENCLOSURE T2TV1 T2TM1 < t2tv_in_t2tm ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum enclosure of T2TV inside T2TM

RESOLVED VARIABLE: 1.0 um

RULE: 302.004__T2TV_inside_T2HS { @ T2HS overlap of T2TV < ^t2tv_in_t2hs um T2TV1 NOT T2HS1 // finds all T2TVs not in t2hs metal
ENCLOSURE T2TV1 T2HS1 < t2tv_in_t2hs ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum enclosure of T2TV inside T2HS

RESOLVED VARIABLE: 1.0 um

RULE: 302.005__T2TV_must_interact_T2TM {@ T2TV must interact with T2TM

NOT INTERACT T2TV1 T2TM1}

PURPOSE: Flags all T2TV that does not touch T2TM.

This rule has been used as a safety net to ensure that all via are connected, included those in shifted cells which may not meet other design rules.

RESOLVED VARIABLE: Tier 2 Top Via must touch Tier 2 Top Metal

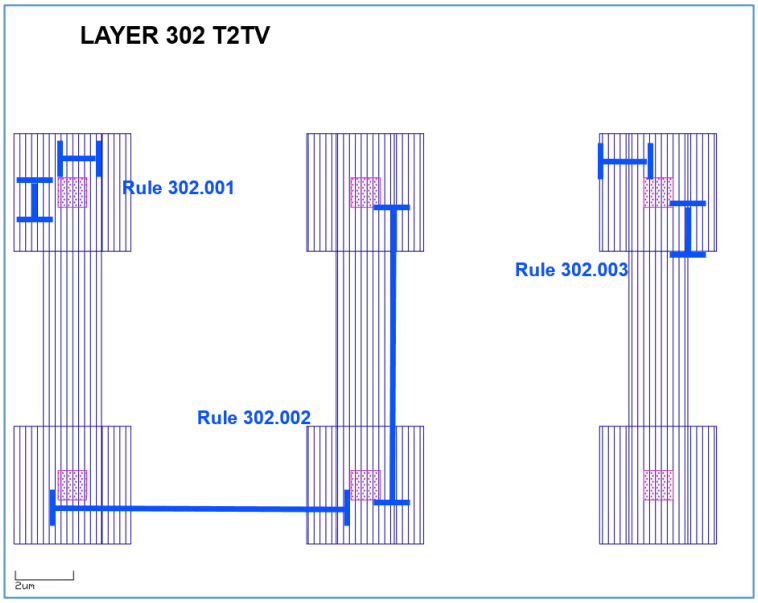
RULE: 302.006__T2TV_must_interact_T2HS {@ T2TV must interact with T2HS

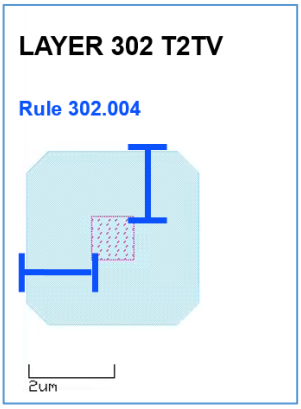
NOT INTERACT T2TV1 T2HS1}

PURPOSE: Flags all T2TV that does not touch T2TM.

This rule has been used as a safety net to ensure that all via are connected, included those in shifted cells which may not meet other design rules.

RESOLVED VARIABLE: Tier 2 Top Via must touch Tier 2 Hybrid Seed


LAYER 302 T2TV
Rule 302.001
Rule 302.002
Rule 302.003
2um


LAYER 302 T2TV
Rule 302.004
2um

LAYER 203 T1HS – Tier 1 Hybrid Seed Metal

RULE: 203.001__T1HS_width { @ T1HS width < ^t1hs_min_width um

INTERNAL T1HS1 < t1hs_min_width ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum width allowable for layer T1HS

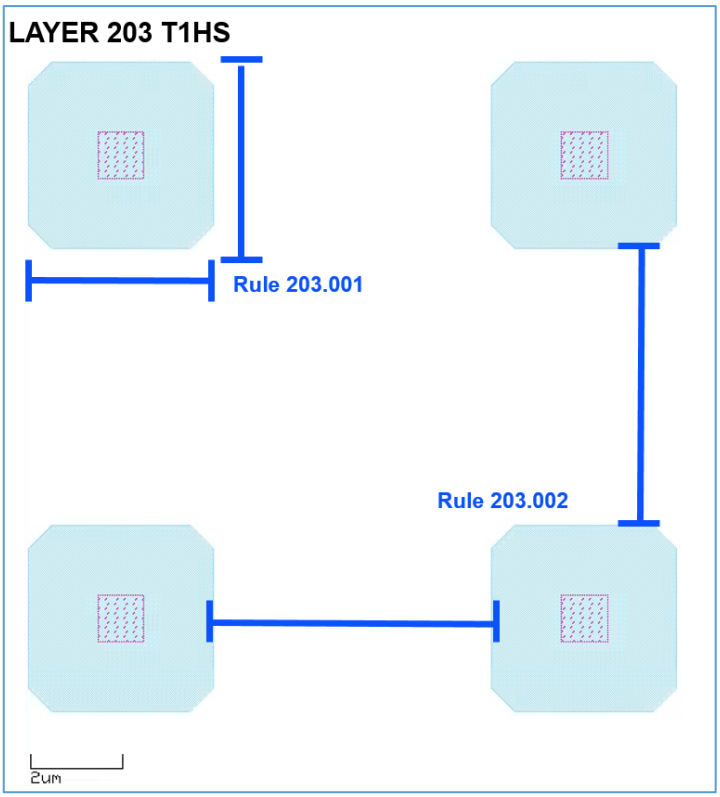
RESOLVED VARIABLE: 2.0 um

RULE: 203.002__T1HS_spacing { @ T1HS spacing < ^t1hs_to_t1hs um

EXTERNAL T1HS1 < t1hs_to_t1hs ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum allowable space between adjacent layer T1HS features

RESOLVED VARIABLE: 1.5 um



LAYER 303 T2HS – Tier 2 Hybrid Seed Metal

RULE: 303.001__T2HS_Width {@ T2HS width < ^t2hs_min_width um

INTERNAL T2HS1 < t2hs_min_width ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum width allowable for layer T2HS

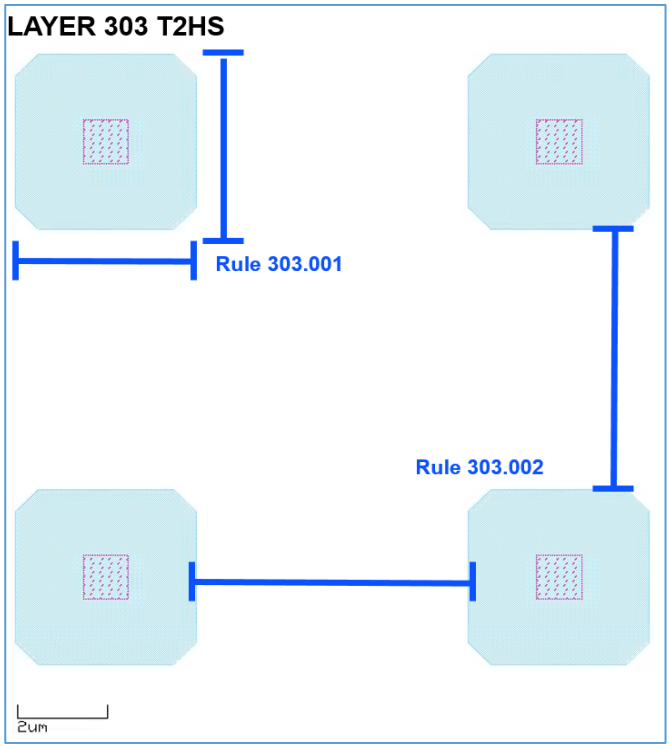
RESOLVED VARIABLE: 2.0 um

RULE: 303.002__T2HS_Spacing {@ T2HS spacing < ^t2hs_to_t2hs um

EXTERNAL T2HS1 < t2hs_to_t2hs ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum allowable space between adjacent layer T2HS features

RESOLVED VARIABLE: 1.5 um



LAYER 204 T1HI – Tier 1 Hybrid Interconnect (small post formation)

RULE: 204.001__T1HI_over_T1HS {@ T1HI must overlap T1HS

T1HI1 NOT T1HS1}

PURPOSE: Flags all T1HI that does not fully overlap T1HS.

RESOLVED VARIABLE: T1 Hybrid Interconnect must fully overlap T1 Hybrid Seed

RULE: 204.002__T1HI_not_interact_T1HS {@ T1HI must interact with T1HS

NOT INTERACT T1HI1 T1HS1}

PURPOSE: Flags all TIHI that does not touch T1HS.

This rule has been used as a safety net to ensure that all interconnects function, including those in shifted cells which may not meet other design rules.

RESOLVED VARIABLE: Non-Applicable

RULE: 204.003__T1HI_over_T2HI {@ T2HI must overlap T1HI

T1HI1 NOT T2HI1}

PURPOSE: Flags all T1HI that does not fully overlap T2HI.

RESOLVED VARIABLE: T1 Hybrid Interconnect must fully overlap T2 Hybrid Interconnect

RULE: 204.004__T1HI_not_interact_T2HI {@ T1HI must interact with T2HI

NOT INTERACT T1HI1 T2HI1}

PURPOSE: Flags all T1HI that does not touch T2HI.

This rule has been used as a safety net to ensure that all interconnects function, including those in shifted cells which may not meet other design rules.

RESOLVED VARIABLE: Non-Applicable

RULE: 204.005__T1HI_width {@ T1HI width < ^t1hi_width um

INTERNAL T1HI1 < t1hi_width ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum width allowable for layer T1HI

RESOLVED VARIABLE: 2.0 um

RULE: 204.006__T1HI_spacing {@ T1HI spacing < ^t1hi_spacing um

EXTERNAL T1HI1 < t1hi_spacing ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum allowable space between adjacent layer T1HI features

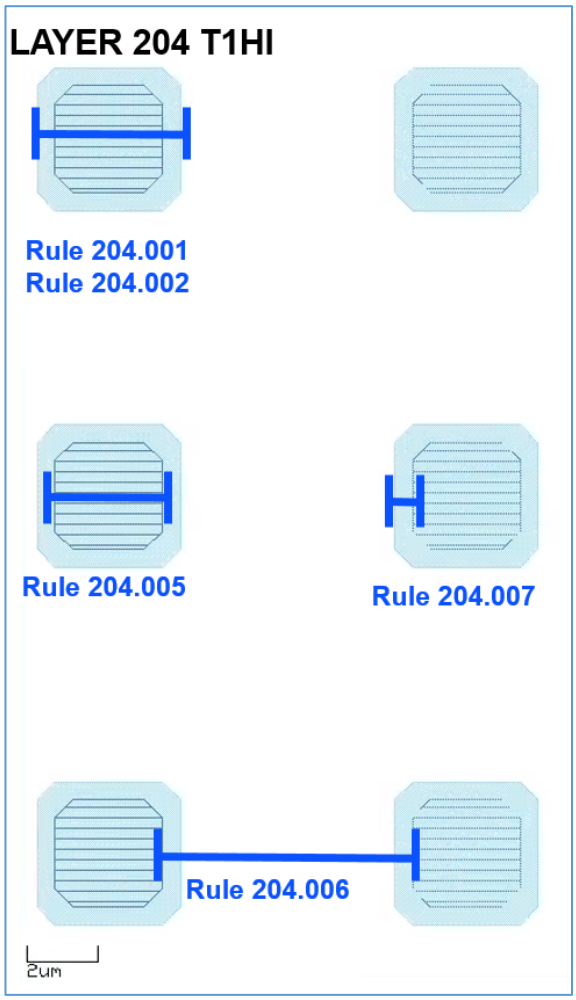
RESOLVED VARIABLE: 7.0 um

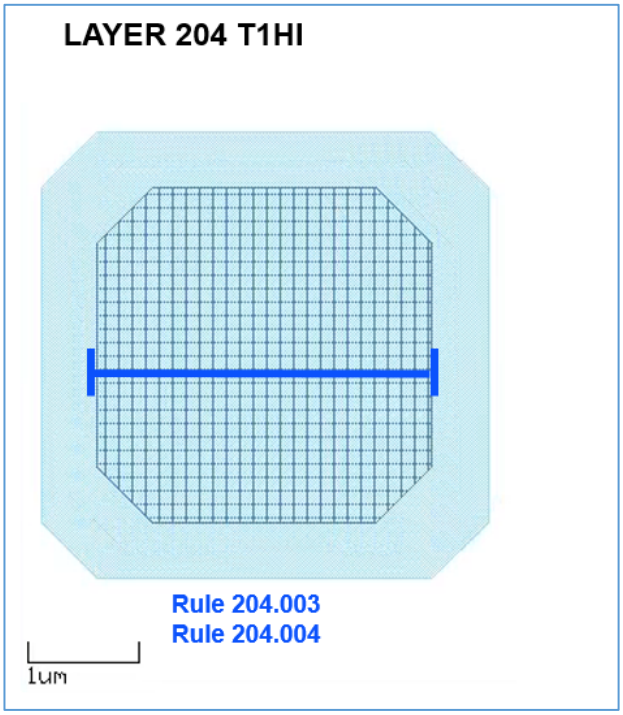
RULE: 204.007__T1HI_inside_T1HS {@ T1HS overlap of T1HI = ^t1hi_overlap um

ENCLOSURE T1HI1 T1HS1 < t1hi_overlap ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum inset of T1HI features inside of T1HS features except where NODRC exists

RESOLVED VARIABLE: 0.250 um


LAYER 204 T1HI
Rule 204.001
Rule 204.002
Rule 204.005
Rule 204.007
Rule 204.006
2um


LAYER 204 T1HI
Rule 204.003
Rule 204.004
1um

LAYER 205 T1HIB – Tier 1 Hybrid Interconnect B (large post)

RULE: 205.001__T1HIB_over_T1HS { @ T1HIB must overlap T1HS

T1HIB1 NOT T1HS1}

PURPOSE: Flags all T1HIB that does not fully overlap T1HS.

RESOLVED VARIABLE: T1 Hybrid Interconnect B must fully overlap T1B Hybrid Seed

RULE: 205.002__T1HIB_not_interact_T1HS {@ T1HIB must interact with T1HS

NOT INTERACT T1HIB1 T1HS1}

PURPOSE: Flags all T1HIB that does not touch T1HS.

This rule has been used as a safety net to ensure that all interconnects function, including those in shifted cells which may not meet other design rules.

RESOLVED VARIABLE: Non-Applicable

RULE: 205.003__T1HIB_over_T2HIB {@ T2HIB must overlap T1HIB

T1HIB1 NOT T2HIB1}

PURPOSE: Flags all T1HIB that does not fully overlap T2HIB.

RESOLVED VARIABLE: T1 Hybrid Interconnect B must fully overlap T2 Hybrid Interconnect B

RULE: 205.004__T1HIB_not_interact_T2HIB { @ T1HIB must interact with T2HIB

NOT INTERACT T1HIB1 T2HIB1}

PURPOSE: Flags all T1HIB that does not touch T2HIB.

This rule has been used as a safety net to ensure that all interconnects function, including those in shifted cells which may not meet other design rules.

RESOLVED VARIABLE: Non-Applicable

RULE: 205.005__T1HIB_width { @ T1HIB width < ^t1hib_width um

INTERNAL T1HIB1 < t1hib_width ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum width allowable for layer T1HIB

RESOLVED VARIABLE: 3.0 um

RULE: 205.006__T1HIB_spacing { @ T1HIB spacing < ^t1hib_spacing um

EXTERNAL T1HIB1 < t1hib_spacing ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum allowable space between adjacent layer T1HIB features

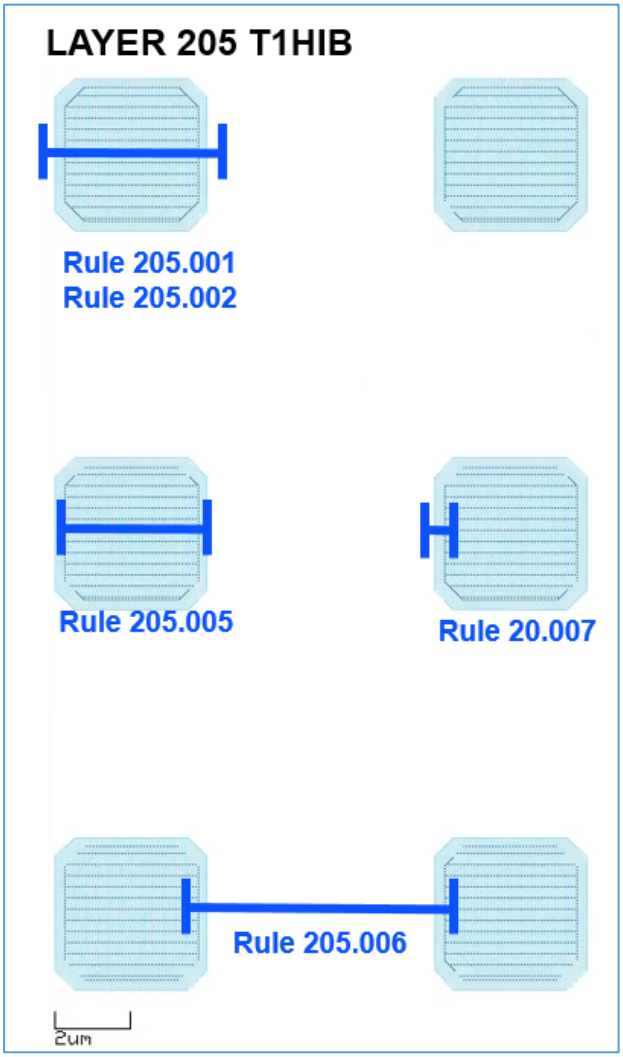
RESOLVED VARIABLE: 6.5 um

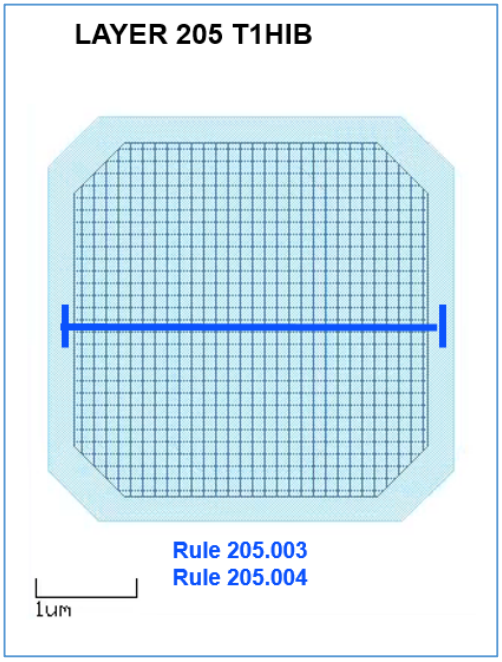
RULE: 205.007__T1HIB_inside_T1HS {@ T1HS overlap of T1HIB = ^t1hib_overlap um

ENCLOSURE T1HIB1 T1HS1 < t1hib_overlap ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum inset of T1HIB features inside of T1HS features except where NODRC exists

RESOLVED VARIABLE: 0.250 um


LAYER 205 T1HIB
Rule 205.001
Rule 205.002
Rule 205.005
Rule 20.007
Rule 205.006
2um


LAYER 205 T1HIB
Rule 205.003
Rule 205.004
1um

LAYER 206 T1HIC – TIER 1 Hybrid Interconnect C (single slot formation)

RULE: 06.001__T1HIC_over_T1HS {@ T1HIC must overlap T1HS

T1HIC1 NOT T1HS1}

PURPOSE: Flags all T1HIC that does not fully overlap T1HS.

RESOLVED VARIABLE: T1 Hybrid Interconnect C must fully overlap T1 Hybrid Seed

Note: This feature will always violate this rule by design

RULE: 206.002_T1HIC_not_interact_T1HS {@ T1HIC must interact with T1HS

NOT INTERACT T1HIC1 T1HS1}

PURPOSE: Flags all T1HIC that does not touch T1HS.

This rule has been used as a safety net to ensure that all interconnects function, including those in shifted cells which may not meet other design rules.

RESOLVED VARIABLE: Non-Applicable

RULE: 206.003__T1HIC_over_T2HIC {@ T2HIC must overlap T1HIC

T1HIC1 NOT T2HIC1}

PURPOSE: Flags all T1HIC that does not fully overlap TCHIB.

RESOLVED VARIABLE: T1 Hybrid Interconnect C must fully overlap T2 Hybrid Interconnect C

Note: This feature will always violate this rule by design

RULE: 206.004__T1HIC_not_interact_T2HIC {@ T1HIC must interact with T2HIC

NOT INTERACT T1HIC1 T2HIC1}

PURPOSE: Flags all T1HIC that does not touch T1HIC.

This rule has been used as a safety net to ensure that all interconnects function, including those in shifted cells which may not meet other design rules.

RESOLVED VARIABLE: Non-Applicable

RULE: 206.005__T1HIC_width {@ T1HIC width < ^t1hic_width um

INTERNAL T1HIC1 < t1hic_width ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum width allowable for layer T1HIC

RESOLVED VARIABLE: 1.0 um

RULE: 206.006__T1HIC_spacing { @ T1HIC spacing < ^t1hic_spacing um

EXTERNAL T1HIC1 < t1hic_spacing ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum allowable space between adjacent

layer T1HIC features

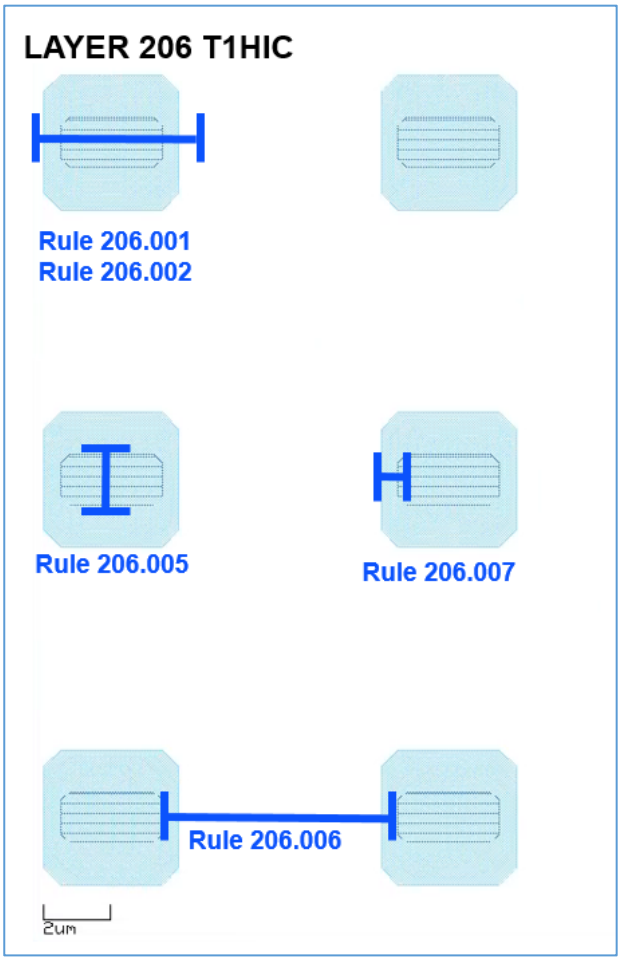
RESOLVED VARIABLE: 7.0 um

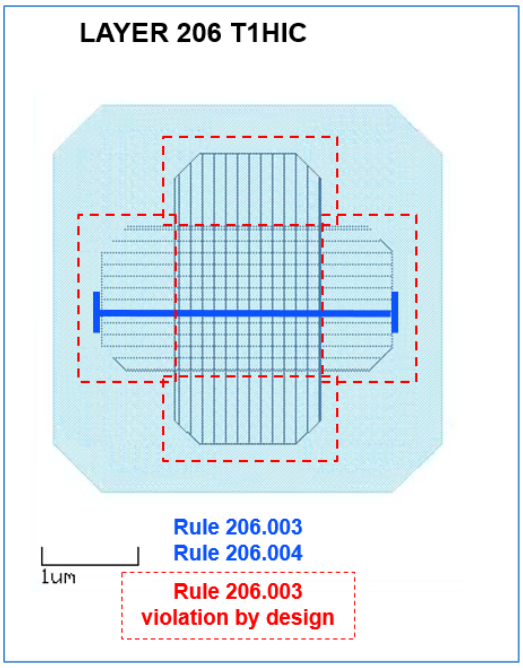
RULE: 206.007__T1HIC_inside_T1HS {@ T1HS overlap of T1HIC = ^t1hic_overlap um

ENCLOSURE T1HIC1 T1HS1 < t1hic_overlap ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum inset of T1HIC features inside of T1HS features except where NODRC exists

RESOLVED VARIABLE: 0.05 um


LAYER 206 T1HIC
Rule 206.001
Rule 206.002
Rule 206.005
Rule 206.007
Rule 206.006
2um


LAYER 206 T1HIC
Rule 206.003
Rule 206.004
1um
Rule 206.003
violation by design

LAYER 207 T1HID – Tier 1 Hybrid Interconnect D (double slot formation)

RULE: 207.001__T1HID_over_T1HS {@ T1HID must overlap T1HS

T1HID1 NOT T1HS1}

PURPOSE: Flags all T1HID that does not fully overlap T1HS.

RESOLVED VARIABLE: T1 Hybrid Interconnect D must fully overlap T1 Hybrid Seed
Note: This feature will always violate this rule by design

RULE: 207.002__T1HID_not_interact_T1HS {@ T1HID must interact with T1HS

NOT INTERACT T1HID1 T1HS1}

PURPOSE: Flags all T1HID that does not touch T1HS.

This rule has been used as a safety net to ensure that all interconnects function, including those in shifted cells which may not meet other design rules.

RESOLVED VARIABLE: Non-Applicable

RULE: 207.003__T1HID_over_T2HID {@ T2HID must overlap T1HID

T1HID1 NOT T2HID1}

PURPOSE: Flags all T1HIC that does not fully overlap TCHIB.

RESOLVED VARIABLE: T1 Hybrid Interconnect D must fully overlap T2 Hybrid Interconnect D
Note: This feature will always violate this rule by design

RULE: 207.004__T1HID_not_interact_T2HID {@ T1HID must interact with T2HID

NOT INTERACT T1HID1 T2HID1}

PURPOSE: Flags all T1HID that does not touch T1HID.

This rule has been used as a safety net to ensure that all interconnects function, including those in shifted cells which may not meet other design rules.

RESOLVED VARIABLE: Non-Applicable

RULE: 207.005__T1HID_width {@ T1HID width < ^t1hid_width um

INTERNAL T1HID1 < t1hid_width ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum width allowable for layer T1HID

RESOLVED VARIABLE: 1.0 um

RULE: 207.006__T1HID_spacing {@ T1HID spacing < ^t1hid_spacing um

EXTERNAL T1HID1 < t1hid_spacing ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum allowable space between adjacent layer T1HiD features

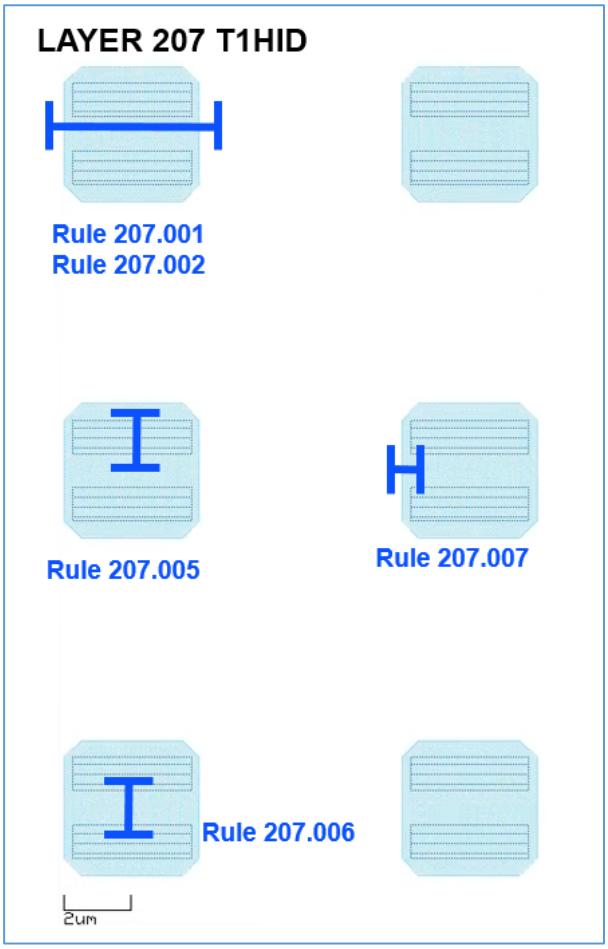
RESOLVED VARIABLE: 5.0 um

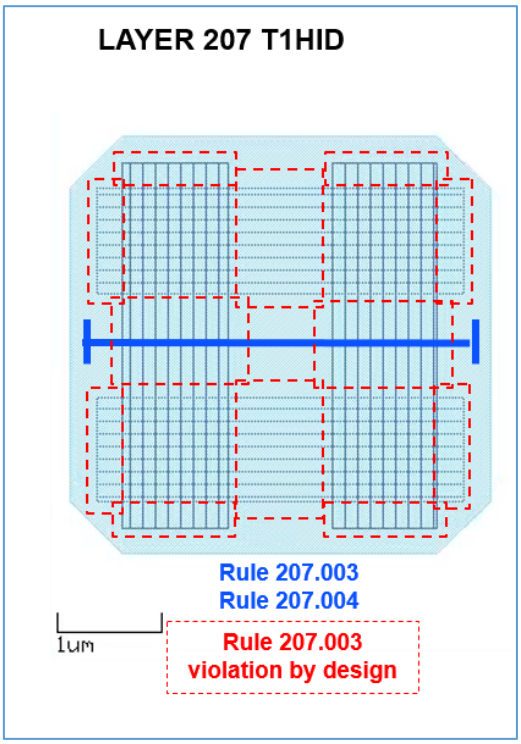
RULE: 207.007__T1HID_inside_T1HS {@ T1HS overlap of T1HID = ^t1hid_overlap um

ENCLOSURE T1HID1 T1HS1 < t1hid_overlap ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum inset of T1HID features inside of T1HS features except where NODRC exists

RESOLVED VARIABLE: 0.05 um


LAYER 207 T1HID
Rule 207.001
Rule 207.002
Rule 207.005
Rule 207.007
Rule 207.006
2um


LAYER 207 T1HID
Rule 207.003
Rule 207.004
1um
Rule 207.003
violation by design

LAYER 304 T2HI – Tier 2 Hybrid Interconnect (small post formation)

RULE: 304.001__T2HI_over_T2HS { @ T2HI must overlap T2HS

T2HI1 NOT T2HS1}

PURPOSE: Flags all T2HI that does not fully overlap T2HS.

RESOLVED VARIABLE: T2 Hybrid Interconnect must fully overlap T2 Hybrid Seed

RULE: 304.002__T2HI_not_interact_T2HS {@ T2HI must interact with T2HS

NOT INTERACT T2HI1 T2HS1}

PURPOSE: Flags all T2HI that does not touch T2HS.

This rule has been used as a safety net to ensure that all interconnects function, including those in shifted cells which may not meet other design rules.

RESOLVED VARIABLE: Non-Applicable

RULE: 304.003__T2HI_over_T1HI { @ T2HI must overlap T2HI

T2HI1 NOT T1HI1}

PURPOSE: Flags all T2HI that does not fully overlap T1HI.

RESOLVED VARIABLE: T2 Hybrid Interconnect must fully overlap T1 Hybrid Interconnect

RULE: 304.004__T2HI_not_interact_T1HI { @ T2HI must interact with T2HI

NOT INTERACT T2HI1 T1HI1}

PURPOSE: Flags all T2HI that does not touch T1HI.

This rule has been used as a safety net to ensure that all interconnects function, including those in shifted cells which may not meet other design rules.

RESOLVED VARIABLE: Non-Applicable

RULE: 304.005__T2HI_width { @ T2HI width < ^t2hi_width um

INTERNAL T2HI1 < t2hi_width ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum width allowable for layer T2HI

RESOLVED VARIABLE: 2.0 um

RULE: 304.006__T2HI_spacing { @ T2HI spacing < ^t2hi_spacing um

EXTERNAL T2HI1 < t2hi_spacing ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum allowable space between adjacent layer T1HI features

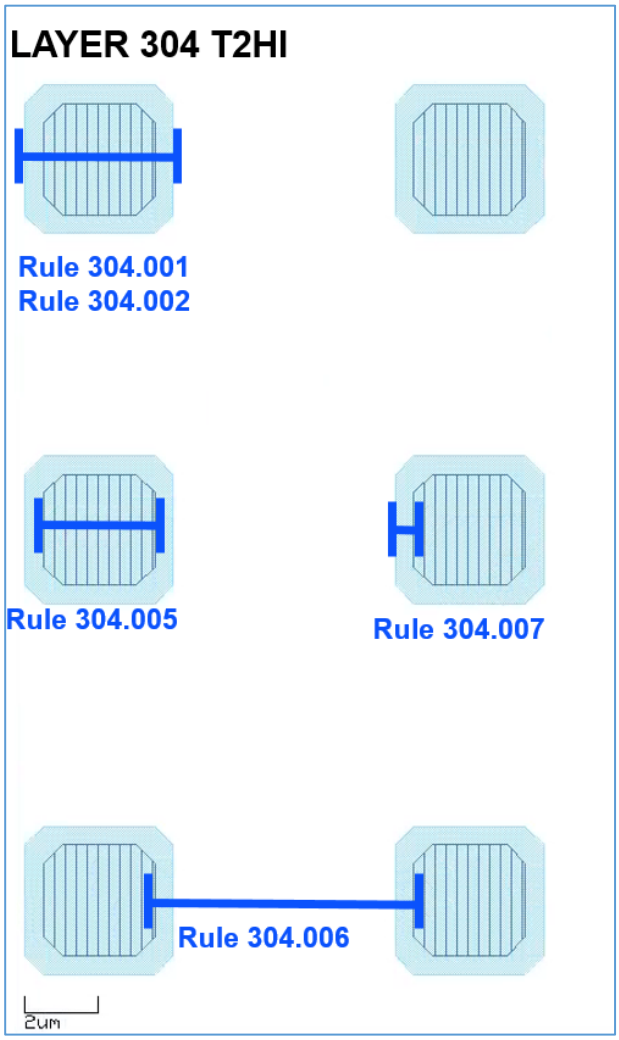
RESOLVED VARIABLE: 5.0 um

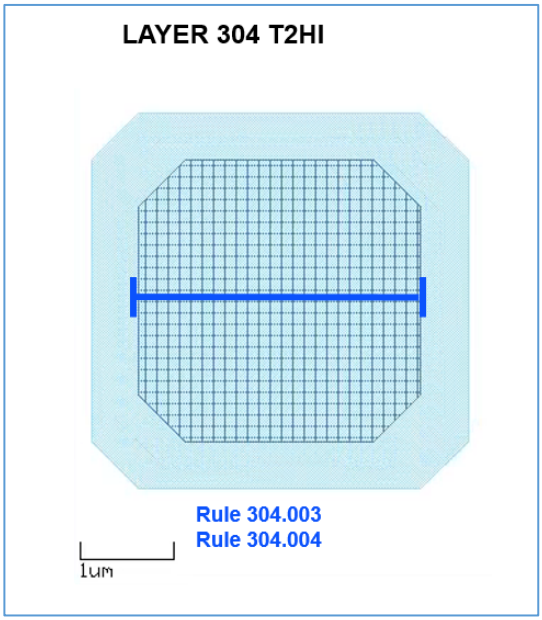
RULE: 304.007__T2HI_inside_T2HS { @ T2HS overlap of T2HI = ^t2hi_overlap um

ENCLOSURE T2HI1 T2HS1 < t2hi_overlap ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum inset of T2HI features inside of T2HS features except where NODRC exists

RESOLVED VARIABLE: 0.250 um


LAYER 304 T2HI
Rule 304.001
Rule 304.002
Rule 304.005
Rule 304.007
Rule 304.006
2um


LAYER 304 T2HI
Rule 304.003
Rule 304.004
1um

LAYER 305 T2HIB – Tier 2 Hybrid Interconnect B (large post formation)

RULE: 305.001__T2HIB_over_T2HS { @ T1HIB must overlap T2HS

T2HIB1 NOT T2HS1}

PURPOSE: Flags all T2HIB that does not fully overlap T2HS.

RESOLVED VARIABLE: T2 Hybrid Interconnect B must fully overlap T2 Hybrid Seed

RULE: 305.002__T2HIB_not_interact_T2HS { @ T1HIB must interact with T2HS

NOT INTERACT T2HIB1 T2HS1}

PURPOSE: Flags all T2HIB that does not touch T2HS.

This rule has been used as a safety net to ensure that all interconnects function, including those in shifted cells which may not meet other design rules.

RESOLVED VARIABLE: Non-Applicable

RULE: 305.003__T2HIB_over_T1HIB { @ T2HIB must overlap T2HIB

T2HIB1 NOT T1HIB1}

PURPOSE: Flags all T2HIB that does not fully overlap T1HIB.

RESOLVED VARIABLE: T2 Hybrid Interconnect B must fully overlap T1 Hybrid Interconnect B

RULE: 305.004__T2HIB_must_interact_T1HIB {@ T2HIB must interact with T2HIB

NOT INTERACT T2HIB1 T1HIB1}

PURPOSE: Flags all T2HIB that does not touch T1HIB.

This rule has been used as a safety net to ensure that all interconnects function, including those in shifted cells which may not meet other design rules.

RESOLVED VARIABLE: Non-Applicable

RULE: 305.005__T2HIB_width { @ T2HIB width < ^t2hib_width um

INTERNAL T2HIB1 < t2hib_width ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum width allowable for layer T2HIB

RESOLVED VARIABLE: 3.0 um

RULE: 305.006__T2HIB_spacing { @ T2HIB spacing < ^t2hib_spacing um

EXTERNAL T2HIB1 < t2hib_spacing ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum allowable space between adjacent layer T1HIB features

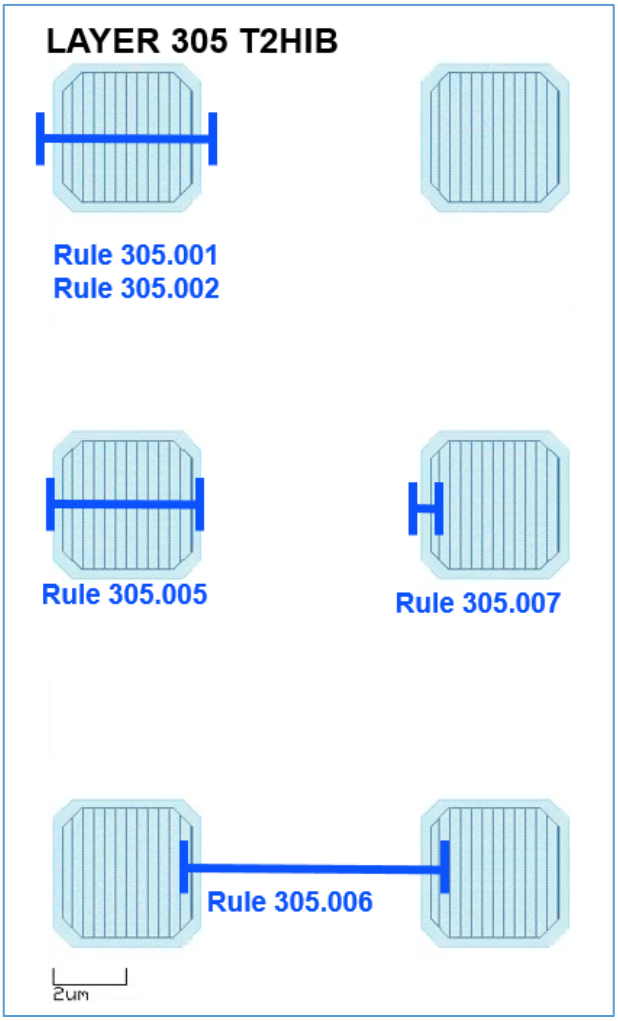
RESOLVED VARIABLE: 4.5 um

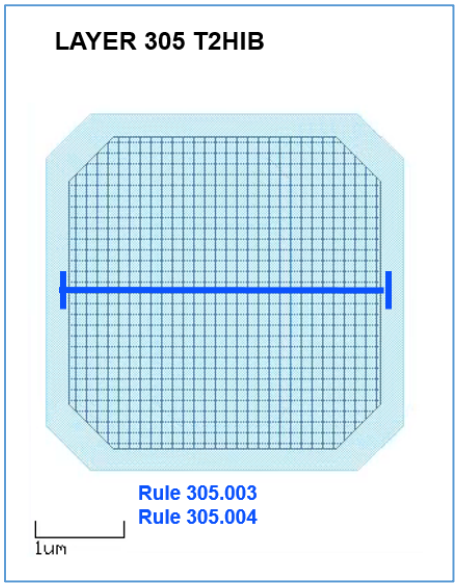
RULE: 305.007__T2HIB_inside_T2HS {@ T2HS overlap of T2HIB = ^t2hib_overlap um

ENCLOSURE T2HIB1 T2HS1 < t2hib_overlap ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum inset of T2HIB features inside of T2HS features except where NODRC exists

RESOLVED VARIABLE: 0.250 um


LAYER 305 T2HIB
Rule 305.001
Rule 305.002
Rule 305.005
Rule 305.007
Rule 305.006
2um


LAYER 305 T2HIB
Rule 305.003
Rule 305.004
1um

LAYER 306 T2HIC – Tier 2 Hybrid Interconnect C (single slot formation)

RULE: 306.001__T2HIC_over_T2HS { @ T1HIC must overlap T2HS

T2HIC1 NOT T2HS1}

PURPOSE: Flags all T2HIC that does not fully overlap T2HS.

RESOLVED VARIABLE: T2 Hybrid Interconnect C must fully overlap T2 Hybrid Seed Note: This feature will always violate this rule by design

RULE: 306.002__T2HIC_not_interact_T1HS { @ T2HIC must interact with T1HS

NOT INTERACT T2HIC1 T1HS1}

PURPOSE: Flags all T2HIC that does not touch T2HS.

This rule has been used as a safety net to ensure that all interconnects function, including those in shifted cells which may not meet other design rules.

RESOLVED VARIABLE: Non-Applicable

RULE: 306.003__T2HIC_over_T1HIC {@ T2HIB must overlap T2HIB

T2HIC1 NOT T1HIC1}

PURPOSE: Flags all T2HIC that does not fully overlap T1HIC.

RESOLVED VARIABLE: T2 Hybrid Interconnect C must fully overlap T1 Hybrid Interconnect C Note: This feature will always violate this rule by design

RULE: 306.004__T2HIC_not_interact_T1HIC { @ T2HIC must interact with T1HIC

NOT INTERACT T2HIC1 T1HIC1}

PURPOSE: Flags all T2HIC that does not touch T1HIC.

This rule has been used as a safety net to ensure that all interconnects function, including those in shifted cells which may not meet other design rules.

RESOLVED VARIABLE: Non-Applicable

RULE: 306.005__T2HIC_width {@ T2HIC width < ^t2hic_width um

INTERNAL T2HIC1 < t2hic_width ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum width allowable for layer T2HIC

RESOLVED VARIABLE: 1.0 um

RULE: 306.006__T2HIC_spacing { @ T2HIC spacing < ^t2hic_spacing um

EXTERNAL T2HIC1 < t2hic_spacing ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum allowable space between adjacent layer T1HT features

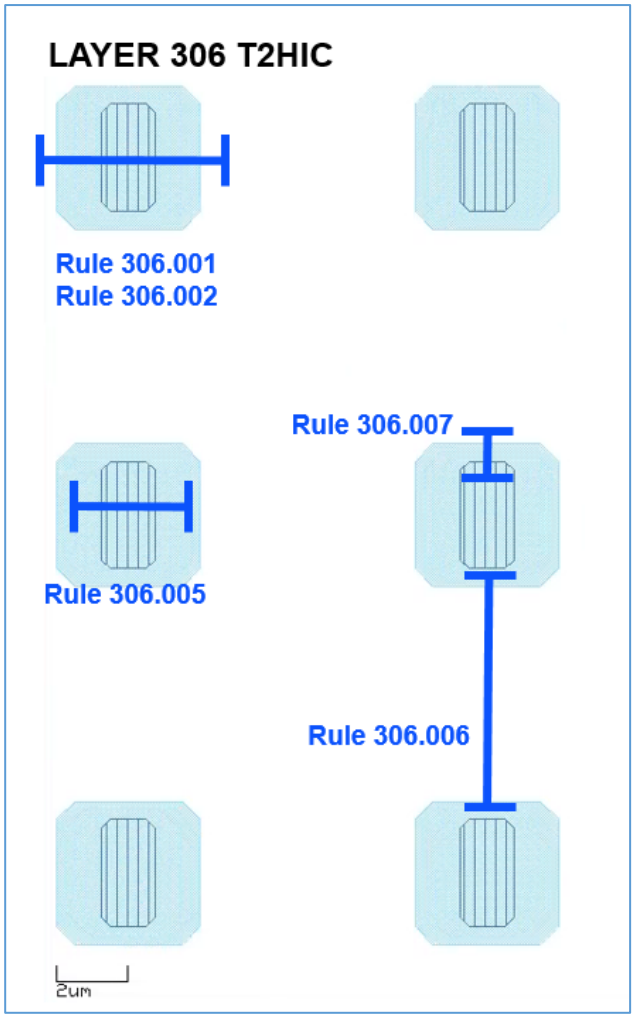
RESOLVED VARIABLE: 5.5 um

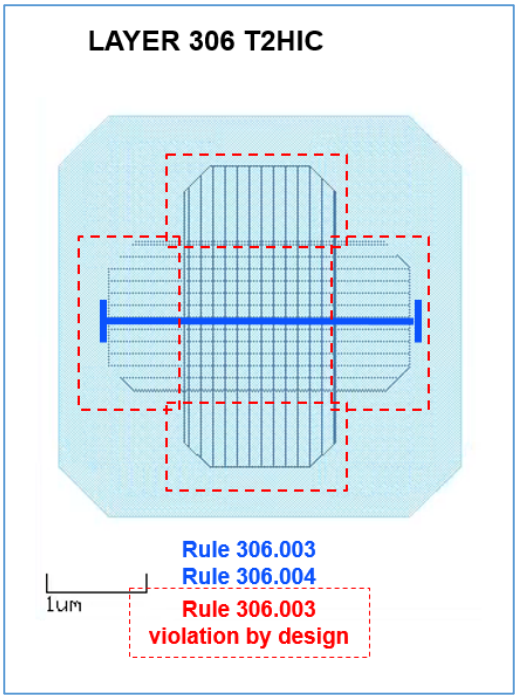
RULE: 306.007__T2HIC_inside_T2HS {@ T2HS overlap of T2HIC = ^t2hic_overlap um

ENCLOSURE T2HIC1 T2HS1 < t2hic_overlap ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum inset of T2HIC features inside of T2HS features except where NODRC exists

RESOLVED VARIABLE: 0.05 um


LAYER 306 T2HIC
Rule 306.001
Rule 306.002
Rule 306.007
Rule 306.005
Rule 306.006
2um


LAYER 306 T2HIC
Rule 306.003
Rule 306.004
1um
Rule 306.003
violation by design

LAYER 307 T2HID – Tier 2 Hybrid Interconnect D (double slot formation)

RULE: 307.001__T2HID_over_T2HS {@ T1HID must overlap T2HS

T2HID1 NOT T2HS1}

PURPOSE: Flags all T2HID that does not fully overlap T2HS.

RESOLVED VARIABLE: T2 Hybrid Interconnect D must fully overlap T2 Hybrid Seed Note: This feature will always violate this rule by design

RULE: 307.002__T2HID_not_interact_T2HS { @ T1HID must interact with T2HS

NOT INTERACT T2HID1 T2HS1}

PURPOSE: Flags all T2HID that does not touch T2HS.

This rule has been used as a safety net to ensure that all interconnects function, including those in shifted cells which may not meet other design rules.

RULE: 307.003__T2HID_over_T1HID {@ T2HID must overlap T1HID

T2HID1 NOT T1HID1}

PURPOSE: Flags all T2HID that does not fully overlap T1HID.

RESOLVED VARIABLE: T2 Hybrid Interconnect D must fully overlap T1 Hybrid Interconnect D Note: This feature will always violate this rule by design

RULE: 307.004__T2HID_not_interact_T1HID {@ T2HID must interact with T1HID

NOT INTERACT T2HID1 T1HID1}

PURPOSE: Flags all T2HID that does not touch T1HID.

This rule has been used as a safety net to ensure that all interconnects function, including those in shifted cells which may not meet other design rules.

RESOLVED VARIABLE: Non-Applicable

RULE: 307.005__T2HID_width {@ T2HID width < ^t2hid_width um

INTERNAL T2HID1 < t2hid_width ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum width allowable for layer T2HID

RESOLVED VARIABLE: 1.0 um

RULE: 307.006_T2HID_spacing {@ T2HID spacing < ^t2hid_spacing um

EXTERNAL T2HID1 < t2hid_spacing ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum allowable space between adjacent layer T1HID features

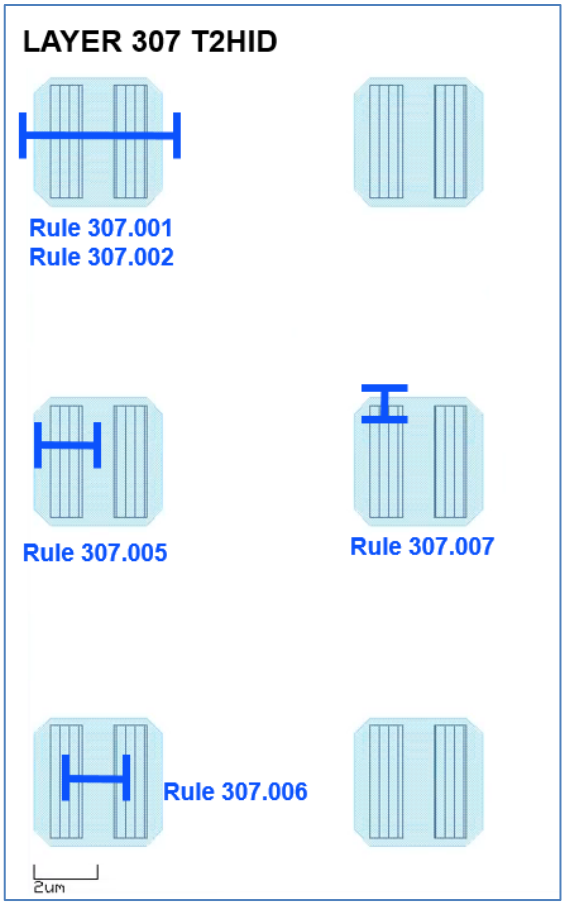
RESOLVED VARIABLE: 1.0 um

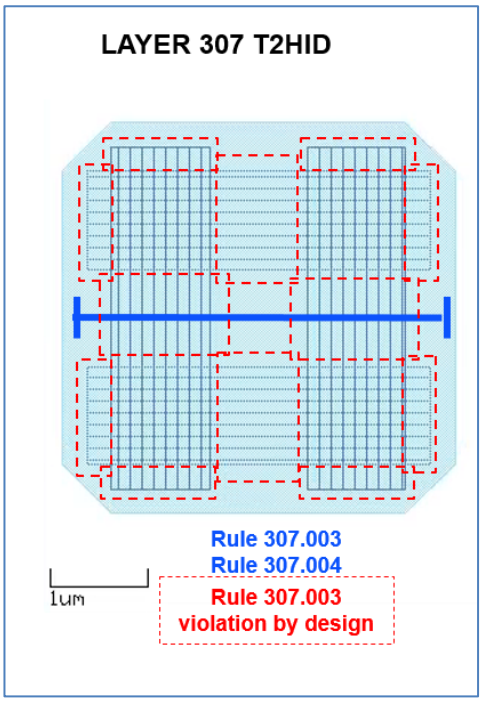
RULE: 307.007_T2HID_inside_T2HS {@ T2HS overlap of T2HID = ^t2hid_overlap um

ENCLOSURE T2HID1 T2HS1 < t2hid_overlap ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum inset of T2HID features inside of T2HS features except where NODRC exists

RESOLVED VARIABLE: 0.05 um


LAYER 307 T2HID
Rule 307.001
Rule 307.002
Rule 307.005
Rule 307.007
Rule 307.006
2um


LAYER 307 T2HID
Rule 307.003
Rule 307.004
1um
Rule 307.003
violation by design

LAYER 400 T2BT – Tier 2 Back Target Canon alignment marks placed by Canon

RULE: 400.001__T2BT_width {@ T2BT width < ^t2bt_min_width um

INTERNAL T2BT1 < t2bt_min_width ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum width allowable for layer T2BT

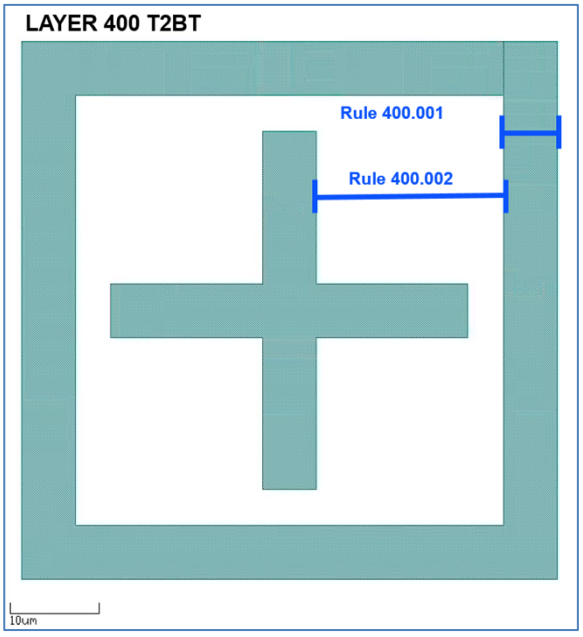
RESOLVED VARIABLE: 2.0 um

RULE: 400.002__T2BT_spacing {@ T2BT spacing < ^t2bt_to_t2bt um

EXTERNAL T2BT1 < t2bt_to_t2bt ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum allowable space between adjacent layer T2BT features

RESOLVED VARIABLE: 1.95 um



LAYER 401 T2BV – Tier 2 Back Via

RULE: 401.001__T2BV_inside_T2TM { @ T2BV inside T2TM < ^t2bv_in_t2tm um ENCLOSURE T2BV1 T2TM1 < t2bv_in_t2tm ABUT <90 SINGULAR REGION}

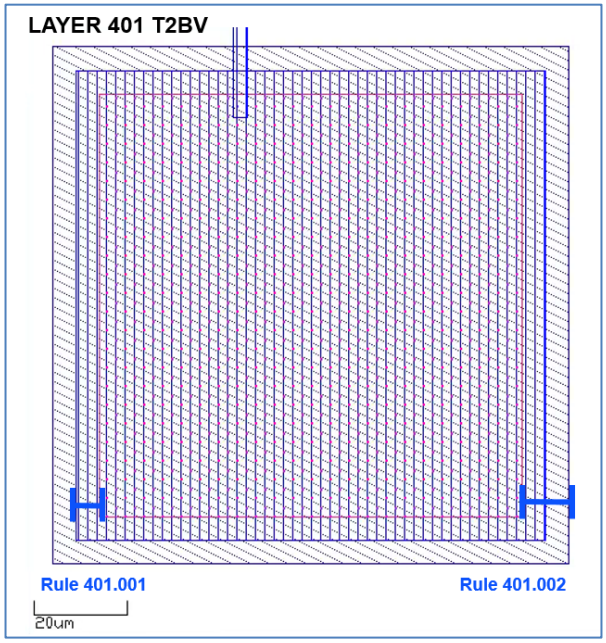
PURPOSE: Defines the minimum inset of T2BV features inside of T2TM features

RESOLVED VARIABLE: 5.0 um

RULE: 401.002__T2BV_inside_T2BM { @ T2BV inside T2BM < ^t2bv_in_t2bm um ENCLOSURE T2BV1 T2BM1 < t2bv_in_t2bm ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum inset of T2BV features inside of T2BM features

RESOLVED VARIABLE: 5.0 um



LAYER 402 T2BM – Tier 2 Back Metal

All design rule checks associated with Tier 2 Back Metal are completed within design layers Tier 2 Back Via and Tier 2 Back-Over Glass.

LAYER 403 T2BO – Tier 2 Back Over Glass Cut

RULE: 403.001__T2BO_inside_T2TM { @ T2BO inside T2TM < ^t2bo_in_t2tm um

ENCLOSURE T2BO1 T2TM1 < t2bo_in_t2tm ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum inset of T2BO features inside of T2TM features

RESOLVED VARIABLE: 5.0 um

RULE: 403.002__T2BO_inside_T2BM { @ T2BO inside T2BM < ^t2bo_in_t2bm um

ENCLOSURE T2BO1 T2BM1 < t2bo_in_t2bm ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum inset of T2BO features inside of T2BM features

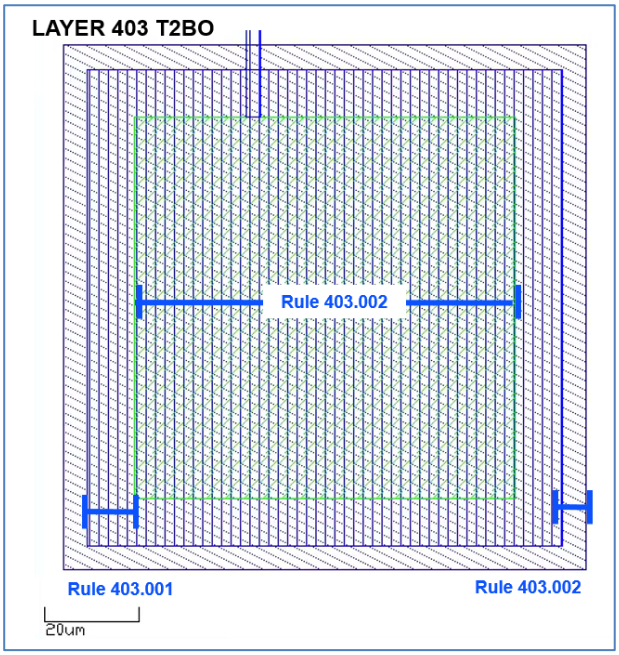
RESOLVED VARIABLE: 5.0 um

RULE: 403.003__T2BO_Width { @ T2BO width >= ^t2bo_min_width um

INTERNAL T2BO1 < t2bo_min_width ABUT <90 SINGULAR REGION}

PURPOSE: Defines the minimum width allowable for layer T2BO

RESOLVED VARIABLE: 60.0 um


LAYER 403 T2BO
Rule 403.002
Rule 403.001
Rule 403.002
20um

LAYER DENSITY CHECKS

RULE: T1TM_DENSMIN {@T1TM density must be >= ^density_t1tm_min within a 1000um window

DENSITY T1TM >=density_t1tm_min WINDOW 1000 STEP 200}

PURPOSE: Defines minimum T1TM layer within a 1000 x 1000um window

RESOLVED VARIABLE: 20%

RULE: T1TM_DENSMAX {@T1TM density must be <= ^density_t1tm_max within a 1000um window

DENSITY T1TM >=density_t1tm_min WINDOW 1000 STEP 200}

PURPOSE: Defines maximum T1TM layer within a 1000 x 1000um window

RESOLVED VARIABLE: Maximum 30%

RULE: T2TM_DENSMIN {@T2TM density must be >= ^density_t2tm_min within a 1000um window

DENSITY T2TM >=density_t2tm_min WINDOW 1000 STEP 200}

PURPOSE: Defines minimum T2TM layer within a 1000 x 1000um window

RESOLVED VARIABLE: 20%

RULE: T2TM_DENSMAX {@T2TM density must be <= ^density_t2tm_max within a 1000um window

DENSITY T2TM >=density_t2tm_min WINDOW 1000 STEP 200}

PURPOSE: Defines maximum T2TM layer within a 1000 x 1000um window

RESOLVED VARIABLE: Maximum 30%

RULE: T1HS_DENSMIN {@T1HS density must be >= ^density_t1hs_min within a 1000um window

DENSITY T1HS >=density_t1hs_min WINDOW 1000 STEP 200}

PURPOSE: Defines minimum T1HS layer within a 1000 x 1000um window

RESOLVED VARIABLE: 20%

RULE: T1HS_DENSMAX {@T1HS density must be <= ^density_t1hs_max within a 1000um window

DENSITY T1HS >=density_t1hs_min WINDOW 1000 STEP 200}

PURPOSE: Defines maximum T1HS layer within a 1000 x 1000um window

RESOLVED VARIABLE: Maximum 30%

RULE: T2HS_DENSMIN {@T2HS density must be >= ^density_t2hs_min within a 1000um window

DENSITY T2HS >=density_t2hs_min WINDOW 1000 STEP 200}

PURPOSE: Defines minimum T2HS layer within a 1000 x 1000um window

RESOLVED VARIABLE: 20%

RULE: T2HS_DENSMAX {@T2HS density must be <= ^density_t2hs_max within a 1000um window

DENSITY T2HS >=density_t2hs_min WINDOW 1000 STEP 200}

PURPOSE: Defines maximum T2HS layer within a 1000 x 1000um window

RESOLVED VARIABLE: Maximum 30%

PURPOSE: *The following prints a report of the density results to the text file indicated*

denschk = extent

DENSITY_REPORT { @ This check reports all the chip extent density for top and seed metals

DENSITY T1TM <= 1 INSIDE OF LAYER denschk PRINT ONLY T1TM_DENSITY.TXT

DENSITY T2TM <= 1 INSIDE OF LAYER denschk PRINT ONLY T2TM_DENSITY.TXT

DENSITY T1HS <= 1 INSIDE OF LAYER denschk PRINT ONLY T1HS_DENSITY.TXT

DENSITY T2HS <= 1 INSIDE OF LAYER denschk PRINT ONLY T2HS_DENSITY.TXT

DENSITY T1HI <= 1 INSIDE OF LAYER denschk PRINT ONLY T1HI_DENSITY.TXT

DENSITY T2HI <= 1 INSIDE OF LAYER denschk PRINT ONLY T2HI_DENSITY.TXT

DENSITY T1HIB <= 1 INSIDE OF LAYER denschk PRINT ONLY T1HIB_DENSITY.TXT

DENSITY T2HIB <= 1 INSIDE OF LAYER denschk PRINT ONLY T2HIB_DENSITY.TXT

DENSITY T1HIC <= 1 INSIDE OF LAYER denschk PRINT ONLY T1HIC_DENSITY.TXT

DENSITY T2HIC <= 1 INSIDE OF LAYER denschk PRINT ONLY T2HIC_DENSITY.TXT

DENSITY T1HID <= 1 INSIDE OF LAYER denschk PRINT ONLY T1HID_DENSITY.TXT

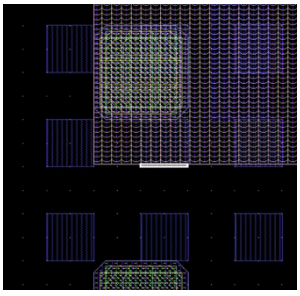
DENSITY T2HID <= 1 INSIDE OF LAYER denschk PRINT ONLY T2HID_DENSITY.TXT}

Net Extraction

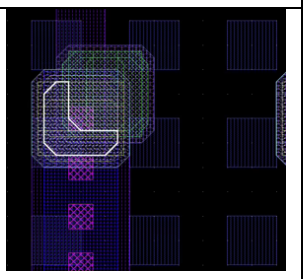
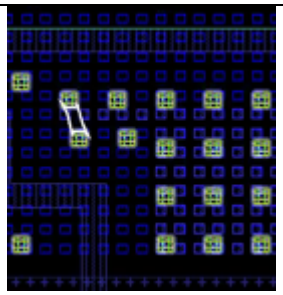
In addition to the Design Rule Checks, Net Extraction (connectivity) was verified for each device.

APPENDIX B
DESIGN RULE CHECK RUN RESULTS

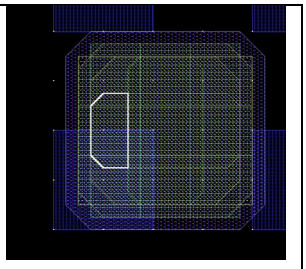
The following are the rules flagged (🏳) during DRC of the 3DFBL reticle set. DRC resulted in 17 of 90 rules being flagged. The flag limit was set to 1000. Rules with counts below that number are actual counts. Rules with violations of 1000 would have higher actual counts.

Rule	Specification	Flag Count	Comment	Sample Image (if applicable)
Off-grid	50.0 nm	0		
000.001__ZERO_width	2.0 um	0		
000.002__ZERO_spacing	1.95 um	0		
200.001__T1HT_width	2.0 um	0		
200.002__T1HT_spacing	1.95 um	0		
300.001__T2HT_width	2.0 um	0		
300.002__T2HT_spacing	1.95 um	0		
🏳201.001__T1TM_width	1.0 um	1000	Inconsequetial – the result of NO DRC blocking layer placement	
201.002__T1TM_spacing	1.0 um	0		

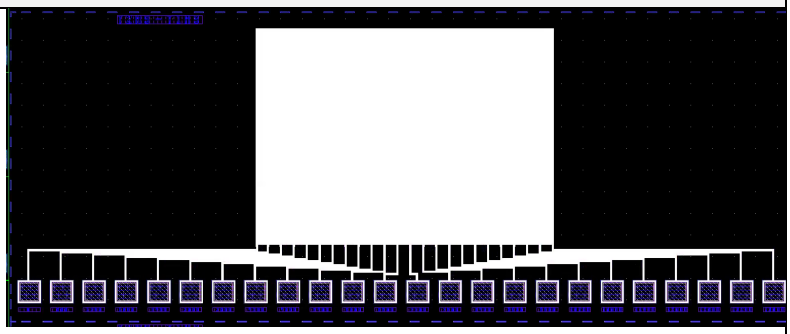
301.001__T2TM_width	1.0 um	0		
301.002__T2TM_spacing	1.0 um	0		
202.001__T1TV_size_rule	1.0 um	0		
202.002__T1TV_spacing	1.0 um	0		
202.003__T1TV_inside_T1TM	1.0 um	0		
202.004__T1TV_inside_T1HS	1.0 um	0		
202.005__T1TV_not_interact_T1TM	n/a	0		
202.006__T1TV_not_interact_T1HS	n/a	0		
302.001__T2TV_size_rule	1.0 um	0		
302.002__T2TV_spacing	1.0 um	0		
302.003__T2TV_inside_T1TM	1.0 um	0		
302.004__T2TV_inside_T1HS	1.0 um	0		
302.005__T2TV_must_interact_T1TM	n/a	0		
302.006__T2TV_must_interact_T1HS	n/a	0		
203.001__T1HS_width	2.0 um	0		
203.002__T1HS_spacing	1.5 um	0		
303.001__T2HS_width	2.0 um	0		
303.002__T2HS_spacing	1.5 um	0		

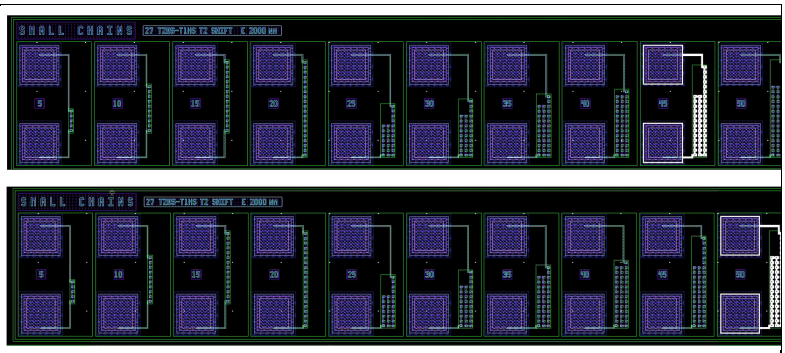
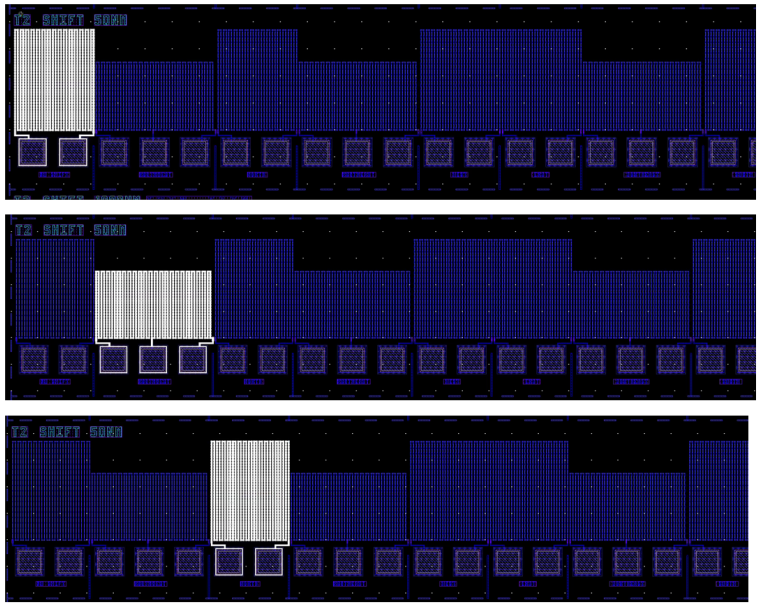
204.001__T1HI_over_T1HS	n/a	0		
204.002__T1HI_not_interact_T1HS	n/a	0		
204.003__T1HI_over_T2HI	n/a	96	Intentional, inter-tier shift	
204.004__T1HI_not_interact_T2HI	n/a	0		
204.005__T1HI_width	2.0 um	0		
204.006__T1HI_spacing	7.0 um	241	Intentional, inter-tier shift	
204.007__T1HI_inside_T1HS	0.25 um	0		
205.001__T1HIB_over_T1HSB	n/a	0		
205.002__T1HIB_not_interact_T1HSB	n/a	0		
205.003__T1HIB_over_T2HIB	n/a	96	Intentional, inter-tier shift	See 204.003 above
205.004__T1HIB_not_interact_T2HIB	n/a	0		

205.005__T1HIB_width	3.0 um	0		
205.006__T1HIB_spacing	6.5 um	241	Intentional, inter-tier shift	See 204.006 above
205.007__T1HIB_inside_T1HS	0.25 um	0		
206.001__T1HIC_over_T1HS	n/a	0		
206.002__T1HIC_not_interact_T1HS	n/a	0		
206.003__T1HIC_over_T2HIC	n/a	1000	Intentional, inter-tier shift	See 204.003 above
206.004__T1HIC_not_interact_T2HIC	n/a	0		
206.005__T1HIC_width	1.0 um	0		
206.006__T1HIC_spacing	7.0 um	240	Intentional, inter-tier shift	See 204.006 above
206.007__T1HIC_inside_T1HS	0.05 um	0		
207.001__T1HID_over_T1HS	n/a	0		
207.002__T1HID_not_interact_T1HS	n/a	0		
207.003__T1HID_over_T2HID	n/a	1000	Intentional, inter-tier shift	See 204.003 above

207.004__T1HID_not_interact_T2HID	n/a	18	Intentional, by design	
207.005__T1HID_width	1.0 um	0		
207.006__T1HID_spacing	1.0 um	0		
207.007__T1HID_inside_T1HS	0.05 um	0		
304.001__T2HI_over_T1HS	n/a	0		
304.002__T2HI_not_interact_T1HS	n/a	0		
304.003__T2HI_over_T2HI	n/a	96	Intentional, inter-tier shift	See 204.003 above
304.004__T2HI_not_interact_T2HS	n/a	0		
304.005__T2HI_width	2.0 um	0		
304.006__T2HI_spacing	5.0 um	208	Intentional, inter-tier shift	See 204.006 above
304.007__T2HI_inside_T2HS	0.25 um	0		
305.001__T2HIB_over_T1HS	n/a	0		
305.002__T2HIB_not_interact_T1HS	n/a	0		

305.003__T2HIB_over_T1HIB	n/a	96	Intentional, inter-tier shift	See 204.003 above
305.004__T2HIB_must_interact_T1HIB	n/a	0		
305.005__T2HIB_width	3.0 um	0		
305.006__T2HIB_spacing	4.5 um	208	Intentional, inter-tier shift	See 204.006 above
305.007__T2HIB_inside_T2HS	0.25 um	0		
306.001__T2HIC_over_T2HS	n/a	0		
306.002__T2HIC_not_interact_T2HS	n/a	0		
306.003__T2HIC_over_T1HIC	n/a	1000	Intentional, inter-tier shift	See 204.003 above
306.004__T2HIC_not_interact_T1HIC	n/a	0		
306.005__T2HIC_width	1.0 um	0		
306.006__T2HIC_spacing	5.5 um	1000	Intentional, inter-tier shift	See 204.006 above
306.007__T2HIC_inside_T2HS	0.05 um	0		
307.001__T2HID_over_T2HS	n/a	0		
307.002__T2HID_not_interact_T2HS	n/a	0		
307.003__T2HID_over_T1HID	n/a	1000	Intentional, inter-tier shift	See 204.003 above

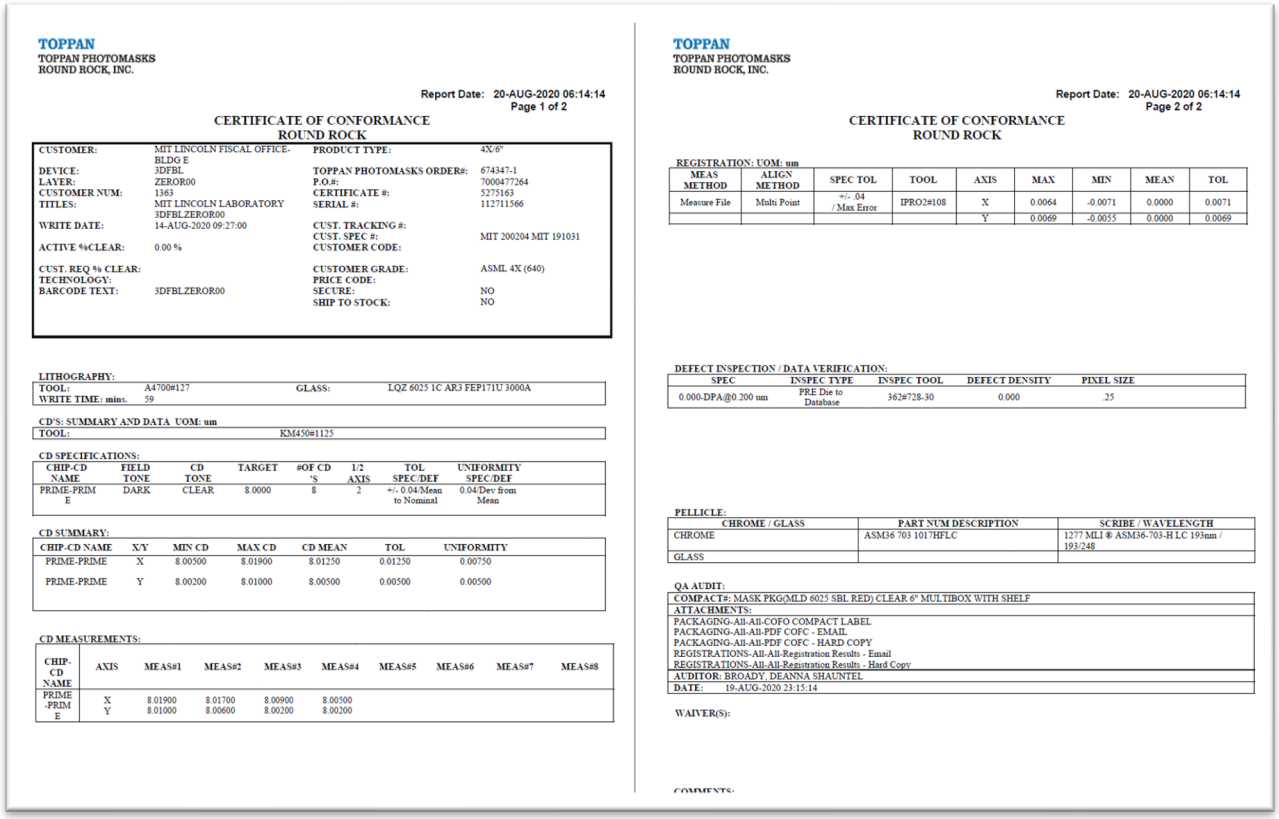
307.004__T2HID_not_interact_T1HID	n/a	18	Intentional, by design	See 207.004 above
307.005__T2HID_width	1.0 um	0		
307.006__T2HID_spacing	1.0 um	0		
307.007__T2HID_inside_T2HS	0.05 um	0		
400.001__T2HT_width	2.0 um	0		
400.002__T2BT_spacing	1.95 um	0		
401.001__T2BV_inside_T2TM	5.0 um	0		
401.002__T2BV_inside_T2BM	5.0 um	0		
403.001__T2BO_inside_T2TM	5.0 um	0		
403.002_T2BO_inside_T2BM	5.0 um	0		
403.003__T2BO_width	60.0 um	0		
Net Extraction Examples				
Net Extraction Example 1 – Large Chain (white highlight = connected, all pads connected in this chain)				

Net Extraction Example 2 – Small Chains (white highlight = connected, each column of TWO pads are connected in these chains)	
Net Extraction Example 2 – Compass Shift Chains (white highlight = connected, either 2 or 3 pads are connected in these chains)	

APPENDIX C
RETICLE CERTIFICATE OF CONFORMANCE DOCUMENTS

The following are the Certificate of Conformance Documents that pertain to the 3DFBL reticle set.

Layer 0 – Zero (Common ASML Target Layer for Tier 1 and Tier 2)



TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 20-AUG-2020 06:14:14
Page 1 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

CUSTOMER:	MIT LINCOLN FISCAL OFFICE-BLDG E	PRODUCT TYPE:	4X/6"
DEVICE:	3DFBL	TOPPAN PHOTOMASKS ORDER#:	674347-1
LAYER:	ZEROR00	P.O.#:	7000477264
CUSTOMER NUM:	1363	CERTIFICATE #:	5275163
TITLES:	MIT LINCOLN LABORATORY 3DFBLZEROR00	SERIAL #:	112711566
WRITE DATE:	14-AUG-2020 09:27:00	CUST. TRACKING #:	
		CUST. SPEC #:	MIT 200204 MIT 191031
ACTIVE %CLEAR:	0.00 %	CUSTOMER CODE:	
CUST. REQ % CLEAR:		CUSTOMER GRADE:	ASML 4X (640)
TECHNOLOGY:		PRICE CODE:	
BARCODE TEXT:	3DFBLZEROR00	SECURE:	NO
		SHIP TO STOCK:	NO

LITHOGRAPHY:

TOOL:	A4700#127	GLASS:	LQZ 6025 1C AR3 FEP171U 3000A
WRITE TIME: mins.	59		

CD'S: SUMMARY AND DATA UOM: um

TOOL:	KM450#1125

CD SPECIFICATIONS:

CHIP-CD NAME	FIELD TONE	CD TONE	TARGET	#OF CD 'S	1/2 AXIS	TOL SPEC/DEF	UNIFORMITY SPEC/DEF
PRIME-PRIME	DARK	CLEAR	8.0000	8	2	+/- 0.04/Mean to Nominal	0.04/Dev from Mean

CD SUMMARY:

CHIP-CD NAME	X/Y	MIN CD	MAX CD	CD MEAN	TOL	UNIFORMITY
PRIME-PRIME	X	8.00500	8.01900	8.01250	0.01250	0.00750
PRIME-PRIME	Y	8.00200	8.01000	8.00500	0.00500	0.00500

CD MEASUREMENTS:

CHIP-CD NAME	AXIS	MEAS#1	MEAS#2	MEAS#3	MEAS#4	MEAS#5	MEAS#6	MEAS#7	MEAS#8
PRIME-PRIME	X	8.01900	8.01700	8.00900	8.00500				
	Y	8.01000	8.00600	8.00200	8.00200				

TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 20-AUG-2020 06:14:14
Page 2 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

REGISTRATION: UOM: um

MEAS METHOD	ALIGN METHOD	SPEC TOL	TOOL	AXIS	MAX	MIN	MEAN	TOL
Measure File	Multi Point	+/- .04 / Max Error	IPRO2#108	X	0.0064	-0.0071	0.0000	0.0071
				Y	0.0069	-0.0055	0.0000	0.0069

DEFECT INSPECTION / DATA VERIFICATION:

SPEC	INSPEC TYPE	INSPEC TOOL	DEFECT DENSITY	PIXEL SIZE
0.000-DPA@0.200 um	PRE Die to Database	362#728-30	0.000	.25

PELLICLE:

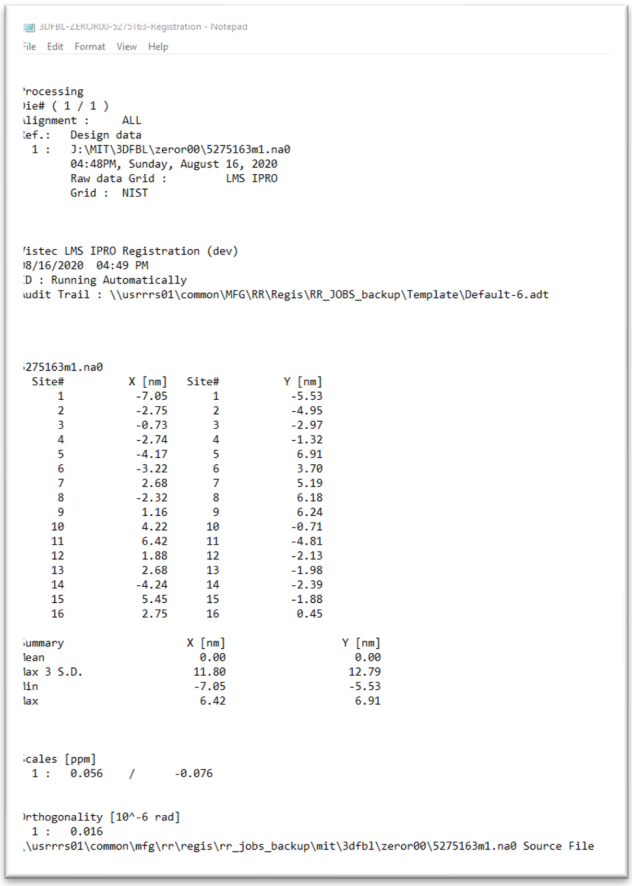
CHROME / GLASS	PART NUM DESCRIPTION	SCRIBE / WAVELENGTH
CHROME	ASM36 703 1017HFLC	1277 MLI ® ASM36-703-H LC 193nm / 193/248
GLASS		

QA AUDIT:

COMPACT#: MASK PKG(MLD 6025 SBL RED) CLEAR 6" MULTIBOX WITH SHELF
ATTACHMENTS:
PACKAGING-All-All-COFO COMPACT LABEL
PACKAGING-All-All-PDF COFC - EMAIL
PACKAGING-All-All-PDF COFC - HARD COPY
REGISTRATIONS-All-All-Registration Results - Email
REGISTRATIONS-All-All-Registration Results - Hard Copy
AUDITOR: BROADY, DEANNA SHAUNTEL
DATE: 19-AUG-2020 23:15:14

WAIVER(S):

COMMENTS:



3DFBL-ZERO00-527516s-Registration - Notepad

File Edit Format View Help

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rocessing
ie# ( 1 / 1 )
lignment :     ALL
ef.:   Design data
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       04:48PM, Sunday, August 16, 2020
       Raw data Grid :          LMS IPRO
       Grid :  NIST


istec LMS IPRO Registration (dev)
8/16/2020  04:49 PM
D : Running Automatically
udit Trail : \\usrrrs01\common\MFG\RR\Regis\RR_JOBS_backup\Template\Default-6.adt



275163m1.na0
 Site#          X [nm]   Site#          Y [nm]
     1           -7.05       1           -5.53
     2           -2.75       2           -4.95
     3           -0.73       3           -2.97
     4           -2.74       4           -1.32
     5           -4.17       5            6.91
     6           -3.22       6            3.70
     7            2.68       7            5.19
     8           -2.32       8            6.18
     9            1.16       9            6.24
    10            4.22      10           -0.71
    11            6.42      11           -4.81
    12            1.88      12           -2.13
    13            2.68      13           -1.98
    14           -4.24      14           -2.39
    15            5.45      15           -1.88
    16            2.75      16            0.45

ummary                   X [nm]                  Y [nm]
ean                        0.00                    0.00
ax 3 S.D.                 11.80                   12.79
in                        -7.05                   -5.53
ax                         6.42                    6.91


cales [ppm]
 1 :   0.056    /      -0.076


rthogonality [10^-6 rad]
 1 :   0.016
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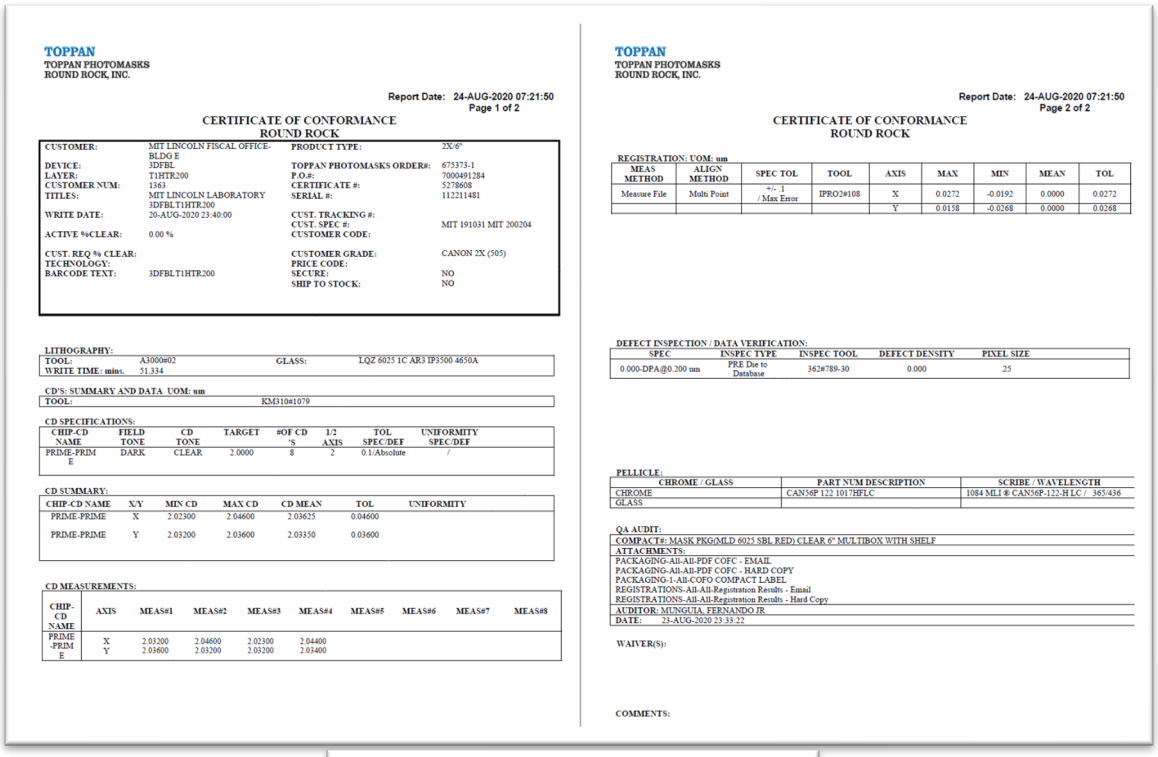
Layer 200 – T1HT (Tier 1 Hybrid Target)



TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 24-AUG-2020 07:21:50
Page 1 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

CUSTOMER:	MIT LINCOLN FISCAL OFFICE-BLDG E	PRODUCT TYPE:	2X/6"
DEVICE:	3DFBL	TOPPAN PHOTOMASKS ORDER#:	675373-1
LAYER:	T1HTR200	P.O.#:	7000491284
CUSTOMER NUM:	1363	CERTIFICATE #:	5278608
TITLES:	MIT LINCOLN LABORATORY 3DFBLT1HTR200	SERIAL #:	112211481
WRITE DATE:	20-AUG-2020 23:40:00	CUST. TRACKING #:	
ACTIVE %CLEAR:	0.00 %	CUST. SPEC #:	MIT 191031 MIT 200204
CUST. REQ % CLEAR:		CUSTOMER CODE:	
TECHNOLOGY:		PRICE CODE:	CANON 2X (505)
BARCODE TEXT:	3DFBLT1HTR200	SECURE:	NO
		SHIP TO STOCK:	NO

LITHOGRAPHY:

TOOL:	A3000#02	GLASS:	LQZ 6025 1C AR3 IP3500 4650A
WRITE TIME: mins.	51.334		

CD'S: SUMMARY AND DATA UOM: um

TOOL:	KM310#1079

CD SPECIFICATIONS:

CHIP-CD NAME	FIELD TONE	CD TONE	TARGET	#OF CD 'S	1/2 AXIS	TOL SPEC/DEF	UNIFORMITY SPEC/DEF
PRIME-PRIME	DARK	CLEAR	2.0000	8	2	0.1/Absolute	/

CD SUMMARY:

CHIP-CD NAME	X/Y	MIN CD	MAX CD	CD MEAN	TOL	UNIFORMITY
PRIME-PRIME	X	2.02300	2.04600	2.03625	0.04600	
PRIME-PRIME	Y	2.03200	2.03600	2.03350	0.03600	

CD MEASUREMENTS:

CHIP-CD NAME	AXIS	MEAS#1	MEAS#2	MEAS#3	MEAS#4	MEAS#5	MEAS#6	MEAS#7	MEAS#8
PRIME-PRIME	X	2.03200	2.04600	2.02300	2.04400				
	Y	2.03600	2.03200	2.03200	2.03400				

TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 24-AUG-2020 07:21:50
Page 2 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

REGISTRATION: UOM: um

MEAS METHOD	ALIGN METHOD	SPEC TOL	TOOL	AXIS	MAX	MIN	MEAN	TOL
Measure File	Multi Point	+/- .1 / Max Error	IPRO2#108	X	0.0272	-0.0192	0.0000	0.0272
				Y	0.0158	-0.0268	0.0000	0.0268

DEFECT INSPECTION / DATA VERIFICATION:

SPEC	INSPEC TYPE	INSPEC TOOL	DEFECT DENSITY	PIXEL SIZE
0.000-DPA@0.200 um	PRE Die to Database	362#789-30	0.000	.25

PELLICLE:

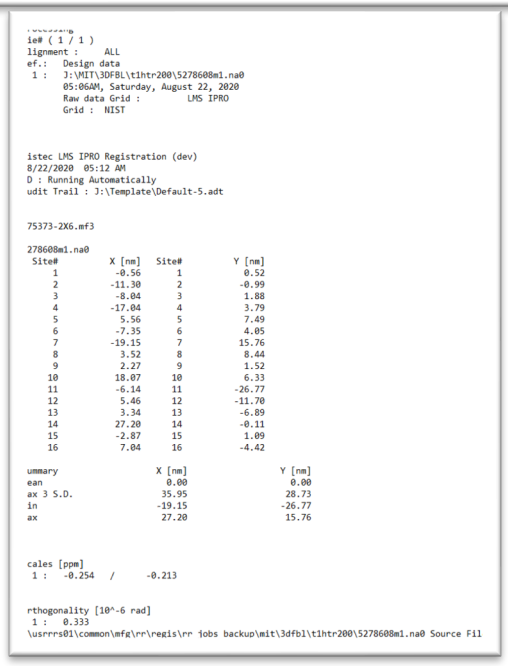
CHROME / GLASS	PART NUM DESCRIPTION	SCRIBE / WAVELENGTH
CHROME	CAN56P 122 1017HFLC	1084 MLI ® CAN56P-122-H LC / 365/436
GLASS		

QA AUDIT:

COMPACT#:	MASK PKG(MLD 6025 SBL RED) CLEAR 6" MULTIBOX WITH SHELF
ATTACHMENTS:	
	PACKAGING-All-All-PDF COFC - EMAIL
	PACKAGING-All-All-PDF COFC - HARD COPY
	PACKAGING-1-All-COFO COMPACT LABEL
	REGISTRATIONS-All-All-Registration Results - Email
	REGISTRATIONS-All-All-Registration Results - Hard Copy
AUDITOR:	MUNGUIA, FERNANDO JR
DATE:	23-AUG-2020 23:33:22

WAIVER(S):

COMMENTS:



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       05:06AM, Saturday, August 22, 2020
       Raw data Grid :          LMS IPRO
       Grid :  NIST


istec LMS IPRO Registration (dev)
8/22/2020  05:12 AM
D : Running Automatically
udit Trail : J:\Template\Default-5.adt


75373-2X6.mf3

278608m1.na0
 Site#          X [nm]   Site#          Y [nm]
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     2          -11.30       2           -0.99
     3           -8.04       3            1.88
     4          -17.04       4            3.79
     5            5.56       5            7.49
     6           -7.35       6            4.05
     7          -19.15       7           15.76
     8            3.52       8            8.44
     9            2.27       9            1.52
    10           18.07      10            6.33
    11           -6.14      11          -26.77
    12            5.46      12          -11.70
    13            3.34      13           -6.89
    14           27.20      14           -0.11
    15           -2.87      15            1.09
    16            7.04      16           -4.42

ummary                  X [nm]              Y [nm]
ean                       0.00                0.00
ax 3 S.D.                35.95               28.73
in                      -19.15              -26.77
ax                       27.20               15.76


cales [ppm]
 1 :   -0.254   /      -0.213


rthogonality [10^-6 rad]
 1 :   0.333
\usrrrs01\common\mfg\rr\regis\rr jobs backup\mit\3dfbl\t1htr200\5278608m1.na0 Source Fil
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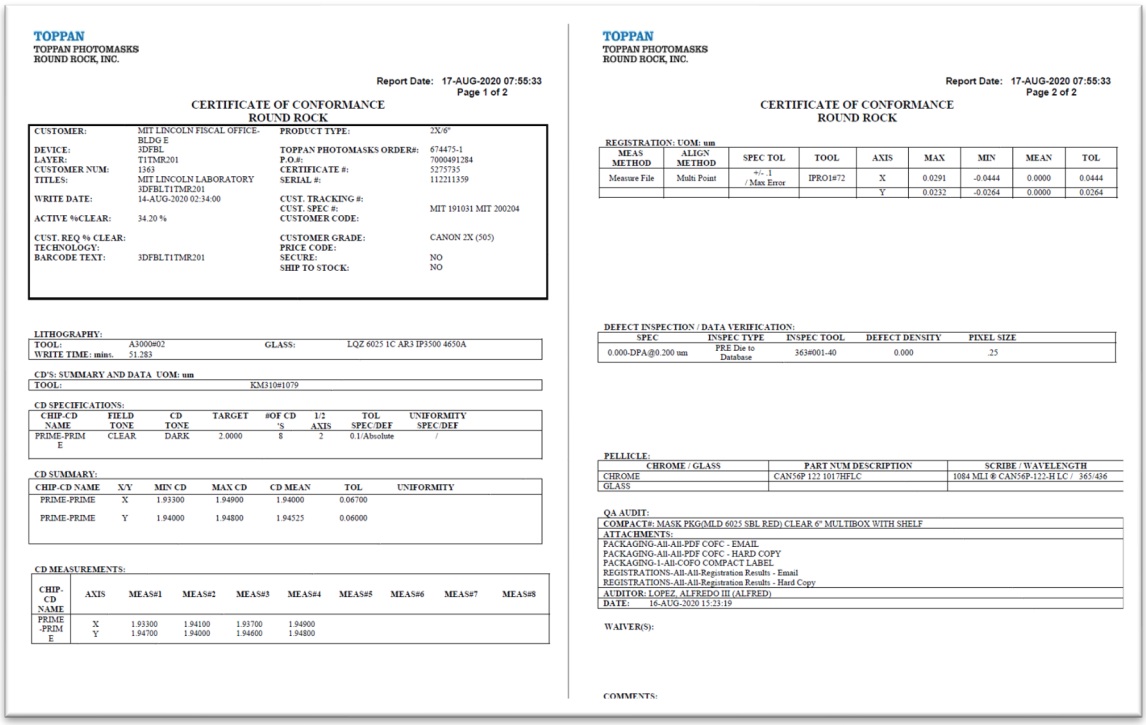
Layer 201 – T1TM (Tier 1 Top Metal)



TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 17-AUG-2020 07:55:33
Page 1 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

CUSTOMER:	MIT LINCOLN FISCAL OFFICE-BLDG E	PRODUCT TYPE:	2X/6"
DEVICE:	3DFBL	TOPPAN PHOTOMASKS ORDER#:	674475-1
LAYER:	T1TMR201	P.O.#:	7000491284
CUSTOMER NUM:	1363	CERTIFICATE #:	5275735
TITLE:	MIT LINCOLN LABORATORY 3DFBLT1TMR201	SERIAL #:	112211359
WRITE DATE:	14-AUG-2020 02:34:00	CUST. TRACKING #:	
		CUST. SPEC #:	MIT 191031 MIT 200204
ACTIVE %CLEAR:	34.20 %	CUSTOMER CODE:	
CUST. REQ % CLEAR:		CUSTOMER GRADE:	CANON 2X (505)
TECHNOLOGY:		PRICE CODE:	
BARCODE TEXT:	3DFBLT1TMR201	SECURE:	NO
		SHIP TO STOCK:	NO

LITHOGRAPHY:

TOOL:	A3000#02	GLASS:	LQZ 6025 1C AR3 IP3500 4650A
WRITE TIME: mins.	51.283		

CD'S: SUMMARY AND DATA UOM: um

TOOL:	KM310#1079

CD SPECIFICATIONS:

CHIP-CD NAME	FIELD TONE	CD TONE	TARGET	#OF CD 'S	1/2 AXIS	TOL SPEC/DEF	UNIFORMITY SPEC/DEF
PRIME-PRIME	CLEAR	DARK	2.0000	8	2	0.1/Absolute	/

CD SUMMARY:

CHIP-CD NAME	X/Y	MIN CD	MAX CD	CD MEAN	TOL	UNIFORMITY
PRIME-PRIME	X	1.93300	1.94900	1.94000	0.06700	
PRIME-PRIME	Y	1.94000	1.94800	1.94525	0.06000	

CD MEASUREMENTS:

CHIP-CD NAME	AXIS	MEAS#1	MEAS#2	MEAS#3	MEAS#4	MEAS#5	MEAS#6	MEAS#7	MEAS#8
PRIME-PRIME	X	1.93300	1.94100	1.93700	1.94900				
	Y	1.94700	1.94000	1.94600	1.94800				

TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 17-AUG-2020 07:55:33
Page 2 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

REGISTRATION: UOM: um

MEAS METHOD	ALIGN METHOD	SPEC TOL	TOOL	AXIS	MAX	MIN	MEAN	TOL
Measure File	Multi Point	+/- .1 / Max Error	IPRO1#72	X	0.0291	-0.0444	0.0000	0.0444
				Y	0.0232	-0.0264	0.0000	0.0264

DEFECT INSPECTION / DATA VERIFICATION:

SPEC	INSPEC TYPE	INSPEC TOOL	DEFECT DENSITY	PIXEL SIZE
0.000-DPA@0.200 um	PRE Die to Database	363#001-40	0.000	.25

PELLICLE:

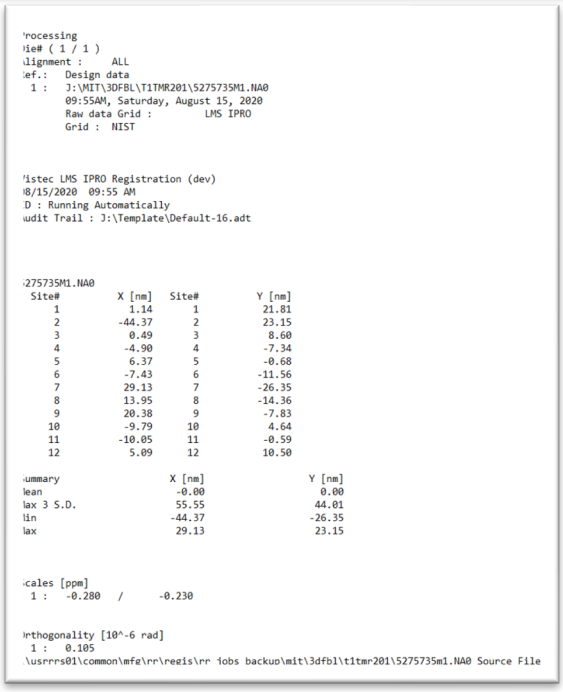
CHROME / GLASS	PART NUM DESCRIPTION	SCRIBE / WAVELENGTH
CHROME	CAN569 122 1017HFLC	1084 MLI ® CAN569-122-H LC / 365/436
GLASS		

QA AUDIT:

COMPACT#: MASK PKG(MLD 6025 SBL RED) CLEAR 6" MULTIBOX WITH SHELF
ATTACHMENTS:
PACKAGING-All-All-PDF COFC - EMAIL PACKAGING-All-All-PDF COFC - HARD COPY PACKAGING-1-All-COFO COMPACT LABEL REGISTRATIONS-All-All-Registration Results - Email REGISTRATIONS-All-All-Registration Results - Hard Copy
AUDITOR: LOPEZ, ALFREDO III (ALFRED)
DATE: 16-AUG-2020 15:23:19

WAIVER(S):

COMMENTS:



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rocessing
ie# ( 1 / 1 )
lignment :     ALL
ef.:    Design data
 1 :    J:\MIT\3DFBL\T1TMR201\5275735M1.NA0
        09:55AM, Saturday, August 15, 2020
        Raw data Grid :          LMS IPRO
        Grid :  NIST


istec LMS IPRO Registration (dev)
8/15/2020  09:55 AM
D : Running Automatically
udit Trail : J:\Template\Default-16.adt



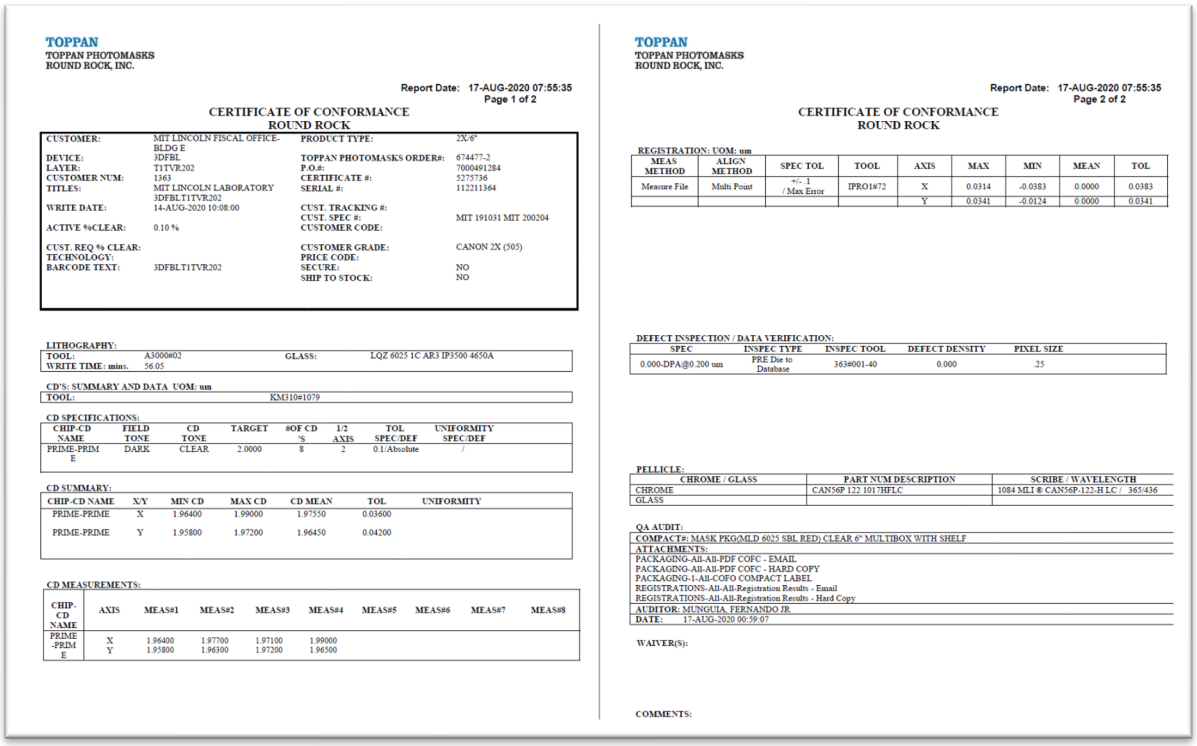
275735M1.NA0
  Site#          X [nm]    Site#          Y [nm]
      1            1.14        1           21.81
      2          -44.37        2           23.15
      3            0.49        3            8.60
      4           -4.90        4           -7.34
      5            6.37        5           -0.68
      6           -7.43        6          -11.56
      7           29.13        7          -26.35
      8           13.95        8          -14.36
      9           20.38        9           -7.83
     10           -9.79       10            4.64
     11          -10.05       11           -0.59
     12            5.09       12           10.50

ummary                    X [nm]                 Y [nm]
ean                         -0.00                  0.00
ax 3 S.D.                   55.55                 44.01
in                         -44.37                -26.35
ax                          29.13                 23.15


cales [ppm]
 1 :    -0.280   /      -0.230


rthogonality [10^-6 rad]
 1 :     0.105
\\usrrrs01\common\mfg\rr\regis\rr jobs backup\mit\3dfbl\t1tmr201\5275735m1.NA0 Source File
```

Layer 202 – T1TV (Tier 1 Top Via)



TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 17-AUG-2020 07:55:35
Page 1 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

CUSTOMER:	MIT LINCOLN FISCAL OFFICE-BLDG E	PRODUCT TYPE:	2X/6"
DEVICE:	3DFBL	TOPPAN PHOTOMASKS ORDER#:	674477-2
LAYER:	T1TVR202	P.O.#:	7000491284
CUSTOMER NUM:	1363	CERTIFICATE #:	5275736
TITLES:	MIT LINCOLN LABORATORY 3DFBLT1TVR202	SERIAL #:	112211364
WRITE DATE:	14-AUG-2020 10:08:00	CUST. TRACKING #:	
		CUST. SPEC #:	MIT 191031 MIT 200204
ACTIVE %CLEAR:	0.10 %	CUSTOMER CODE:	
CUST. REQ % CLEAR:		CUSTOMER GRADE:	CANON 2X (505)
TECHNOLOGY:		PRICE CODE:	
BARCODE TEXT:	3DFBLT1TVR202	SECURE:	NO
		SHIP TO STOCK:	NO

LITHOGRAPHY:

TOOL:	A3000#02	GLASS:	LQZ 6025 1C AR3 IP3500 4650A
WRITE TIME : mins.	56.05		

CD'S: SUMMARY AND DATA UOM: um

TOOL:	KM310#1079

CD SPECIFICATIONS:

CHIP-CD NAME	FIELD TONE	CD TONE	TARGET	#OF CD 'S	1/2 AXIS	TOL SPEC/DEF	UNIFORMITY SPEC/DEF
PRIME-PRIME	DARK	CLEAR	2.0000	8	2	0.1/Absolute	/

CD SUMMARY:

CHIP-CD NAME	X/Y	MIN CD	MAX CD	CD MEAN	TOL	UNIFORMITY
PRIME-PRIME	X	1.96400	1.99000	1.97550	0.03600	
PRIME-PRIME	Y	1.95800	1.97200	1.96450	0.04200	

CD MEASUREMENTS:

CHIP-CD NAME	AXIS	MEAS#1	MEAS#2	MEAS#3	MEAS#4	MEAS#5	MEAS#6	MEAS#7	MEAS#8
PRIME-PRIME	X	1.96400	1.97700	1.97100	1.99000				
	Y	1.95800	1.96300	1.97200	1.96500				

TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 17-AUG-2020 07:55:35
Page 2 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

REGISTRATION: UOM: um

MEAS METHOD	ALIGN METHOD	SPEC TOL	TOOL	AXIS	MAX	MIN	MEAN	TOL
Measure File	Multi Point	+/- 1 / Max Error	IPRO1#72	X	0.0314	-0.0383	0.0000	0.0383
				Y	0.0341	-0.0124	0.0000	0.0341

DEFECT INSPECTION / DATA VERIFICATION:

SPEC	INSPEC TYPE	INSPEC TOOL	DEFECT DENSITY	PIXEL SIZE
0.000-DPA@0.200 um	PRE Die to Database	363#001-40	0.000	.25

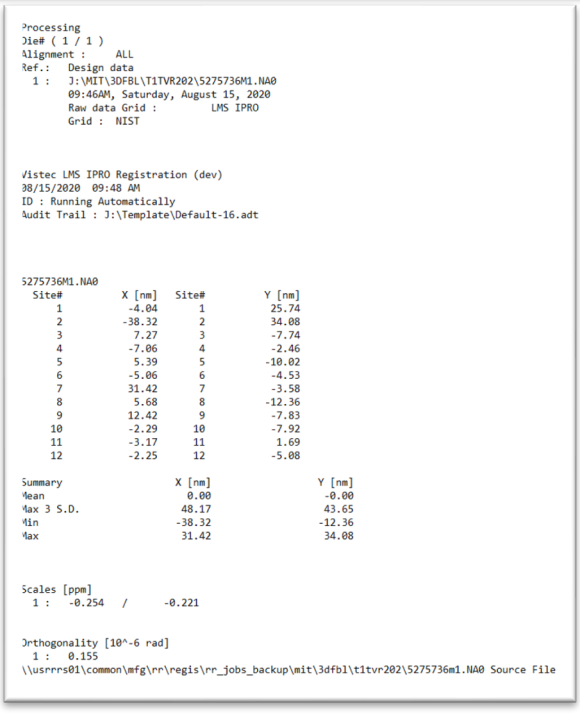
PELLICLE:

CHROME / GLASS	PART NUM DESCRIPTION	SCRIBE / WAVELENGTH
CHROME	CAN56P 122 1017HFLC	1084 MLI ® CAN56P-122-H LC / 365/436
GLASS		

QA AUDIT:
COMPACT#: MASK PKG(MLD 6025 SBL RED) CLEAR 6" MULTIBOX WITH SHELF
ATTACHMENTS:
PACKAGING-All-All-PDF COFC - EMAIL
PACKAGING-All-All-PDF COFC - HARD COPY
PACKAGING-1-All-COFO COMPACT LABEL
REGISTRATIONS-All-All-Registration Results - Email
REGISTRATIONS-All-All-Registration Results - Hard Copy
AUDITOR: MUNGUIA, FERNANDO JR.
DATE: 17-AUG-2020 00:59:07

WAIVER(S):

COMMENTS:



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Processing
Die# ( 1 / 1 )
Alignment :     ALL
Ref.:   Design data
  1 :   J:\MIT\3DFBL\T1TVR202\5275736M1.NA0
        09:46AM, Saturday, August 15, 2020
        Raw data Grid :          LMS IPRO
        Grid :  NIST


Vistec LMS IPRO Registration (dev)
08/15/2020  09:48 AM
ID : Running Automatically
Audit Trail : J:\Template\Default-16.adt



5275736M1.NA0
  Site#          X [nm]   Site#          Y [nm]
      1           -4.04       1           25.74
      2          -38.32       2           34.08
      3            7.27       3           -7.74
      4           -7.06       4           -2.46
      5            5.39       5          -10.02
      6           -5.06       6           -4.53
      7           31.42       7           -3.58
      8            5.68       8          -12.36
      9           12.42       9           -7.83
     10           -2.29      10           -7.92
     11           -3.17      11            1.69
     12           -2.25      12           -5.08

Summary                  X [nm]               Y [nm]
Mean                       0.00                -0.00
Max 3 S.D.                48.17                43.65
Min                      -38.32               -12.36
Max                       31.42                34.08


Scales [ppm]
  1 :   -0.254   /      -0.221


Orthogonality [10^-6 rad]
  1 :   0.155
\\usrrs01\common\mfg\rr\regis\rr_jobs_backup\mit\3dfbl\t1tvr202\5275736m1.NA0 Source File
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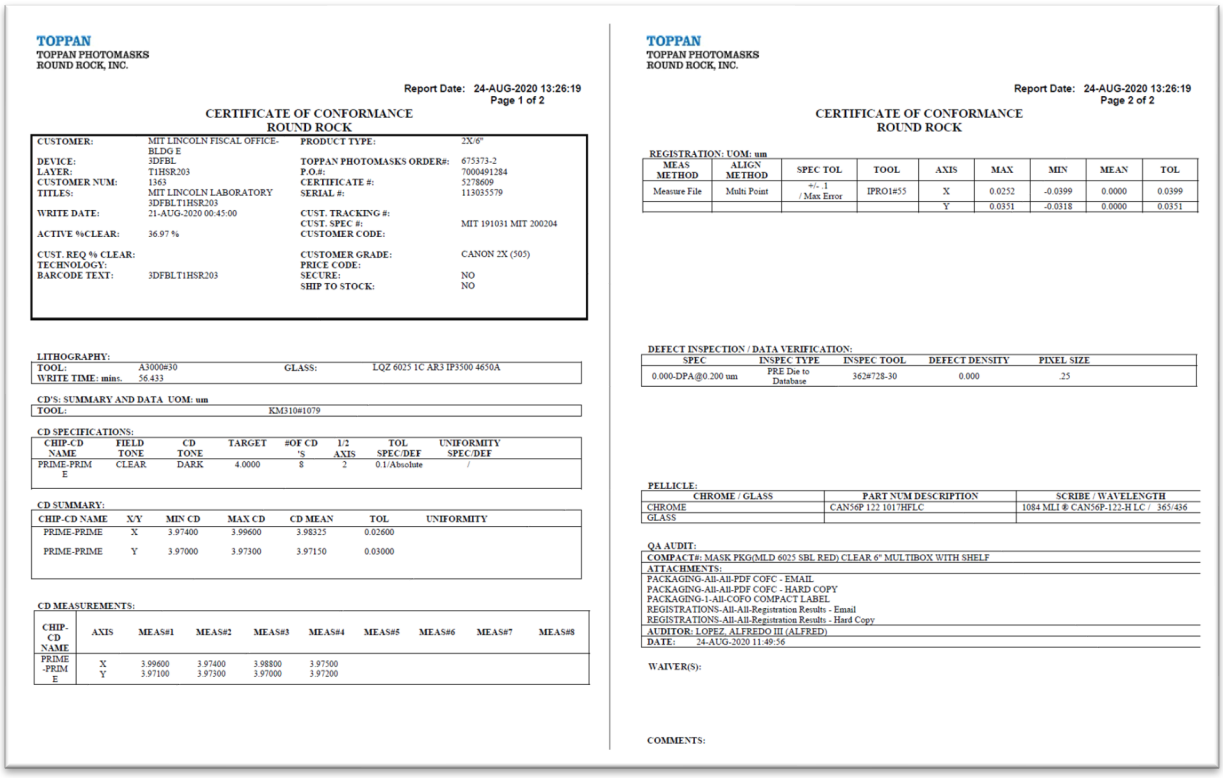
Layer 203 – T1HS (Tier 1 Hybrid Seed)



TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 24-AUG-2020 13:26:19
Page 1 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

CUSTOMER:	MIT LINCOLN FISCAL OFFICE-BLDG E	PRODUCT TYPE:	2X/6"
DEVICE:	3DFBL	TOPPAN PHOTOMASKS ORDER#:	675373-2
LAYER:	T1HSR203	P.O.#:	7000491284
CUSTOMER NUM:	1363	CERTIFICATE #:	5278609
TITLES:	MIT LINCOLN LABORATORY 3DFBLT1HSR203	SERIAL #:	113035579
WRITE DATE:	21-AUG-2020 00:45:00	CUST. TRACKING #:	
ACTIVE %CLEAR:	36.97 %	CUST. SPEC #: CUSTOMER CODE:	MIT 191031 MIT 200204
CUST. REQ % CLEAR:		CUSTOMER GRADE:	CANON 2X (505)
TECHNOLOGY:		PRICE CODE:	
BARCODE TEXT:	3DFBLT1HSR203	SECURE:	NO
		SHIP TO STOCK:	NO

LITHOGRAPHY:

TOOL:	A3000#30	GLASS:	LQZ 6025 1C AR3 IP3500 4650A
WRITE TIME: mins.	56.433		

CD'S: SUMMARY AND DATA UOM: um

TOOL:	KM310#1079

CD SPECIFICATIONS:

CHIP-CD NAME	FIELD TONE	CD TONE	TARGET	#OF CD 'S	1/2 AXIS	TOL SPEC/DEF	UNIFORMITY SPEC/DEF
PRIME-PRIME	CLEAR	DARK	4.0000	8	2	0.1/Absolute	/

CD SUMMARY:

CHIP-CD NAME	X/Y	MIN CD	MAX CD	CD MEAN	TOL	UNIFORMITY
PRIME-PRIME	X	3.97400	3.99600	3.98325	0.02600	
PRIME-PRIME	Y	3.97000	3.97300	3.97150	0.03000	

CD MEASUREMENTS:

CHIP-CD NAME	AXIS	MEAS#1	MEAS#2	MEAS#3	MEAS#4	MEAS#5	MEAS#6	MEAS#7	MEAS#8
PRIME-PRIME	X	3.99600	3.97400	3.98800	3.97500				
	Y	3.97100	3.97300	3.97000	3.97200				

TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 24-AUG-2020 13:26:19
Page 2 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

REGISTRATION: UOM: um

MEAS METHOD	ALIGN METHOD	SPEC TOL	TOOL	AXIS	MAX	MIN	MEAN	TOL
Measure File	Multi Point	+/- 1 / Max Error	IPRO1#55	X	0.0252	-0.0399	0.0000	0.0399
				Y	0.0351	-0.0318	0.0000	0.0351

DEFECT INSPECTION / DATA VERIFICATION:

SPEC	INSPEC TYPE	INSPEC TOOL	DEFECT DENSITY	PIXEL SIZE
0.000-DPA@0.200 um	PRE Die to Database	362#728-30	0.000	.25

PELLICLE:

CHROME / GLASS	PART NUM DESCRIPTION	SCRIBE / WAVELENGTH
CHROME	CAN56P 122 1017HFLC	1084 MLI ® CAN56P-122-H LC / 365/436
GLASS		

QA AUDIT:

COMPACT#: MASK PKG(MLD 6025 SBL RED) CLEAR 6" MULTIBOX WITH SHELF

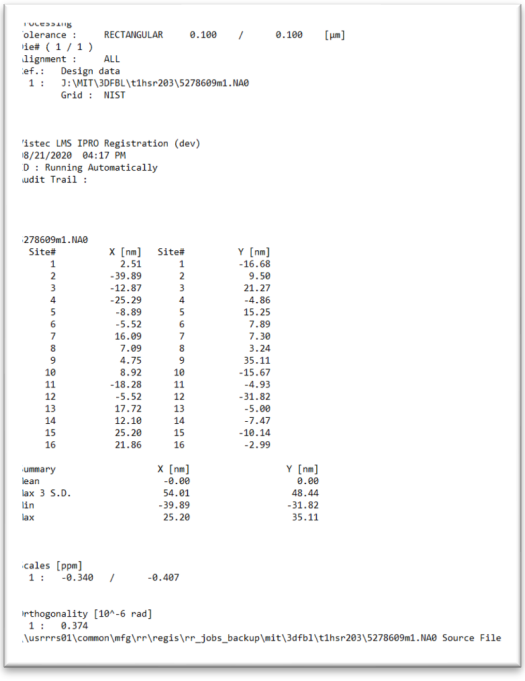
ATTACHMENTS:

PACKAGING-All-All-PDF COFC - EMAIL
PACKAGING-All-All-PDF COFC - HARD COPY
PACKAGING-1-All-COFO COMPACT LABEL
REGISTRATIONS-All-All-Registration Results - Email
REGISTRATIONS-All-All-Registration Results - Hard Copy

AUDITOR: LOPEZ, ALFREDO III (ALFRED)
DATE: 24-AUG-2020 11:49:56

WAIVER(S):

COMMENTS:



```
olerance :     RECTANGULAR     0.100    /      0.100    [µm]
ie# ( 1 / 1 )
lignment :     ALL
ef.:   Design data
 1 :   J:\MIT\3DFBL\t1hsr203\5278609m1.NA0
       Grid :  NIST


istec LMS IPRO Registration (dev)
8/21/2020  04:17 PM
D : Running Automatically
udit Trail :



278609m1.NA0
 Site#          X [nm]   Site#          Y [nm]
     1            2.51       1          -16.68
     2          -39.89       2            9.50
     3          -12.87       3           21.27
     4          -25.29       4           -4.86
     5           -8.89       5           15.25
     6           -5.52       6            7.89
     7           16.09       7            7.30
     8            7.09       8            3.24
     9            4.75       9           35.11
    10            8.92      10          -15.67
    11          -18.28      11           -4.93
    12           -5.52      12          -31.82
    13           17.72      13           -5.00
    14           12.10      14           -7.47
    15           25.20      15          -10.14
    16           21.86      16           -2.99

ummary                  X [nm]                Y [nm]
ean                       -0.00                 0.00
ax 3 S.D.                 54.01                48.44
in                       -39.89               -31.82
ax                        25.20                35.11


cales [ppm]
 1 :   -0.340   /      -0.407


rthogonality [10^-6 rad]
 1 :   0.374
\\usrrrs01\common\mfg\rr\regis\rr_jobs_backup\mit\3dfb1\t1hsr203\5278609m1.NA0 Source File
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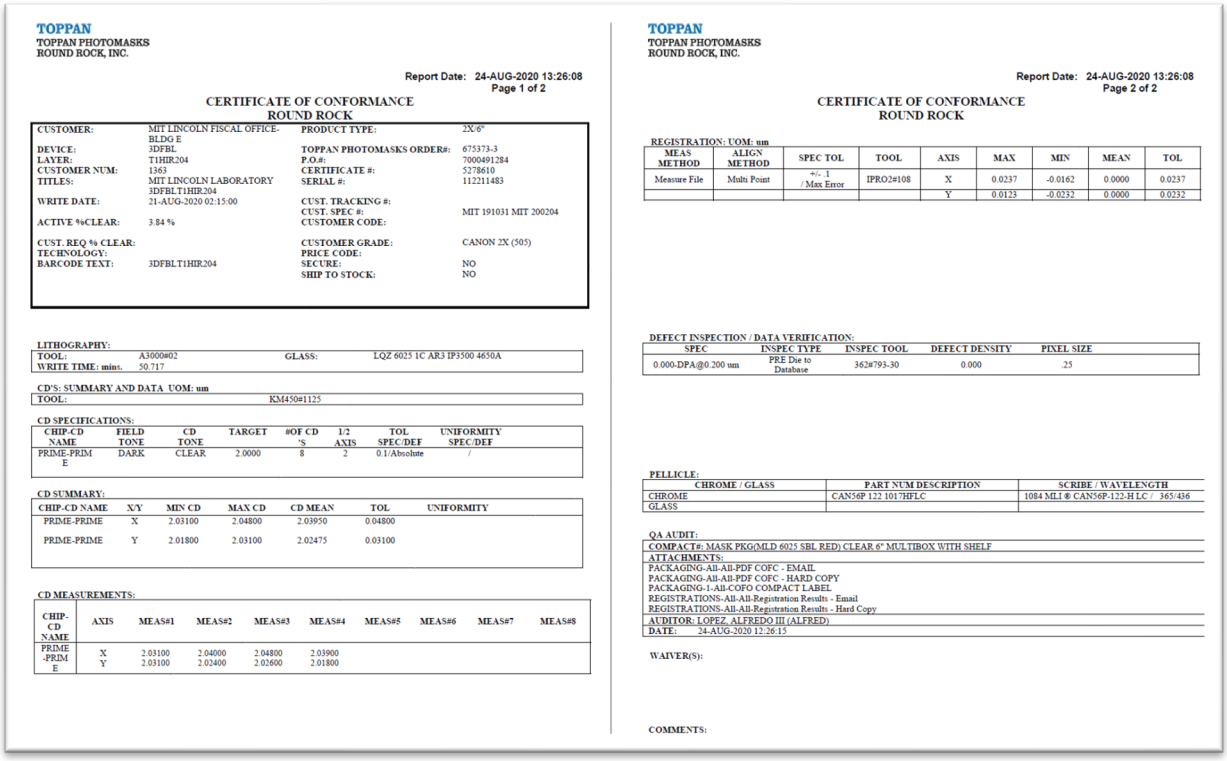
Layer 204 – T1HI (Tier 1 Hybrid Interconnect)



TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 24-AUG-2020 13:26:08
Page 1 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

CUSTOMER:	MIT LINCOLN FISCAL OFFICE-BLDG E	PRODUCT TYPE:	2X/6"
DEVICE:	3DFBL	TOPPAN PHOTOMASKS ORDER#:	675373-3
LAYER:	T1HIR204	P.O.#:	7000491284
CUSTOMER NUM:	1363	CERTIFICATE #:	5278610
TITLES:	MIT LINCOLN LABORATORY 3DFBLT1HIR204	SERIAL #:	112211483
WRITE DATE:	21-AUG-2020 02:15:00	CUST. TRACKING #:	
		CUST. SPEC #:	MIT 191031 MIT 200204
ACTIVE %CLEAR:	3.84 %	CUSTOMER CODE:	
CUST. REQ % CLEAR:		CUSTOMER GRADE:	CANON 2X (505)
TECHNOLOGY:		PRICE CODE:	
BARCODE TEXT:	3DFBLT1HIR204	SECURE:	NO
		SHIP TO STOCK:	NO

LITHOGRAPHY:

TOOL:	A3000#02	GLASS:	LQZ 6025 1C AR3 IP3500 4650A
WRITE TIME: mins.	50.717		

CD'S: SUMMARY AND DATA UOM: um

TOOL:	KM450#1125

CD SPECIFICATIONS:

CHIP-CD NAME	FIELD TONE	CD TONE	TARGET	#OF CD 'S	1/2 AXIS	TOL SPEC/DEF	UNIFORMITY SPEC/DEF
PRIME-PRIME	DARK	CLEAR	2.0000	8	2	0.1/Absolute	/

CD SUMMARY:

CHIP-CD NAME	X/Y	MIN CD	MAX CD	CD MEAN	TOL	UNIFORMITY
PRIME-PRIME	X	2.03100	2.04800	2.03950	0.04800	
PRIME-PRIME	Y	2.01800	2.03100	2.02475	0.03100	

CD MEASUREMENTS:

CHIP-CD NAME	AXIS	MEAS#1	MEAS#2	MEAS#3	MEAS#4	MEAS#5	MEAS#6	MEAS#7	MEAS#8
PRIME-PRIME	X	2.03100	2.04000	2.04800	2.03900				
	Y	2.03100	2.02400	2.02600	2.01800				

TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 24-AUG-2020 13:26:08
Page 2 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

REGISTRATION: UOM: um

MEAS METHOD	ALIGN METHOD	SPEC TOL	TOOL	AXIS	MAX	MIN	MEAN	TOL
Measure File	Multi Point	+/- 1 / Max Error	IPRO2#108	X	0.0237	-0.0162	0.0000	0.0237
				Y	0.0123	-0.0232	0.0000	0.0232

DEFECT INSPECTION / DATA VERIFICATION:

SPEC	INSPEC TYPE	INSPEC TOOL	DEFECT DENSITY	PIXEL SIZE
0.000-DPA@0.200 um	PRE Die to Database	362#793-30	0.000	.25

PELLICLE:

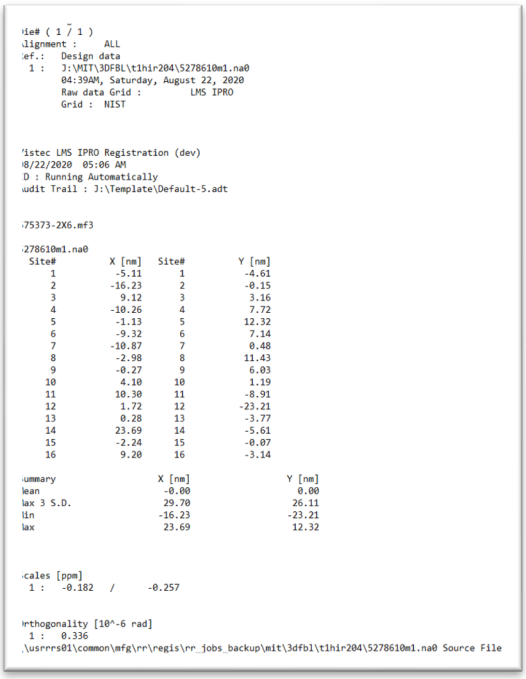
CHROME / GLASS	PART NUM DESCRIPTION	SCRIBE / WAVELENGTH
CHROME	CAN56P 122 1017HFLC	1084 ML1 @ CAN56P-122-H LC / 365/436
GLASS		

QA AUDIT:

COMPACT#: MASK PKG(MLD 6025 SBL RED) CLEAR 6" MULTIBOX WITH SHELF	
ATTACHMENTS:	
PACKAGING-All-All-PDF COFC - EMAIL	
PACKAGING-All-All-PDF COFC - HARD COPY	
PACKAGING-1-All-COFO COMPACT LABEL	
REGISTRATIONS-All-All-Registration Results - Email	
REGISTRATIONS-All-All-Registration Results - Hard Copy	
AUDITOR: LOPEZ, ALFREDO III (ALFRED)	
DATE: 24-AUG-2020 12:26:15	

WAIVER(S):

COMMENTS:



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ılignment :     ALL
ıef.:   Design data
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       04:39AM, Saturday, August 22, 2020
       Raw data Grid :          LMS IPRO
       Grid :  NIST


'istec LMS IPRO Registration (dev)
ı8/22/2020  05:06 AM
ıD : Running Automatically
ıudit Trail : J:\Template\Default-5.adt


ı75373-2X6.mf3

ı278610m1.na0
  Site#          X [nm]   Site#          Y [nm]
      1           -5.11        1           -4.61
      2          -16.23        2           -0.15
      3            9.12        3            3.16
      4          -10.26        4            7.72
      5           -1.13        5           12.32
      6           -9.32        6            7.14
      7          -10.87        7            0.48
      8           -2.98        8           11.43
      9           -0.27        9            6.03
     10            4.10       10            1.19
     11           10.30       11           -8.91
     12            1.72       12          -23.21
     13            0.28       13           -3.77
     14           23.69       14           -5.61
     15           -2.24       15           -0.07
     16            9.20       16           -3.14

ıummary                  X [nm]                Y [nm]
ıean                      -0.00                 0.00
ıax 3 S.D.                29.70                26.11
ılin                     -16.23               -23.21
ıax                       23.69                12.32


ıcales [ppm]
 1 :   -0.182   /      -0.257


ırthogonality [10^-6 rad]
 1 :   0.336
.\usrrs01\common\mfg\rr\regis\rr_jobs_backup\mit\3dfbl\t1hir204\5278610m1.na0 Source File
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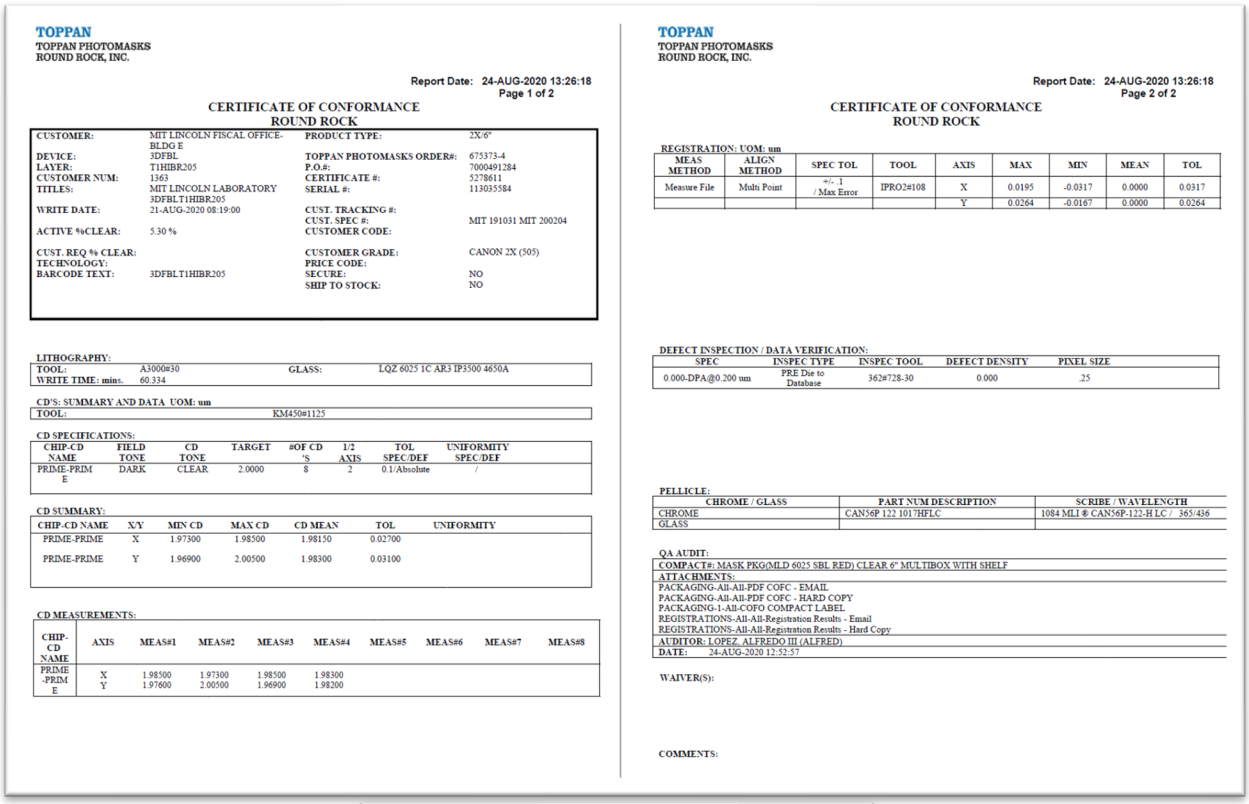
Layer 205 – T1HIB (Tier 1 Hybrid Interconnect B)



TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 24-AUG-2020 13:26:18
Page 1 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

CUSTOMER:	MIT LINCOLN FISCAL OFFICE-BLDG E	PRODUCT TYPE:	2X/6"
DEVICE:	3DFBL	TOPPAN PHOTOMASKS ORDER#:	675373-4
LAYER:	T1HIBR205	P.O.#:	7000491284
CUSTOMER NUM:	1363	CERTIFICATE #:	5278611
TITLES:	MIT LINCOLN LABORATORY 3DFBLT1HIBR205	SERIAL #:	113035584
WRITE DATE:	21-AUG-2020 08:19:00	CUST. TRACKING #:	
ACTIVE %CLEAR:	5.30 %	CUST. SPEC #: CUSTOMER CODE:	MIT 191031 MIT 200204
CUST. REQ % CLEAR:		CUSTOMER GRADE:	CANON 2X (505)
TECHNOLOGY:		PRICE CODE:	
BARCODE TEXT:	3DFBLT1HIBR205	SECURE:	NO
		SHIP TO STOCK:	NO

LITHOGRAPHY:

TOOL:	A3000#30	GLASS:	LQZ 6025 1C AR3 IP3500 4650A
WRITE TIME: mins.	60.334		

CD'S: SUMMARY AND DATA UOM: um

TOOL:	KM450#1125

CD SPECIFICATIONS:

CHIP-CD NAME	FIELD TONE	CD TONE	TARGET	#OF CD 'S	1/2 AXIS	TOL SPEC/DEF	UNIFORMITY SPEC/DEF
PRIME-PRIME	DARK	CLEAR	2.0000	8	2	0.1/Absolute	/

CD SUMMARY:

CHIP-CD NAME	X/Y	MIN CD	MAX CD	CD MEAN	TOL	UNIFORMITY
PRIME-PRIME	X	1.97300	1.98500	1.98150	0.02700	
PRIME-PRIME	Y	1.96900	2.00500	1.98300	0.03100	

CD MEASUREMENTS:

CHIP-CD NAME	AXIS	MEAS#1	MEAS#2	MEAS#3	MEAS#4	MEAS#5	MEAS#6	MEAS#7	MEAS#8
PRIME-PRIME	X	1.98500	1.97300	1.98500	1.98300				
	Y	1.97600	2.00500	1.96900	1.98200				

TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 24-AUG-2020 13:26:18
Page 2 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

REGISTRATION: UOM: um

MEAS METHOD	ALIGN METHOD	SPEC TOL	TOOL	AXIS	MAX	MIN	MEAN	TOL
Measure File	Multi Point	+/- .1 / Max Error	IPRO2#108	X	0.0195	-0.0317	0.0000	0.0317
				Y	0.0264	-0.0167	0.0000	0.0264

DEFECT INSPECTION / DATA VERIFICATION:

SPEC	INSPEC TYPE	INSPEC TOOL	DEFECT DENSITY	PIXEL SIZE
0.000-DPA@0.200 um	PRE Die to Database	362#728-30	0.000	.25

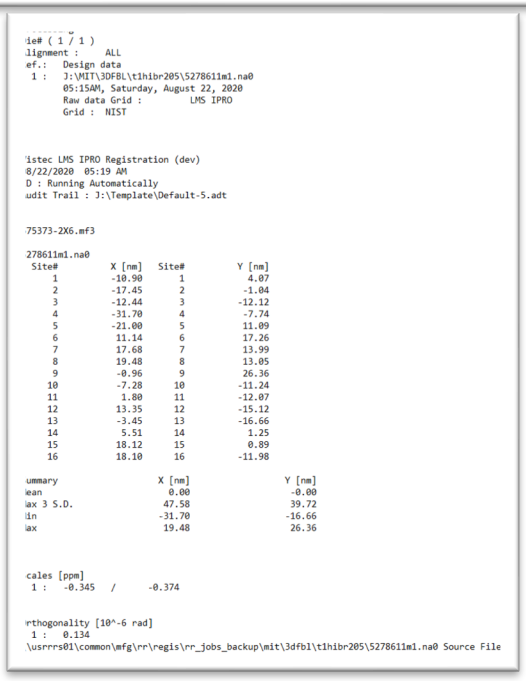
PELLICLE:

CHROME / GLASS	PART NUM DESCRIPTION	SCRIBE / WAVELENGTH
CHROME	CAN56P 122 1017HFLC	1084 MLI ® CAN56P-122-H LC / 365/436
GLASS		

QA AUDIT:
COMPACT#: MASK PKG(MLD 6025 SBL RED) CLEAR 6" MULTIBOX WITH SHELF
ATTACHMENTS:
PACKAGING-All-All-PDF COFC - EMAIL
PACKAGING-All-All-PDF COFC - HARD COPY
PACKAGING-1-All-COFO COMPACT LABEL
REGISTRATIONS-All-All-Registration Results - Email
REGISTRATIONS-All-All-Registration Results - Hard Copy
AUDITOR: LOPEZ, ALFREDO III (ALFRED)
DATE: 24-AUG-2020 12:52:57

WAIVER(S):

COMMENTS:



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lignment :     ALL
ef.:   Design data
 1 :   J:\MIT\3DFBL\t1hibr205\5278611m1.na0
       05:15AM, Saturday, August 22, 2020
       Raw data Grid :          LMS IPRO
       Grid :  NIST


istec LMS IPRO Registration (dev)
8/22/2020  05:19 AM
D : Running Automatically
udit Trail : J:\Template\Default-5.adt


75373-2X6.mf3

278611m1.na0
 Site#          X [nm]   Site#          Y [nm]
     1          -10.90       1            4.07
     2          -17.45       2           -1.04
     3          -12.44       3          -12.12
     4          -31.70       4           -7.74
     5          -21.00       5           11.09
     6           11.14       6           17.26
     7           17.68       7           13.99
     8           19.48       8           13.05
     9           -0.96       9           26.36
    10           -7.28      10          -11.24
    11            1.80      11          -12.07
    12           13.35      12          -15.12
    13           -3.45      13          -16.66
    14            5.51      14            1.25
    15           18.12      15            0.89
    16           18.10      16          -11.98

ummary                  X [nm]                 Y [nm]
ean                       0.00                  -0.00
ax 3 S.D.                47.58                  39.72
in                      -31.70                 -16.66
ax                       19.48                  26.36


cales [ppm]
 1 :   -0.345   /      -0.374


rthogonality [10^-6 rad]
 1 :   0.134
\usrrrs01\common\mfg\rr\regis\rr_jobs_backup\mit\3dfbl\t1hibr205\5278611m1.na0 Source File
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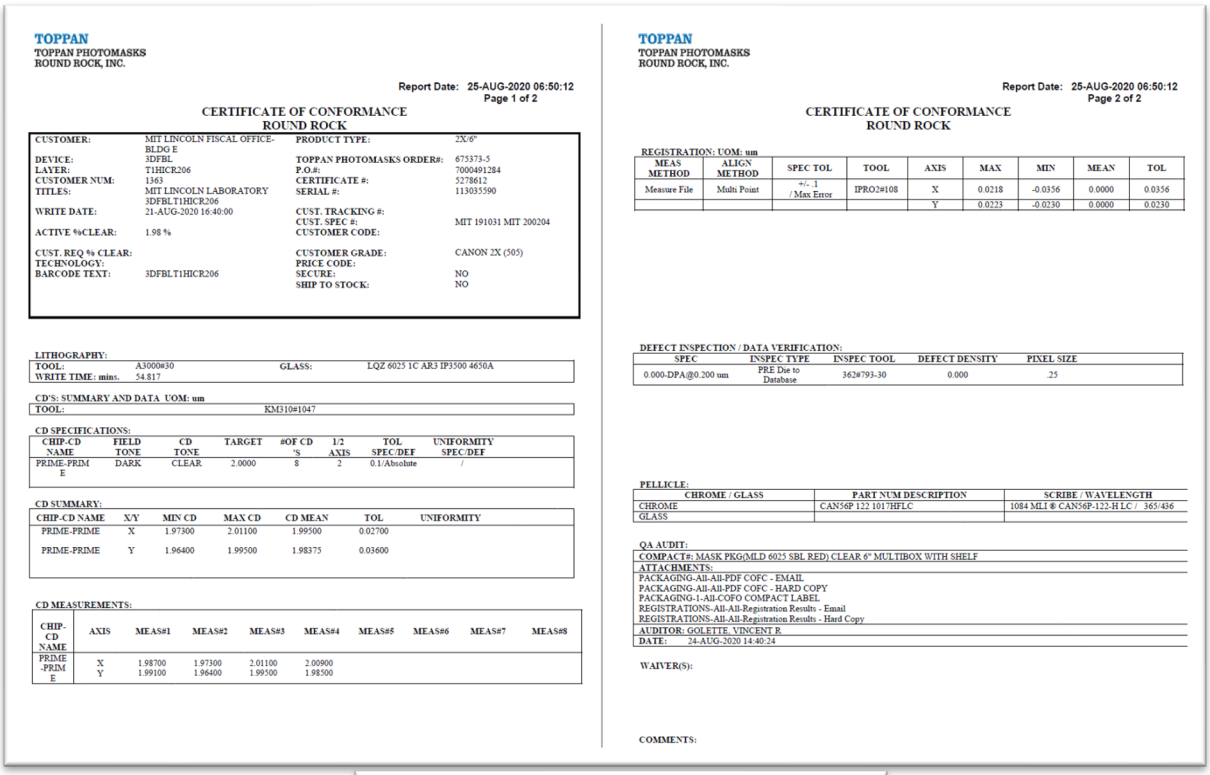
Layer 206 – T1HIC (Tier 1 Hybrid Interconnect C)



TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 25-AUG-2020 06:50:12
Page 1 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

CUSTOMER:	MIT LINCOLN FISCAL OFFICE-BLDG E	PRODUCT TYPE:	2X/6"
DEVICE:	3DFBL	TOPPAN PHOTOMASKS ORDER#:	675373-5
LAYER:	T1HICR206	P.O.#:	7000491284
CUSTOMER NUM:	1363	CERTIFICATE #:	5278612
TITLES:	MIT LINCOLN LABORATORY 3DFBLT1HICR206	SERIAL #:	113035590
WRITE DATE:	21-AUG-2020 16:40:00	CUST. TRACKING #:	
ACTIVE %CLEAR:	1.98 %	CUST. SPEC #: CUSTOMER CODE:	MIT 191031 MIT 200204
CUST. REQ % CLEAR:		CUSTOMER GRADE:	CANON 2X (505)
TECHNOLOGY:		PRICE CODE:	
BARCODE TEXT:	3DFBLT1HICR206	SECURE:	NO
		SHIP TO STOCK:	NO

LITHOGRAPHY:

TOOL:	A3000#30	GLASS:	LQZ 6025 1C AR3 IP3500 4650A
WRITE TIME: mins.	54.817		

CD'S: SUMMARY AND DATA UOM: um

TOOL:	KM310#1047

CD SPECIFICATIONS:

CHIP-CD NAME	FIELD TONE	CD TONE	TARGET	#OF CD 'S	1/2 AXIS	TOL SPEC/DEF	UNIFORMITY SPEC/DEF
PRIME-PRIME	DARK	CLEAR	2.0000	8	2	0.1/Absolute	/

CD SUMMARY:

CHIP-CD NAME	X/Y	MIN CD	MAX CD	CD MEAN	TOL	UNIFORMITY
PRIME-PRIME	X	1.97300	2.01100	1.99500	0.02700	
PRIME-PRIME	Y	1.96400	1.99500	1.98375	0.03600	

CD MEASUREMENTS:

CHIP-CD NAME	AXIS	MEAS#1	MEAS#2	MEAS#3	MEAS#4	MEAS#5	MEAS#6	MEAS#7	MEAS#8
PRIME-PRIME	X	1.98700	1.97300	2.01100	2.00900				
	Y	1.99100	1.96400	1.99500	1.98500				

TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 25-AUG-2020 06:50:12
Page 2 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

REGISTRATION: UOM: um

MEAS METHOD	ALIGN METHOD	SPEC TOL	TOOL	AXIS	MAX	MIN	MEAN	TOL
Measure File	Multi Point	+/- .1 / Max Error	IPRO2#108	X	0.0218	-0.0356	0.0000	0.0356
				Y	0.0223	-0.0230	0.0000	0.0230

DEFECT INSPECTION / DATA VERIFICATION:

SPEC	INSPEC TYPE	INSPEC TOOL	DEFECT DENSITY	PIXEL SIZE
0.000-DPA@0.200 um	PRE Die to Database	3628#793-30	0.000	.25

PELLICLE:

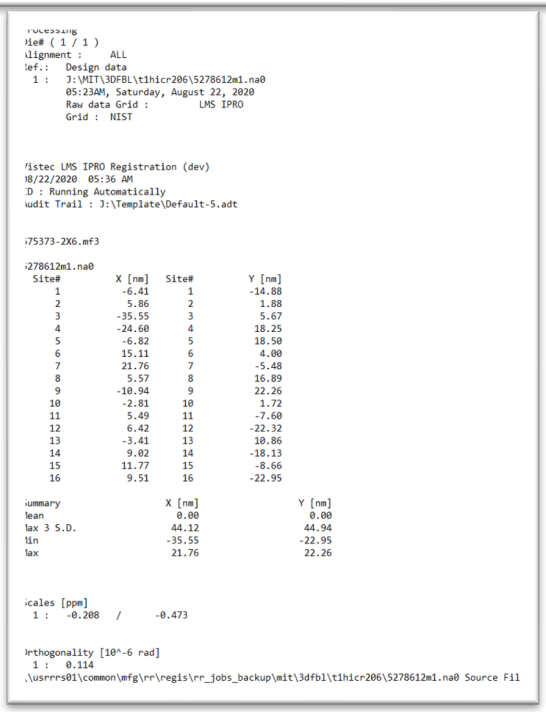
CHROME / GLASS	PART NUM DESCRIPTION	SCRIBE / WAVELENGTH
CHROME	CAN56P 122 1017HFLC	1084 MLI ® CAN56P-122-H LC / 365/436
GLASS		

QA AUDIT:

COMPACT#:	MASK PKG(MLD 6025 SBL RED) CLEAR 6" MULTIBOX WITH SHELF
ATTACHMENTS:	
	PACKAGING-All-All-PDF COFC - EMAIL
	PACKAGING-All-All-PDF COFC - HARD COPY
	PACKAGING-1-All-COFO COMPACT LABEL
	REGISTRATIONS-All-All-Registration Results - Email
	REGISTRATIONS-All-All-Registration Results - Hard Copy
AUDITOR:	GOLETTE, VINCENT R
DATE:	24-AUG-2020 14:40:24

WAIVER(S):

COMMENTS:



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Processing
Die# ( 1 / 1 )
Alignment :      ALL
Ref.:    Design data
  1 :    J:\MIT\3DFBL\t1hicr206\5278612m1.na0
         05:23AM, Saturday, August 22, 2020
         Raw data Grid :          LMS IPRO
         Grid :  NIST


Vistec LMS IPRO Registration (dev)
08/22/2020  05:36 AM
ID : Running Automatically
Audit Trail : J:\Template\Default-5.adt


675373-2X6.mf3

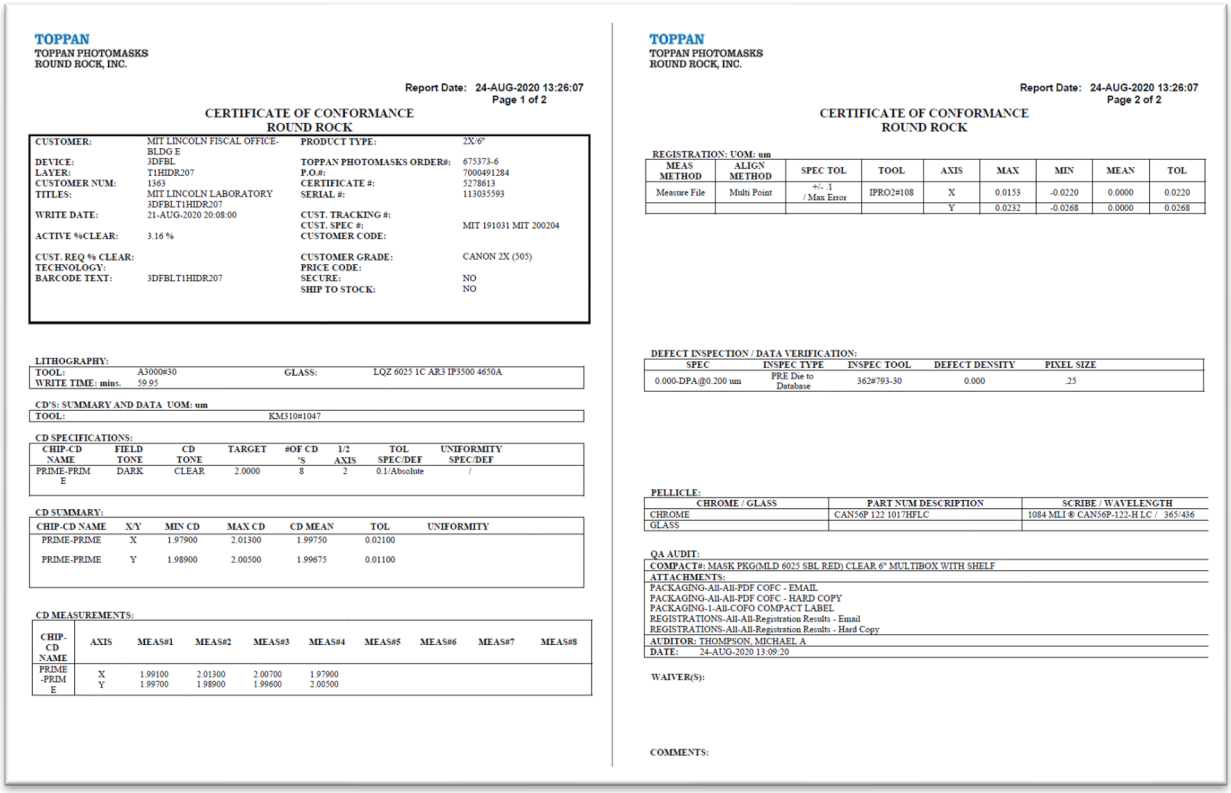
5278612m1.na0
 Site#          X [nm]   Site#          Y [nm]
     1           -6.41       1         -14.88
     2            5.86       2           1.88
     3          -35.55       3           5.67
     4          -24.60       4          18.25
     5           -6.82       5          18.50
     6           15.11       6           4.00
     7           21.76       7          -5.48
     8            5.57       8          16.89
     9          -10.94       9          22.26
    10           -2.81      10           1.72
    11            5.49      11          -7.60
    12            6.42      12         -22.32
    13           -3.41      13          10.86
    14            9.02      14         -18.13
    15           11.77      15          -8.66
    16            9.51      16         -22.95

Summary                  X [nm]               Y [nm]
Mean                       0.00                 0.00
Max 3 S.D.                44.12                44.94
Min                      -35.55               -22.95
Max                       21.76                22.26


Scales [ppm]
  1 :    -0.208   /      -0.473


Orthogonality [10^-6 rad]
  1 :    0.114
\\usrrrs01\common\mfg\rr\regis\rr_jobs_backup\mit\3dfbl\t1hicr206\5278612m1.na0 Source Fil
```

Layer 207 – T1HID (Tier 1 Hybrid Interconnect D)



TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 24-AUG-2020 13:26:07
Page 1 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

CUSTOMER:	MIT LINCOLN FISCAL OFFICE-BLDG E	PRODUCT TYPE:	2X/6"
DEVICE:	3DFBL	TOPPAN PHOTOMASKS ORDER#:	675373-6
LAYER:	T1HIDR207	P.O.#:	7000491284
CUSTOMER NUM:	1363	CERTIFICATE #:	5278613
TITLES:	MIT LINCOLN LABORATORY 3DFBLT1HIDR207	SERIAL #:	113035593
WRITE DATE:	21-AUG-2020 20:08:00	CUST. TRACKING #:	
		CUST. SPEC #:	MIT 191031 MIT 200204
ACTIVE %CLEAR:	3.16 %	CUSTOMER CODE:	
CUST. REQ % CLEAR:		CUSTOMER GRADE:	CANON 2X (505)
TECHNOLOGY:		PRICE CODE:	
BARCODE TEXT:	3DFBLT1HIDR207	SECURE:	NO
		SHIP TO STOCK:	NO

LITHOGRAPHY:

TOOL:	A3000#30	GLASS:	LQZ 6025 1C AR3 IP3500 4650A
WRITE TIME: mins.	59.95		

CD'S: SUMMARY AND DATA UOM: um

TOOL:	KM310#1047

CD SPECIFICATIONS:

CHIP-CD NAME	FIELD TONE	CD TONE	TARGET	#OF CD 'S	1/2 AXIS	TOL SPEC/DEF	UNIFORMITY SPEC/DEF
PRIME-PRIME	DARK	CLEAR	2.0000	8	2	0.1/Absolute	/

CD SUMMARY:

CHIP-CD NAME	X/Y	MIN CD	MAX CD	CD MEAN	TOL	UNIFORMITY
PRIME-PRIME	X	1.97900	2.01300	1.99750	0.02100	
PRIME-PRIME	Y	1.98900	2.00500	1.99675	0.01100	

CD MEASUREMENTS:

CHIP-CD NAME	AXIS	MEAS#1	MEAS#2	MEAS#3	MEAS#4	MEAS#5	MEAS#6	MEAS#7	MEAS#8
PRIME-PRIME	X	1.99100	2.01300	2.00700	1.97900				
	Y	1.99700	1.98900	1.99600	2.00500				

TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 24-AUG-2020 13:26:07
Page 2 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

REGISTRATION: UOM: um

MEAS METHOD	ALIGN METHOD	SPEC TOL	TOOL	AXIS	MAX	MIN	MEAN	TOL
Measure File	Multi Point	+/- 1 / Max Error	IPRO2#108	X	0.0153	-0.0220	0.0000	0.0220
				Y	0.0232	-0.0268	0.0000	0.0268

DEFECT INSPECTION / DATA VERIFICATION:

SPEC	INSPEC TYPE	INSPEC TOOL	DEFECT DENSITY	PIXEL SIZE
0.000-DPA@0.200 um	PRE Die to Database	362#793-30	0.000	.25

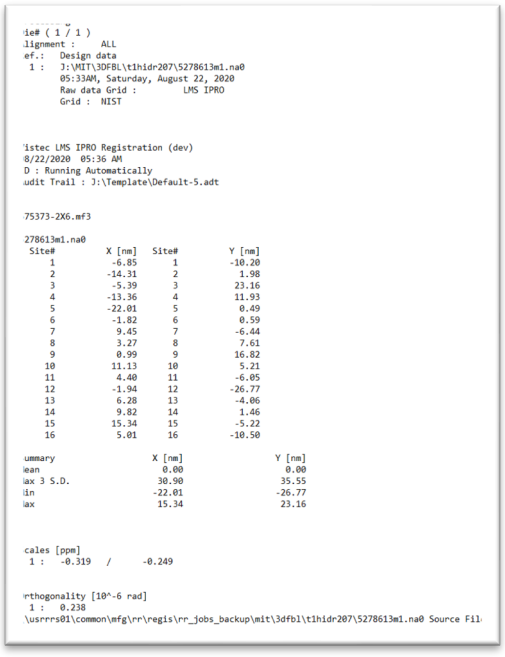
PELLICLE:

CHROME / GLASS	PART NUM DESCRIPTION	SCRIBE / WAVELENGTH
CHROME	CAN56P 122 1017HFLC	1084 MLI ® CAN56P-122-H LC / 365/436
GLASS		

QA AUDIT:
COMPACT#: MASK PKG(MLD 6025 SBL RED) CLEAR 6" MULTIBOX WITH SHELF
ATTACHMENTS:
PACKAGING-All-All-PDF COFC - EMAIL
PACKAGING-All-All-PDF COFC - HARD COPY
PACKAGING-1-All-COFO COMPACT LABEL
REGISTRATIONS-All-All-Registration Results - Email
REGISTRATIONS-All-All-Registration Results - Hard Copy
AUDITOR: THOMPSON, MICHAEL A
DATE: 24-AUG-2020 13:09:20

WAIVER(S):

COMMENTS:



ie# (1 / 1)
lignment : ALL
ef.: Design data
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05:33AM, Saturday, August 22, 2020
Raw data Grid : LMS IPRO
Grid : NIST

istec LMS IPRO Registration (dev)
8/22/2020 05:36 AM
D : Running Automatically
udit Trail : J:\Template\Default-5.adt

75373-2X6.mf3

278613m1.na0

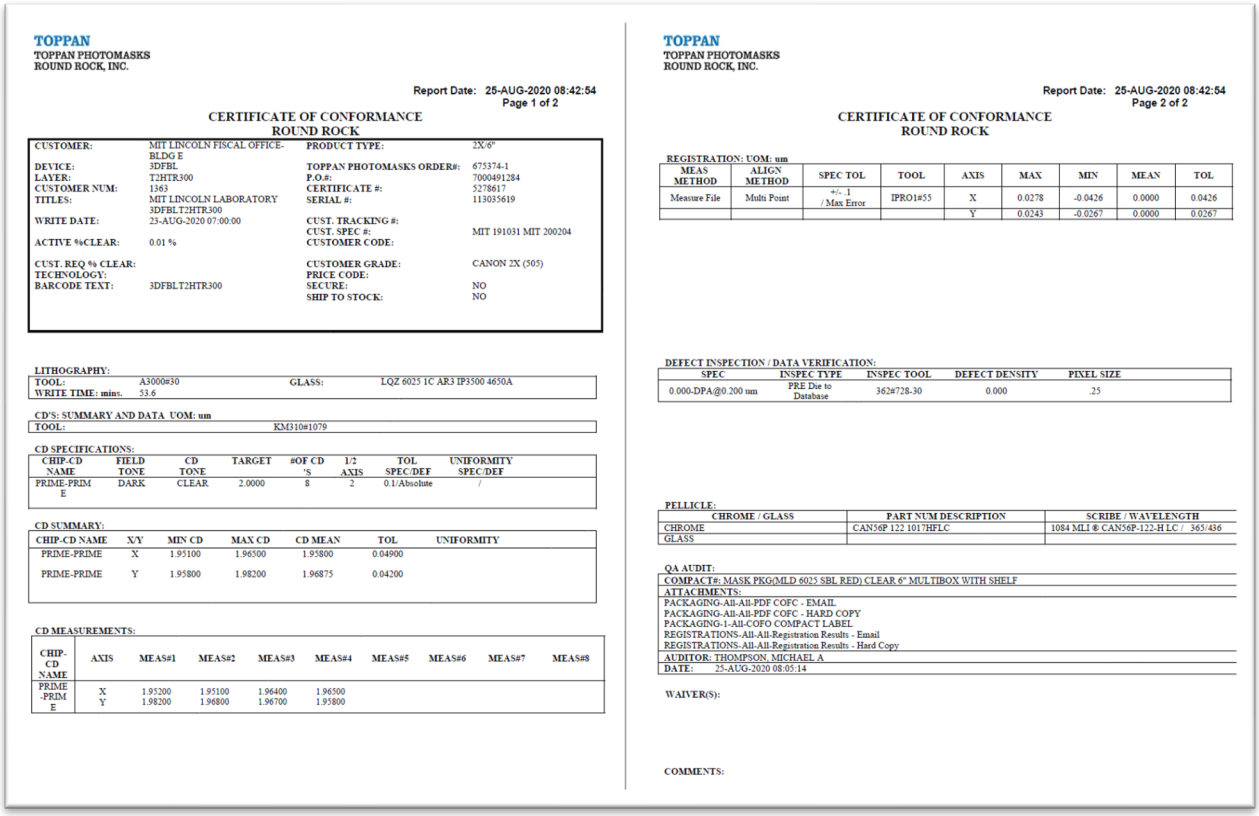
Site#	X [nm]	Site#	Y [nm]
1	-6.85	1	-10.20
2	-14.31	2	1.98
3	-5.39	3	23.16
4	-13.36	4	11.93
5	-22.01	5	0.49
6	-1.82	6	0.59
7	9.45	7	-6.44
8	3.27	8	7.61
9	0.99	9	16.82
10	11.13	10	5.21
11	4.40	11	-6.05
12	-1.94	12	-26.77
13	6.28	13	-4.06
14	9.82	14	1.46
15	15.34	15	-5.22
16	5.01	16	-10.50

ummary	X [nm]	Y [nm]
ean	0.00	0.00
ax 3 S.D.	30.90	35.55
in	-22.01	-26.77
ax	15.34	23.16

cales [ppm]
1 : -0.319 / -0.249

rthogonality [10^-6 rad]
1 : 0.238
\usrrrs01\common\mfg\rr\regis\rr_jobs_backup\mit\3dfbl\t1hidr207\5278613m1.na0 Source Fil

Layer 300 – T2HT (Tier 2 Hybrid Target)



TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 25-AUG-2020 08:42:54
Page 1 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

CUSTOMER:	MIT LINCOLN FISCAL OFFICE-BLDG E	PRODUCT TYPE:	2X/6"
DEVICE:	3DFBL	TOPPAN PHOTOMASKS ORDER#:	675374-1
LAYER:	T2HTR300	P.O.#:	7000491284
CUSTOMER NUM:	1363	CERTIFICATE #:	5278617
TITLES:	MIT LINCOLN LABORATORY 3DFBLT2HTR300	SERIAL #:	113035619
WRITE DATE:	23-AUG-2020 07:00:00	CUST. TRACKING #:	
		CUST. SPEC #:	MIT 191031 MIT 200204
ACTIVE %CLEAR:	0.01 %	CUSTOMER CODE:	
CUST. REQ % CLEAR:		CUSTOMER GRADE:	CANON 2X (505)
TECHNOLOGY:		PRICE CODE:	
BARCODE TEXT:	3DFBLT2HTR300	SECURE:	NO
		SHIP TO STOCK:	NO

LITHOGRAPHY:

TOOL:	A3000#30	GLASS:	LQZ 6025 1C AR3 IP3500 4650A
WRITE TIME: mins.	53.6		

CD'S: SUMMARY AND DATA UOM: um

TOOL:	KM310#1079

CD SPECIFICATIONS:

CHIP-CD NAME	FIELD TONE	CD TONE	TARGET	#OF CD 'S	1/2 AXIS	TOL SPEC/DEF	UNIFORMITY SPEC/DEF
PRIME-PRIME	DARK	CLEAR	2.0000	8	2	0.1/Absolute	/

CD SUMMARY:

CHIP-CD NAME	X/Y	MIN CD	MAX CD	CD MEAN	TOL	UNIFORMITY
PRIME-PRIME	X	1.95100	1.96500	1.95800	0.04900	
PRIME-PRIME	Y	1.95800	1.98200	1.96875	0.04200	

CD MEASUREMENTS:

CHIP-CD NAME	AXIS	MEAS#1	MEAS#2	MEAS#3	MEAS#4	MEAS#5	MEAS#6	MEAS#7	MEAS#8
PRIME-PRIME	X	1.95200	1.95100	1.96400	1.96500				
	Y	1.98200	1.96800	1.96700	1.95800				

TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 25-AUG-2020 08:42:54
Page 2 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

REGISTRATION: UOM: um

MEAS METHOD	ALIGN METHOD	SPEC TOL	TOOL	AXIS	MAX	MIN	MEAN	TOL
Measure File	Multi Point	+/- .1 / Max Error	IPRO1#55	X	0.0278	-0.0426	0.0000	0.0426
				Y	0.0243	-0.0267	0.0000	0.0267

DEFECT INSPECTION / DATA VERIFICATION:

SPEC	INSPEC TYPE	INSPEC TOOL	DEFECT DENSITY	PIXEL SIZE
0.000-DPA@0.200 um	PRE Die to Database	362#728-30	0.000	.25

PELLICLE:

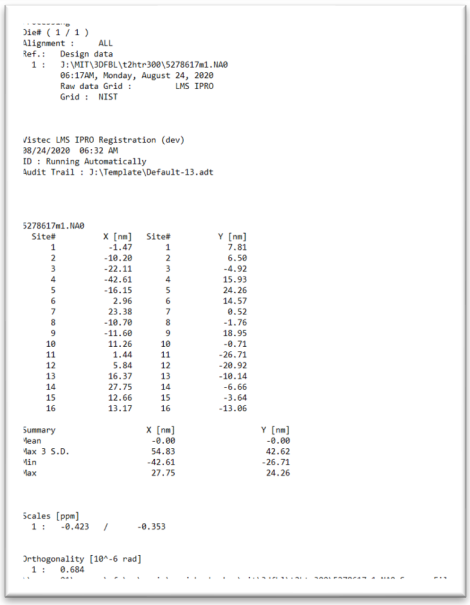
CHROME / GLASS	PART NUM DESCRIPTION	SCRIBE / WAVELENGTH
CHROME	CAN56P 122 1017HFLC	1084 MLI ® CAN56P-122-H LC / 365/436
GLASS		

QA AUDIT:

COMPACT#: MASK PKG(MLD 6025 SBL RED) CLEAR 6" MULTIBOX WITH SHELF
ATTACHMENTS:
PACKAGING-All-All-PDF COFC - EMAIL
PACKAGING-All-All-PDF COFC - HARD COPY
PACKAGING-1-All-COFO COMPACT LABEL
REGISTRATIONS-All-All-Registration Results - Email
REGISTRATIONS-All-All-Registration Results - Hard Copy
AUDITOR: THOMPSON, MICHAEL A
DATE: 25-AUG-2020 08:05:14

WAIVER(S):

COMMENTS:



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Die# ( 1 / 1 )
Alignment :    ALL
Ref.:   Design data
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        06:17AM, Monday, August 24, 2020
        Raw data Grid :          LMS IPRO
        Grid :  NIST


Distec LMS IPRO Registration (dev)
08/24/2020  06:32 AM
ID : Running Automatically
Audit Trail : J:\Template\Default-13.adt



5278617m1.NA0
  Site#          X [nm]   Site#          Y [nm]
      1           -1.47      1           7.81
      2          -10.20      2           6.50
      3          -22.11      3          -4.92
      4          -42.61      4          15.93
      5          -16.15      5          24.26
      6            2.96      6          14.57
      7           23.38      7           0.52
      8          -10.70      8          -1.76
      9          -11.60      9          18.95
     10           11.26     10          -0.71
     11            1.44     11         -26.71
     12            5.84     12         -20.92
     13           16.37     13         -10.14
     14           27.75     14          -6.66
     15           12.66     15          -3.64
     16           13.17     16         -13.06

Summary                 X [nm]              Y [nm]
Mean                     -0.00               -0.00
Max 3 S.D.               54.83               42.62
Min                     -42.61              -26.71
Max                      27.75               24.26


Scales [ppm]
  1 :   -0.423   /     -0.353


Orthogonality [10^-6 rad]
  1 :    0.684
```
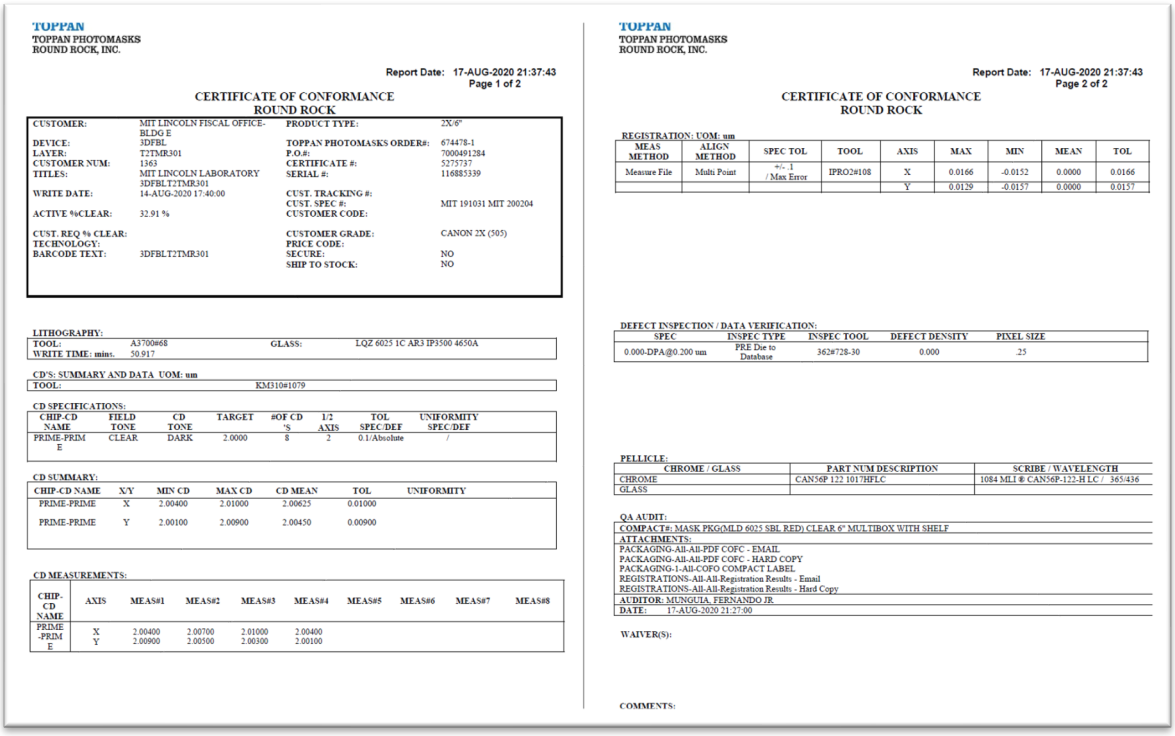

Layer 301 – T2TM (Tier 2 Top Metal)



TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 17-AUG-2020 21:37:43
Page 1 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

CUSTOMER:	MIT LINCOLN FISCAL OFFICE-BLDG E	PRODUCT TYPE:	2X/6"
DEVICE:	3DFBL	TOPPAN PHOTOMASKS ORDER#:	674478-1
LAYER:	T2TMR301	P.O.#:	7000491284
CUSTOMER NUM:	1363	CERTIFICATE #:	5275737
TITLES:	MIT LINCOLN LABORATORY 3DFBLT2TMR301	SERIAL #:	116885339
WRITE DATE:	14-AUG-2020 17:40:00	CUST. TRACKING #:	
		CUST. SPEC #:	MIT 191031 MIT 200204
ACTIVE %CLEAR:	32.91 %	CUSTOMER CODE:	
CUST. REQ % CLEAR:		CUSTOMER GRADE:	CANON 2X (505)
TECHNOLOGY:		PRICE CODE:	
BARCODE TEXT:	3DFBLT2TMR301	SECURE:	NO
		SHIP TO STOCK:	NO

LITHOGRAPHY:

TOOL:	A3700#68	GLASS:	LQZ 6025 1C AR3 IP3500 4650A
WRITE TIME: mins.	50.917		

CD'S: SUMMARY AND DATA UOM: um

TOOL:	KM310#1079

CD SPECIFICATIONS:

CHIP-CD NAME	FIELD TONE	CD TONE	TARGET	#OF CD 'S	1/2 AXIS	TOL SPEC/DEF	UNIFORMITY SPEC/DEF
PRIME-PRIME	CLEAR	DARK	2.0000	8	2	0.1/Absolute	/

CD SUMMARY:

CHIP-CD NAME	X/Y	MIN CD	MAX CD	CD MEAN	TOL	UNIFORMITY
PRIME-PRIME	X	2.00400	2.01000	2.00625	0.01000	
PRIME-PRIME	Y	2.00100	2.00900	2.00450	0.00900	

CD MEASUREMENTS:

CHIP-CD NAME	AXIS	MEAS#1	MEAS#2	MEAS#3	MEAS#4	MEAS#5	MEAS#6	MEAS#7	MEAS#8
PRIME-PRIME	X	2.00400	2.00700	2.01000	2.00400				
	Y	2.00900	2.00500	2.00300	2.00100				

TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 17-AUG-2020 21:37:43
Page 2 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

REGISTRATION: UOM: um

MEAS METHOD	ALIGN METHOD	SPEC TOL	TOOL	AXIS	MAX	MIN	MEAN	TOL
Measure File	Multi Point	+/- .1 / Max Error	IPRO2#108	X	0.0166	-0.0152	0.0000	0.0166
				Y	0.0129	-0.0157	0.0000	0.0157

DEFECT INSPECTION / DATA VERIFICATION:

SPEC	INSPEC TYPE	INSPEC TOOL	DEFECT DENSITY	PIXEL SIZE
0.000-DPA@0.200 um	PRE Die to Database	362#728-30	0.000	.25

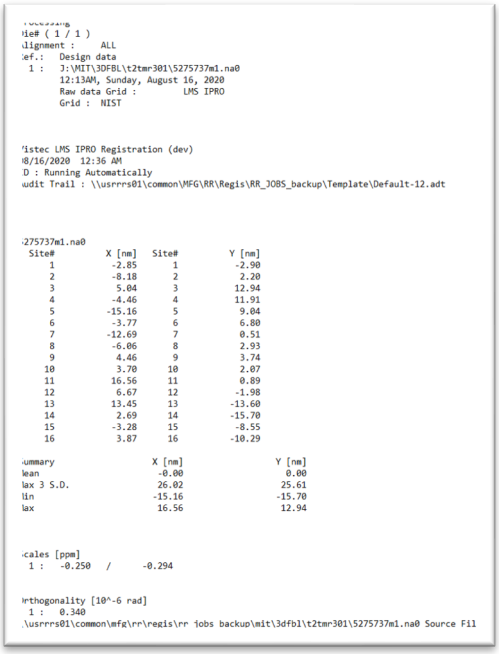
PELLICLE:

CHROME / GLASS	PART NUM DESCRIPTION	SCRIBE / WAVELENGTH
CHROME	CAN56P 122 1017HFLC	1084 MLI @ CAN56P-122-H LC / 365/436
GLASS		

QA AUDIT:
COMPACT#: MASK PKGMLD 6025 SBL RED) CLEAR 6" MULTIBOX WITH SHELF
ATTACHMENTS:
PACKAGING-All-All-PDF COFC - EMAIL
PACKAGING-All-All-PDF COFC - HARD COPY
PACKAGING-1-All-COFO COMPACT LABEL
REGISTRATIONS-All-All-Registration Results - Email
REGISTRATIONS-All-All-Registration Results - Hard Copy
AUDITOR: MUNGUIA, FERNANDO JR.
DATE: 17-AUG-2020 21:27:00

WAIVER(S):

COMMENTS:



ie# (1 / 1)
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ef.: Design data
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12:13AM, Sunday, August 16, 2020
Raw data Grid : LMS IPRO
Grid : NIST

istec LMS IPRO Registration (dev)
8/16/2020 12:36 AM
D : Running Automatically
udit Trail : \\usrrrs01\common\MFG\RR\Regis\RR_JOBS_backup\Template\Default-12.adt

275737m1.na0

Site#	X [nm]	Site#	Y [nm]
1	-2.85	1	-2.90
2	-8.18	2	2.20
3	5.04	3	12.94
4	-4.46	4	11.91
5	-15.16	5	9.04
6	-3.77	6	6.80
7	-12.69	7	0.51
8	-6.06	8	2.93
9	4.46	9	3.74
10	3.70	10	2.07
11	16.56	11	0.89
12	6.67	12	-1.98
13	13.45	13	-13.60
14	2.69	14	-15.70
15	-3.28	15	-8.55
16	3.87	16	-10.29

ummary

	X [nm]	Y [nm]
ean	-0.00	0.00
ax 3 S.D.	26.02	25.61
in	-15.16	-15.70
ax	16.56	12.94

cales [ppm]
1 : -0.250 / -0.294

rthogonality [10^-6 rad]
1 : 0.340
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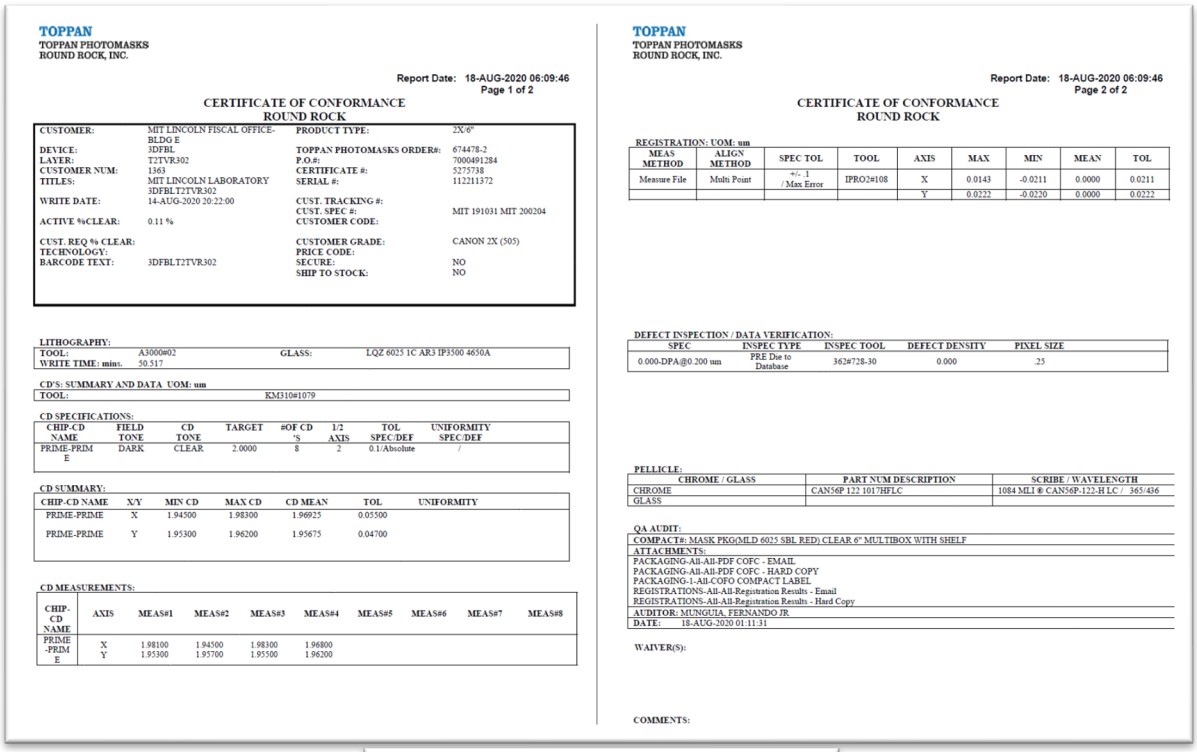
Layer 302 – T2TV (Tier 2 Top Via)



TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 18-AUG-2020 06:09:46
Page 1 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

CUSTOMER:	MIT LINCOLN FISCAL OFFICE-BLDG E	PRODUCT TYPE:	2X/6"
DEVICE:	3DFBL	TOPPAN PHOTOMASKS ORDER#:	674478-2
LAYER:	T2TVR302	P.O.#:	7000491284
CUSTOMER NUM:	1363	CERTIFICATE #:	5275738
TITLES:	MIT LINCOLN LABORATORY 3DFBLT2TVR302	SERIAL #:	112211372
WRITE DATE:	14-AUG-2020 20:22:00	CUST. TRACKING #:	
		CUST. SPEC #:	MIT 191031 MIT 200204
ACTIVE %CLEAR:	0.11 %	CUSTOMER CODE:	
CUST. REQ % CLEAR:		CUSTOMER GRADE:	CANON 2X (505)
TECHNOLOGY:		PRICE CODE:	
BARCODE TEXT:	3DFBLT2TVR302	SECURE:	NO
		SHIP TO STOCK:	NO

LITHOGRAPHY:

TOOL:	A3000#02	GLASS:	LQZ 6025 1C AR3 IP3500 4650A
WRITE TIME: mins.	50.517		

CD'S: SUMMARY AND DATA UOM: um

TOOL:	KM310#1079

CD SPECIFICATIONS:

CHIP-CD NAME	FIELD TONE	CD TONE	TARGET	#OF CD 'S	1/2 AXIS	TOL SPEC/DEF	UNIFORMITY SPEC/DEF
PRIME-PRIME	DARK	CLEAR	2.0000	8	2	0.1/Absolute	/

CD SUMMARY:

CHIP-CD NAME	X/Y	MIN CD	MAX CD	CD MEAN	TOL	UNIFORMITY
PRIME-PRIME	X	1.94500	1.98300	1.96925	0.05500	
PRIME-PRIME	Y	1.95300	1.96200	1.95675	0.04700	

CD MEASUREMENTS:

CHIP-CD NAME	AXIS	MEAS#1	MEAS#2	MEAS#3	MEAS#4	MEAS#5	MEAS#6	MEAS#7	MEAS#8
PRIME-PRIME	X	1.98100	1.94500	1.98300	1.96800				
	Y	1.95300	1.95700	1.95500	1.96200				

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TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 18-AUG-2020 06:09:46
Page 2 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

REGISTRATION: UOM: um

MEAS METHOD	ALIGN METHOD	SPEC TOL	TOOL	AXIS	MAX	MIN	MEAN	TOL
Measure File	Multi Point	+/- .1 / Max Error	IPRO2#108	X	0.0143	-0.0211	0.0000	0.0211
				Y	0.0222	-0.0220	0.0000	0.0222

DEFECT INSPECTION / DATA VERIFICATION:

SPEC	INSPEC TYPE	INSPEC TOOL	DEFECT DENSITY	PIXEL SIZE
0.000-DPA@0.200 um	PRE Die to Database	362#728-30	0.000	.25

PELLICLE:

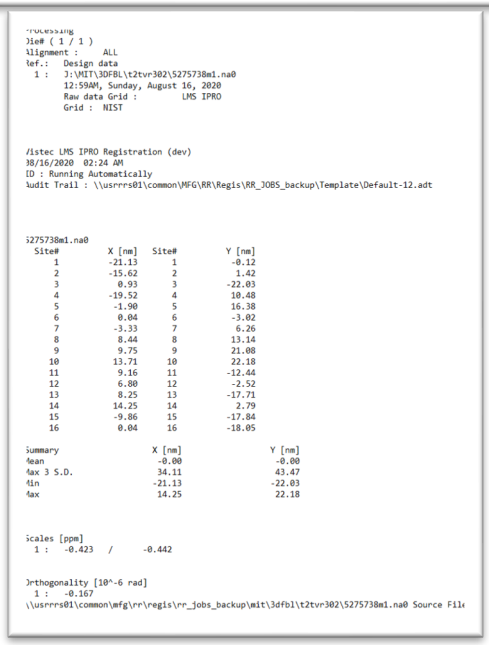
CHROME / GLASS	PART NUM DESCRIPTION	SCRIBE / WAVELENGTH
CHROME	CAN56P 122 1017HFLC	1084 MLI ® CAN56P-122-H LC / 365/436
GLASS		

QA AUDIT:

COMPACT#:	MASK PKG(MLD 6025 SBL RED) CLEAR 6" MULTIBOX WITH SHELF
ATTACHMENTS:	
	PACKAGING-All-All-PDF COFC - EMAIL
	PACKAGING-All-All-PDF COFC - HARD COPY
	PACKAGING-1-All-COFO COMPACT LABEL
	REGISTRATIONS-All-All-Registration Results - Email
	REGISTRATIONS-All-All-Registration Results - Hard Copy
AUDITOR:	MUNGUIA, FERNANDO JR
DATE:	18-AUG-2020 01:11:31

WAIVER(S):

COMMENTS:



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Processing
Die# ( 1 / 1 )
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Ref.:   Design data
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        12:59AM, Sunday, August 16, 2020
        Raw data Grid :          LMS IPRO
        Grid :  NIST


Wistec LMS IPRO Registration (dev)
08/16/2020  02:24 AM
MD : Running Automatically
Audit Trail : \\usrrrs01\common\MFG\RR\Regis\RR_JOBS_backup\Template\Default-12.adt


5275738m1.na0
  Site#          X [nm]   Site#          Y [nm]
      1          -21.13       1           -0.12
      2          -15.62       2            1.42
      3            0.93       3          -22.03
      4          -19.52       4           10.48
      5           -1.90       5           16.38
      6            0.04       6           -3.02
      7           -3.33       7            6.26
      8            8.44       8           13.14
      9            9.75       9           21.08
     10           13.71      10           22.18
     11            9.16      11          -12.44
     12            6.80      12           -2.52
     13            8.25      13          -17.71
     14           14.25      14            2.79
     15           -9.86      15          -17.84
     16            0.04      16          -18.05

Summary                X [nm]               Y [nm]
Mean                    -0.00                -0.00
Max 3 S.D.              34.11                43.47
Min                    -21.13               -22.03
Max                     14.25                22.18


Scales [ppm]
  1 :   -0.423   /      -0.442


Orthogonality [10^-6 rad]
  1 :   -0.167
\\usrrrs01\common\mfg\rr\regis\rr_jobs_backup\mit\3dfbl\t2tvr302\5275738m1.na0 Source File
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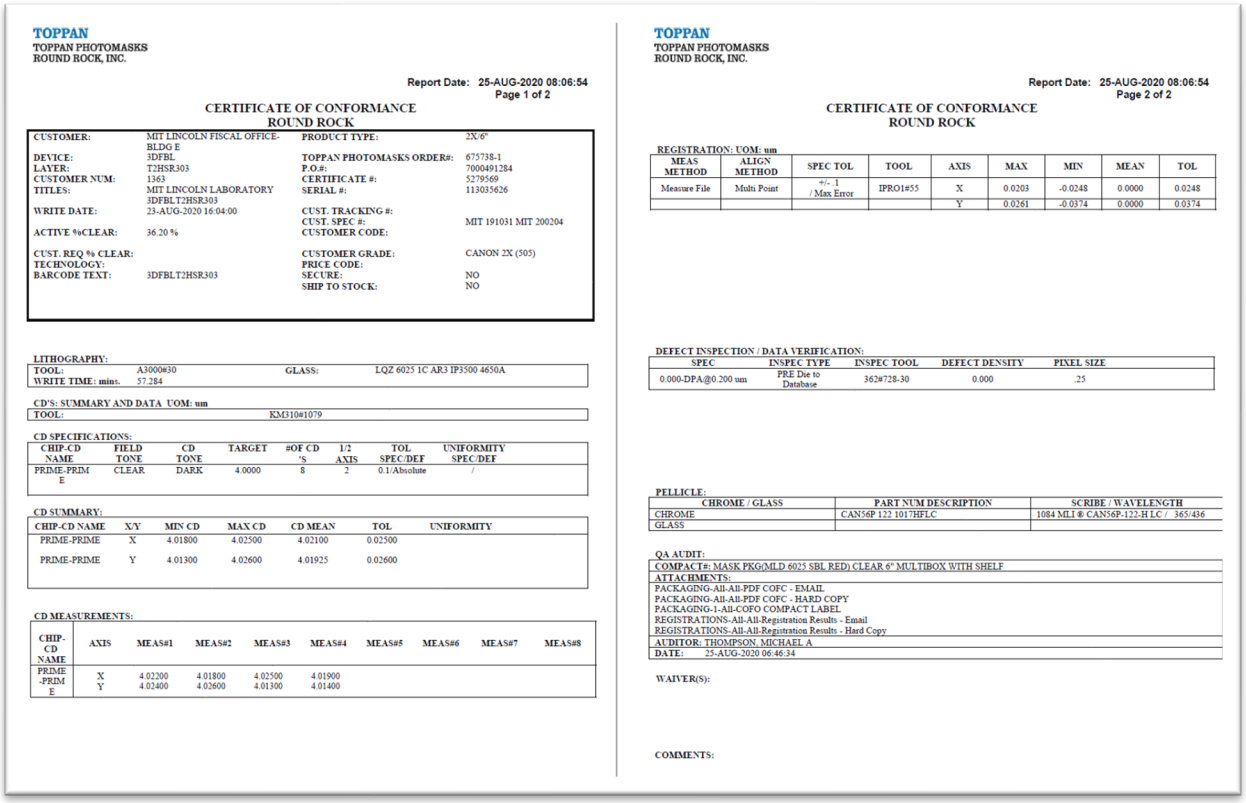
Layer 303 – T2HS (Tier 2 Hybrid Seed)



TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 25-AUG-2020 08:06:54
Page 1 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

CUSTOMER:	MIT LINCOLN FISCAL OFFICE-BLDG E	PRODUCT TYPE:	2X/6"
DEVICE:	3DFBL	TOPPAN PHOTOMASKS ORDER#:	675738-1
LAYER:	T2HSR303	P.O.#:	7000491284
CUSTOMER NUM:	1363	CERTIFICATE #:	5279569
TITLES:	MIT LINCOLN LABORATORY 3DFBLT2HSR303	SERIAL #:	113035626
WRITE DATE:	23-AUG-2020 16:04:00	CUST. TRACKING #:	
		CUST. SPEC #:	MIT 191031 MIT 200204
ACTIVE %CLEAR:	36.20 %	CUSTOMER CODE:	
CUST. REQ % CLEAR:		CUSTOMER GRADE:	CANON 2X (505)
TECHNOLOGY:		PRICE CODE:	
BARCODE TEXT:	3DFBLT2HSR303	SECURE:	NO
		SHIP TO STOCK:	NO

LITHOGRAPHY:

TOOL:	A3000#30	GLASS:	LQZ 6025 1C AR3 IP3500 4650A
WRITE TIME: mins.	57.284		

CD'S: SUMMARY AND DATA UOM: um

TOOL:	KM310#1079

CD SPECIFICATIONS:

CHIP-CD NAME	FIELD TONE	CD TONE	TARGET	#OF CD 'S	1/2 AXIS	TOL SPEC/DEF	UNIFORMITY SPEC/DEF
PRIME-PRIME	CLEAR	DARK	4.0000	8	2	0.1/Absolute	/

CD SUMMARY:

CHIP-CD NAME	X/Y	MIN CD	MAX CD	CD MEAN	TOL	UNIFORMITY
PRIME-PRIME	X	4.01800	4.02500	4.02100	0.02500	
PRIME-PRIME	Y	4.01300	4.02600	4.01925	0.02600	

CD MEASUREMENTS:

CHIP-CD NAME	AXIS	MEAS#1	MEAS#2	MEAS#3	MEAS#4	MEAS#5	MEAS#6	MEAS#7	MEAS#8
PRIME-PRIME	X	4.02200	4.01800	4.02500	4.01900				
	Y	4.02400	4.02600	4.01300	4.01400				

TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 25-AUG-2020 08:06:54
Page 2 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

REGISTRATION: UOM: um

MEAS METHOD	ALIGN METHOD	SPEC TOL	TOOL	AXIS	MAX	MIN	MEAN	TOL
Measure File	Multi Point	+/- 1 / Max Error	IPRO1#55	X	0.0203	-0.0248	0.0000	0.0248
				Y	0.0261	-0.0374	0.0000	0.0374

DEFECT INSPECTION / DATA VERIFICATION:

SPEC	INSPEC TYPE	INSPEC TOOL	DEFECT DENSITY	PIXEL SIZE
0.000-DPA@0.200 um	PRE Die to Database	362#728-30	0.000	.25

PELLICLE:

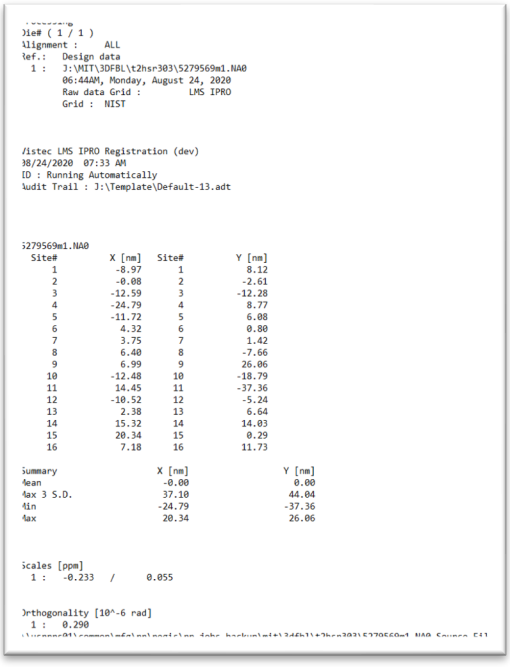
CHROME / GLASS	PART NUM DESCRIPTION	SCRIBE / WAVELENGTH
CHROME	CAN56P 122 1017HFLC	1084 MLI @ CAN56P-122-H LC / 365/436
GLASS		

QA AUDIT:

COMPACT#:	MASK PKG(MLD 6025 SBL RED) CLEAR 6" MULTIBOX WITH SHELF
ATTACHMENTS:	
	PACKAGING-All-All-PDF COFC - EMAIL
	PACKAGING-All-All-PDF COFC - HARD COPY
	PACKAGING-1-All-COFO COMPACT LABEL
	REGISTRATIONS-All-All-Registration Results - Email
	REGISTRATIONS-All-All-Registration Results - Hard Copy
AUDITOR:	THOMPSON, MICHAEL A
DATE:	25-AUG-2020 06:46:34

WAIVER(S):

COMMENTS:



)ie# (1 / 1)
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06:44AM, Monday, August 24, 2020
Raw data Grid : LMS IPRO
Grid : NIST

/istec LMS IPRO Registration (dev)
38/24/2020 07:33 AM
ID : Running Automatically
\udit Trail : J:\Template\Default-13.adt

5279569m1.NA0

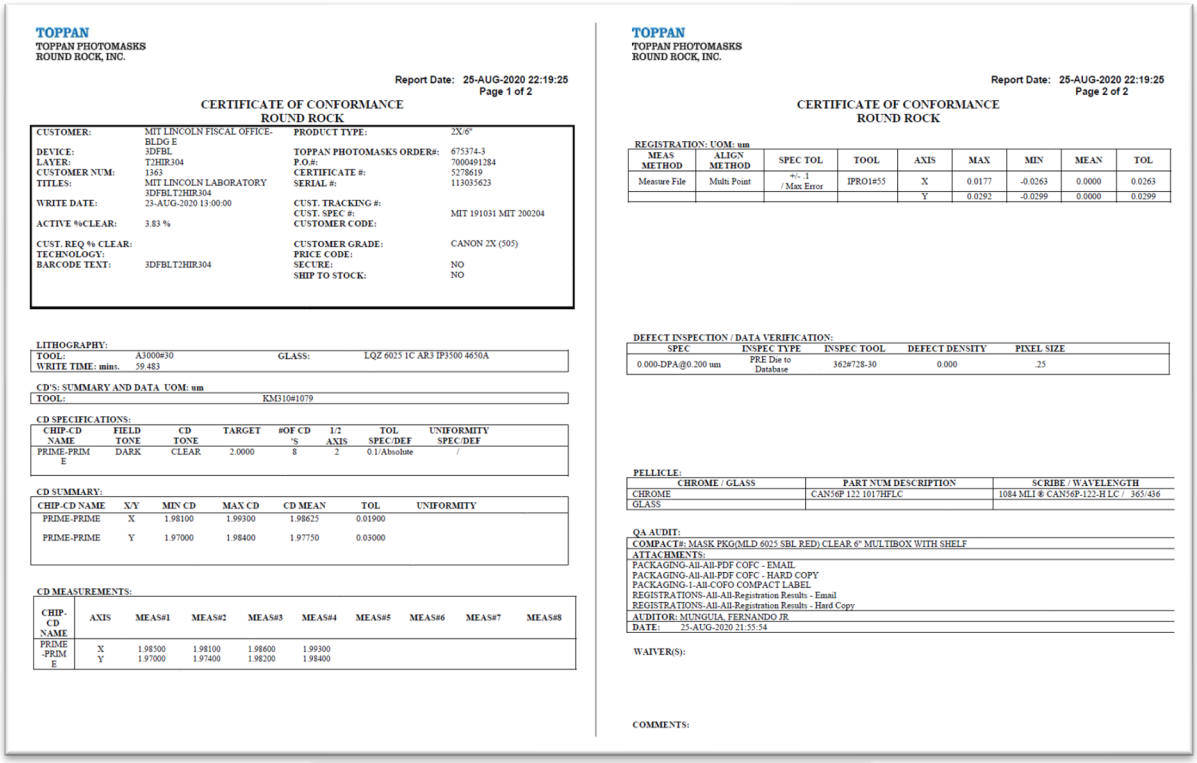
Site#	X [nm]	Site#	Y [nm]
1	-8.97	1	8.12
2	-0.08	2	-2.61
3	-12.59	3	-12.28
4	-24.79	4	8.77
5	-11.72	5	6.08
6	4.32	6	0.80
7	3.75	7	1.42
8	6.40	8	-7.66
9	6.99	9	26.06
10	-12.48	10	-18.79
11	14.45	11	-37.36
12	-10.52	12	-5.24
13	2.38	13	6.64
14	15.32	14	14.03
15	20.34	15	0.29
16	7.18	16	11.73

Summary	X [nm]	Y [nm]
Mean	-0.00	0.00
Max 3 S.D.	37.10	44.04
Min	-24.79	-37.36
Max	20.34	26.06

Scales [ppm]
1 : -0.233 / 0.055

Orthogonality [10^-6 rad]
1 : 0.290

Layer 304 – T2HI (Tier 2 Hybrid Interconnect)



TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 25-AUG-2020 22:19:25
Page 1 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

CUSTOMER:	MIT LINCOLN FISCAL OFFICE-BLDG E	PRODUCT TYPE:	2X/6"
DEVICE:	3DFBL	TOPPAN PHOTOMASKS ORDER#:	675374-3
LAYER:	T2HIR304	P.O.#:	7000491284
CUSTOMER NUM:	1363	CERTIFICATE #:	5278619
TITLES:	MIT LINCOLN LABORATORY 3DFBLT2HIR304	SERIAL #:	113035623
WRITE DATE:	23-AUG-2020 13:00:00	CUST. TRACKING #:	
		CUST. SPEC #:	MIT 191031 MIT 200204
ACTIVE %CLEAR:	3.83 %	CUSTOMER CODE:	
CUST. REQ % CLEAR:		CUSTOMER GRADE:	CANON 2X (505)
TECHNOLOGY:		PRICE CODE:	
BARCODE TEXT:	3DFBLT2HIR304	SECURE:	NO
		SHIP TO STOCK:	NO

LITHOGRAPHY:

TOOL:	A3000#30	GLASS:	LQZ 6025 1C AR3 IP3500 4650A
WRITE TIME: mins.	59.483		

CD'S: SUMMARY AND DATA UOM: um

TOOL:	KM310#1079

CD SPECIFICATIONS:

CHIP-CD NAME	FIELD TONE	CD TONE	TARGET	#OF CD 's	1/2 AXIS	TOL SPEC/DEF	UNIFORMITY SPEC/DEF
PRIME-PRIME	DARK	CLEAR	2.0000	8	2	0.1/Absolute	/

CD SUMMARY:

CHIP-CD NAME	X/Y	MIN CD	MAX CD	CD MEAN	TOL	UNIFORMITY
PRIME-PRIME	X	1.98100	1.99300	1.98625	0.01900	
PRIME-PRIME	Y	1.97000	1.98400	1.97750	0.03000	

CD MEASUREMENTS:

CHIP-CD NAME	AXIS	MEAS#1	MEAS#2	MEAS#3	MEAS#4	MEAS#5	MEAS#6	MEAS#7	MEAS#8
PRIME-PRIME	X	1.98500	1.98100	1.98600	1.99300				
	Y	1.97000	1.97400	1.98200	1.98400				

TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 25-AUG-2020 22:19:25
Page 2 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

REGISTRATION: UOM: um

MEAS METHOD	ALIGN METHOD	SPEC TOL	TOOL	AXIS	MAX	MIN	MEAN	TOL
Measure File	Multi Point	+/- 1 / Max Error	IPRO1#55	X	0.0177	-0.0263	0.0000	0.0263
				Y	0.0292	-0.0299	0.0000	0.0299

DEFECT INSPECTION / DATA VERIFICATION:

SPEC	INSPEC TYPE	INSPEC TOOL	DEFECT DENSITY	PIXEL SIZE
0.000-DPA@0.200 um	PRE Die to Database	362#728-30	0.000	.25

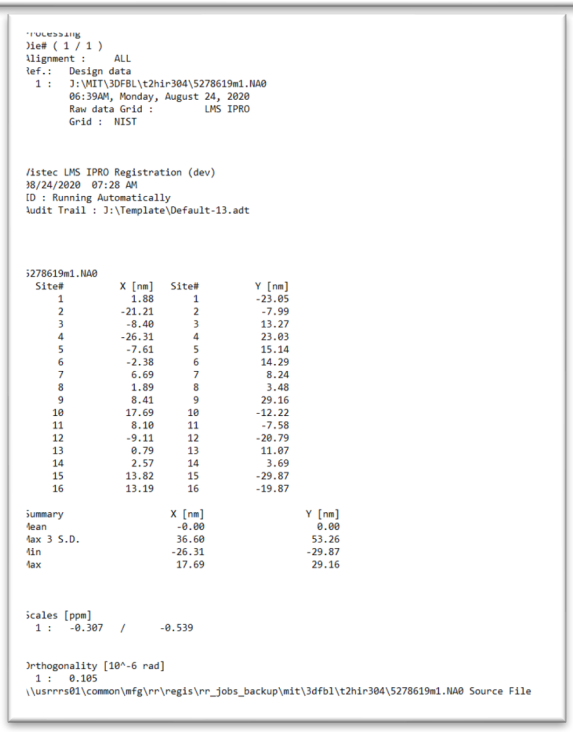
PELLICLE:

CHROME / GLASS	PART NUM DESCRIPTION	SCRIBE / WAVELENGTH
CHROME	CAN56P 122 1017HFLC	1084 MLI ® CAN56P-122-H LC / 365/436
GLASS		

QA AUDIT:
COMPACT#: MASK PKG(MLD 6025 SBL RED) CLEAR 6" MULTIBOX WITH SHELF
ATTACHMENTS:
PACKAGING-All-All-PDF COFC - EMAIL
PACKAGING-All-All-PDF COFC - HARD COPY
PACKAGING-1-All-COFO COMPACT LABEL
REGISTRATIONS-All-All-Registration Results - Email
REGISTRATIONS-All-All-Registration Results - Hard Copy
AUDITOR: MUNGUIA, FERNANDO JR
DATE: 25-AUG-2020 21:55:54

WAIVER(S):

COMMENTS:



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rocessing
)ie# ( 1 / 1 )
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        Grid :  NIST


/istec LMS IPRO Registration (dev)
)8/24/2020  07:28 AM
[D : Running Automatically
\udit Trail : J:\Template\Default-13.adt


5278619m1.NA0
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     1            1.88      1          -23.05
     2          -21.21      2           -7.99
     3           -8.40      3           13.27
     4          -26.31      4           23.03
     5           -7.61      5           15.14
     6           -2.38      6           14.29
     7            6.69      7            8.24
     8            1.89      8            3.48
     9            8.41      9           29.16
    10           17.69     10          -12.22
    11            8.10     11           -7.58
    12           -9.11     12          -20.79
    13            0.79     13           11.07
    14            2.57     14            3.69
    15           13.82     15          -29.87
    16           13.19     16          -19.87

Summary                   X [nm]              Y [nm]
Mean                       -0.00               0.00
Max 3 S.D.                 36.60              53.26
Min                       -26.31             -29.87
Max                        17.69              29.16


Scales [ppm]
  1 :   -0.307   /      -0.539


Orthogonality [10^-6 rad]
  1 :   0.105
\\usrrrs01\common\mfg\rr\regis\rr_jobs_backup\mit\3dfbl\t2hir304\5278619m1.NA0 Source File
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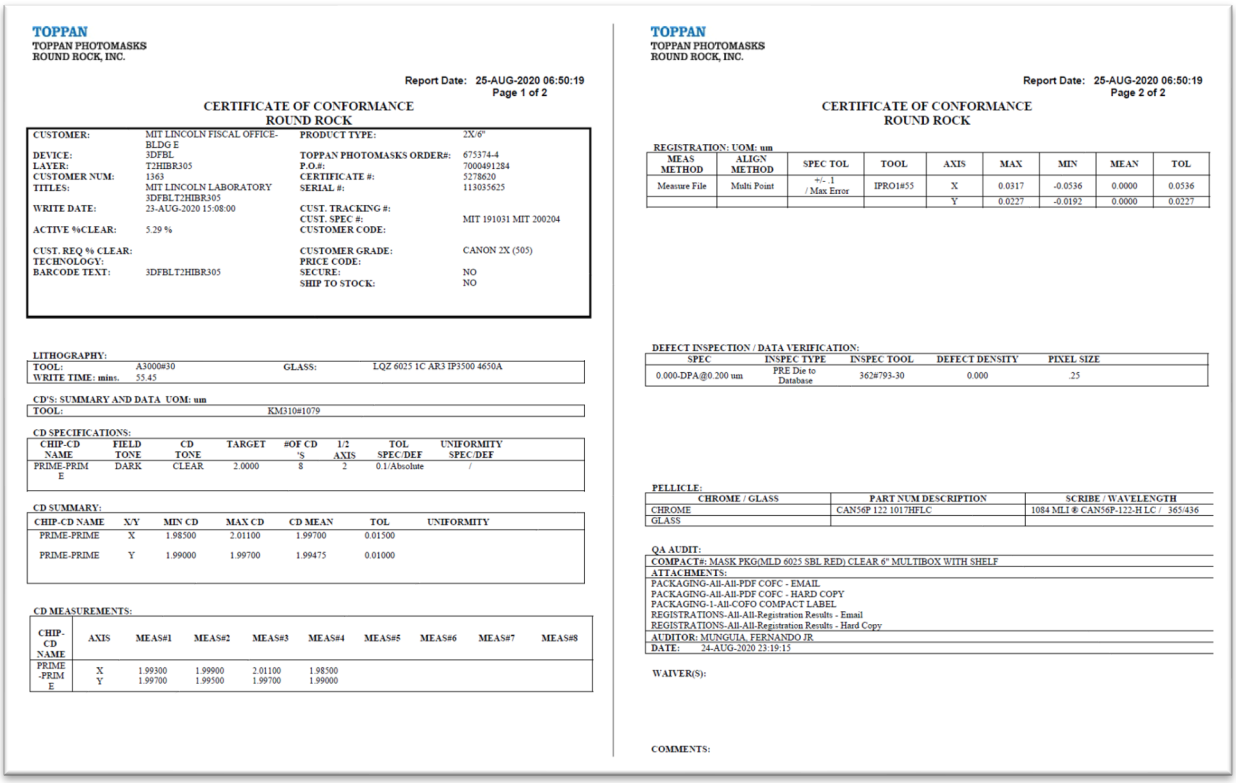
Layer 305 – T2HIB (Tier 2 Hybrid Interconnect B)



TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 25-AUG-2020 06:50:19
Page 1 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

CUSTOMER:	MIT LINCOLN FISCAL OFFICE-BLDG E	PRODUCT TYPE:	2X/6"
DEVICE:	3DFBL	TOPPAN PHOTOMASKS ORDER#:	675374-4
LAYER:	T2HIBR305	P.O.#:	7000491284
CUSTOMER NUM:	1363	CERTIFICATE #:	5278620
TITLES:	MIT LINCOLN LABORATORY 3DFBLT2HIBR305	SERIAL #:	113035625
WRITE DATE:	23-AUG-2020 15:08:00	CUST. TRACKING #:	
		CUST. SPEC #:	MIT 191031 MIT 200204
ACTIVE %CLEAR:	5.29 %	CUSTOMER CODE:	
CUST. REQ % CLEAR:		CUSTOMER GRADE:	CANON 2X (505)
TECHNOLOGY:		PRICE CODE:	
BARCODE TEXT:	3DFBLT2HIBR305	SECURE:	NO
		SHIP TO STOCK:	NO

LITHOGRAPHY:

TOOL:	A3000#30	GLASS:	LQZ 6025 1C AR3 IP3500 4650A
WRITE TIME: mins.	55.45		

CD'S: SUMMARY AND DATA UOM: um

TOOL:	KM310#1079

CD SPECIFICATIONS:

CHIP-CD NAME	FIELD TONE	CD TONE	TARGET	#OF CD 'S	1/2 AXIS	TOL SPEC/DEF	UNIFORMITY SPEC/DEF
PRIME-PRIME	DARK	CLEAR	2.0000	8	2	0.1/Absolute	/

CD SUMMARY:

CHIP-CD NAME	X/Y	MIN CD	MAX CD	CD MEAN	TOL	UNIFORMITY
PRIME-PRIME	X	1.98500	2.01100	1.99700	0.01500	
PRIME-PRIME	Y	1.99000	1.99700	1.99475	0.01000	

CD MEASUREMENTS:

CHIP-CD NAME	AXIS	MEAS#1	MEAS#2	MEAS#3	MEAS#4	MEAS#5	MEAS#6	MEAS#7	MEAS#8
PRIME-PRIME	X	1.99300	1.99900	2.01100	1.98500				
	Y	1.99700	1.99500	1.99700	1.99000				

TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 25-AUG-2020 06:50:19
Page 2 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

REGISTRATION: UOM: um

MEAS METHOD	ALIGN METHOD	SPEC TOL	TOOL	AXIS	MAX	MIN	MEAN	TOL
Measure File	Multi Point	+/- 1 / Max Error	IPRO1#55	X	0.0317	-0.0536	0.0000	0.0536
				Y	0.0227	-0.0192	0.0000	0.0227

DEFECT INSPECTION / DATA VERIFICATION:

SPEC	INSPEC TYPE	INSPEC TOOL	DEFECT DENSITY	PIXEL SIZE
0.000-DPA@0.200 um	PRE Die to Database	362#793-30	0.000	.25

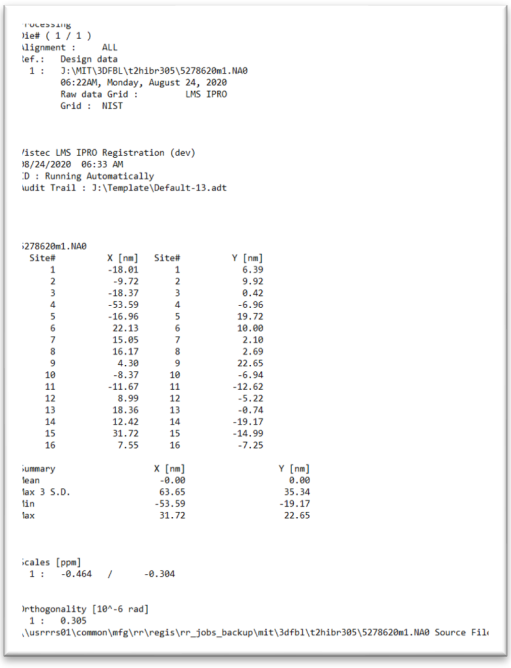
PELLICLE:

CHROME / GLASS	PART NUM DESCRIPTION	SCRIBE / WAVELENGTH
CHROME	CAN56P 122 1017HFLC	1084 MLI ® CAN56P-122-H LC / 365/436
GLASS		

QA AUDIT:
COMPACT#: MASK PKG(MLD 6025 SBL RED) CLEAR 6" MULTIBOX WITH SHELF
ATTACHMENTS:
PACKAGING-All-All-PDF COFC - EMAIL
PACKAGING-All-All-PDF COFC - HARD COPY
PACKAGING-1-All-COFO COMPACT LABEL
REGISTRATIONS-All-All-Registration Results - Email
REGISTRATIONS-All-All-Registration Results - Hard Copy
AUDITOR: MUNGUIA, FERNANDO JR
DATE: 24-AUG-2020 23:19:15

WAIVER(S):

COMMENTS:



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rocessing
)ie# ( 1 / 1 )
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        06:22AM, Monday, August 24, 2020
        Raw data Grid :          LMS IPRO
        Grid :  NIST


/istec LMS IPRO Registration (dev)
)8/24/2020  06:33 AM
:D : Running Automatically
udit Trail : J:\Template\Default-13.adt



:278620m1.NA0
  Site#          X [nm]   Site#          Y [nm]
     1          -18.01       1            6.39
     2           -9.72       2            9.92
     3          -18.37       3            0.42
     4          -53.59       4           -6.96
     5          -16.96       5           19.72
     6           22.13       6           10.00
     7           15.05       7            2.10
     8           16.17       8            2.69
     9            4.30       9           22.65
    10           -8.37      10           -6.94
    11          -11.67      11          -12.62
    12            8.99      12           -5.22
    13           18.36      13           -0.74
    14           12.42      14          -19.17
    15           31.72      15          -14.99
    16            7.55      16           -7.25

ummary                  X [nm]                 Y [nm]
lean                      -0.00                  0.00
lax 3 S.D.                63.65                 35.34
lin                      -53.59                -19.17
lax                       31.72                 22.65


:cales [ppm]
 1 :   -0.464   /      -0.304


rthogonality [10^-6 rad]
 1 :   0.305
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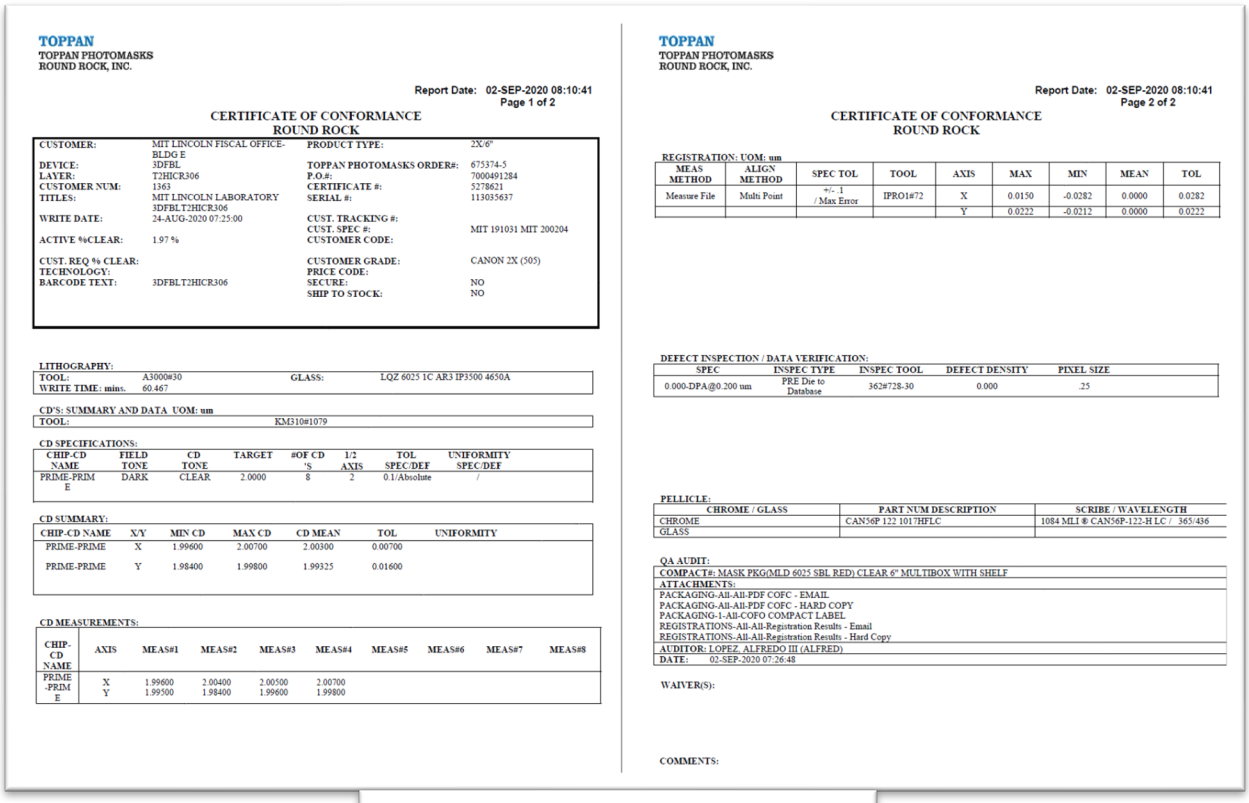
Layer 306 – T2HIC (Tier 2 Hybrid Interconnect C)



TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 02-SEP-2020 08:10:41
Page 1 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

CUSTOMER:	MIT LINCOLN FISCAL OFFICE-BLDG E	PRODUCT TYPE:	2X/6"
DEVICE:	3DFBL	TOPPAN PHOTOMASKS ORDER#:	675374-5
LAYER:	T2HICR306	P.O.#:	7000491284
CUSTOMER NUM:	1363	CERTIFICATE #:	5278621
TITLES:	MIT LINCOLN LABORATORY 3DFBLT2HICR306	SERIAL #:	113035637
WRITE DATE:	24-AUG-2020 07:25:00	CUST. TRACKING #:	
		CUST. SPEC #:	MIT 191031 MIT 200204
ACTIVE %CLEAR:	1.97 %	CUSTOMER CODE:	
CUST. REQ % CLEAR:		CUSTOMER GRADE:	CANON 2X (505)
TECHNOLOGY:		PRICE CODE:	
BARCODE TEXT:	3DFBLT2HICR306	SECURE:	NO
		SHIP TO STOCK:	NO

LITHOGRAPHY:

TOOL:	A3000#30	GLASS:	LQZ 6025 1C AR3 IP3500 4650A
WRITE TIME: mins.	60.467		

CD'S: SUMMARY AND DATA UOM: um

TOOL:	KM310#1079

CD SPECIFICATIONS:

CHIP-CD NAME	FIELD TONE	CD TONE	TARGET	#OF CD 'S	1/2 AXIS	TOL SPEC/DEF	UNIFORMITY SPEC/DEF
PRIME-PRIME	DARK	CLEAR	2.0000	8	2	0.1/Absolute	/

CD SUMMARY:

CHIP-CD NAME	X/Y	MIN CD	MAX CD	CD MEAN	TOL	UNIFORMITY
PRIME-PRIME	X	1.99600	2.00700	2.00300	0.00700	
PRIME-PRIME	Y	1.98400	1.99800	1.99325	0.01600	

CD MEASUREMENTS:

CHIP-CD NAME	AXIS	MEAS#1	MEAS#2	MEAS#3	MEAS#4	MEAS#5	MEAS#6	MEAS#7	MEAS#8
PRIME-PRIME	X	1.99600	2.00400	2.00500	2.00700				
	Y	1.99500	1.98400	1.99600	1.99800				

TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 02-SEP-2020 08:10:41
Page 2 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

REGISTRATION: UOM: um

MEAS METHOD	ALIGN METHOD	SPEC TOL	TOOL	AXIS	MAX	MIN	MEAN	TOL
Measure File	Multi Point	+/- .1 / Max Error	IPRO1#72	X	0.0150	-0.0282	0.0000	0.0282
				Y	0.0222	-0.0212	0.0000	0.0222

DEFECT INSPECTION / DATA VERIFICATION:

SPEC	INSPEC TYPE	INSPEC TOOL	DEFECT DENSITY	PIXEL SIZE
0.000-DPA@0.200 um	PRE Die to Database	362#728-30	0.000	.25

PELLICLE:

CHROME / GLASS	PART NUM DESCRIPTION	SCRIBE / WAVELENGTH
CHROME	CAN56P 122 1017HFLC	1084 MLI ® CAN56P-122-H LC / 365/436
GLASS		

QA AUDIT:

COMPACT#: MASK PKG(MLD 6025 SBL RED) CLEAR 6" MULTIBOX WITH SHELF

ATTACHMENTS:

PACKAGING-All-All-PDF COFC - EMAIL
PACKAGING-All-All-PDF COFC - HARD COPY
PACKAGING-1-All-COFO COMPACT LABEL
REGISTRATIONS-All-All-Registration Results - Email
REGISTRATIONS-All-All-Registration Results - Hard Copy

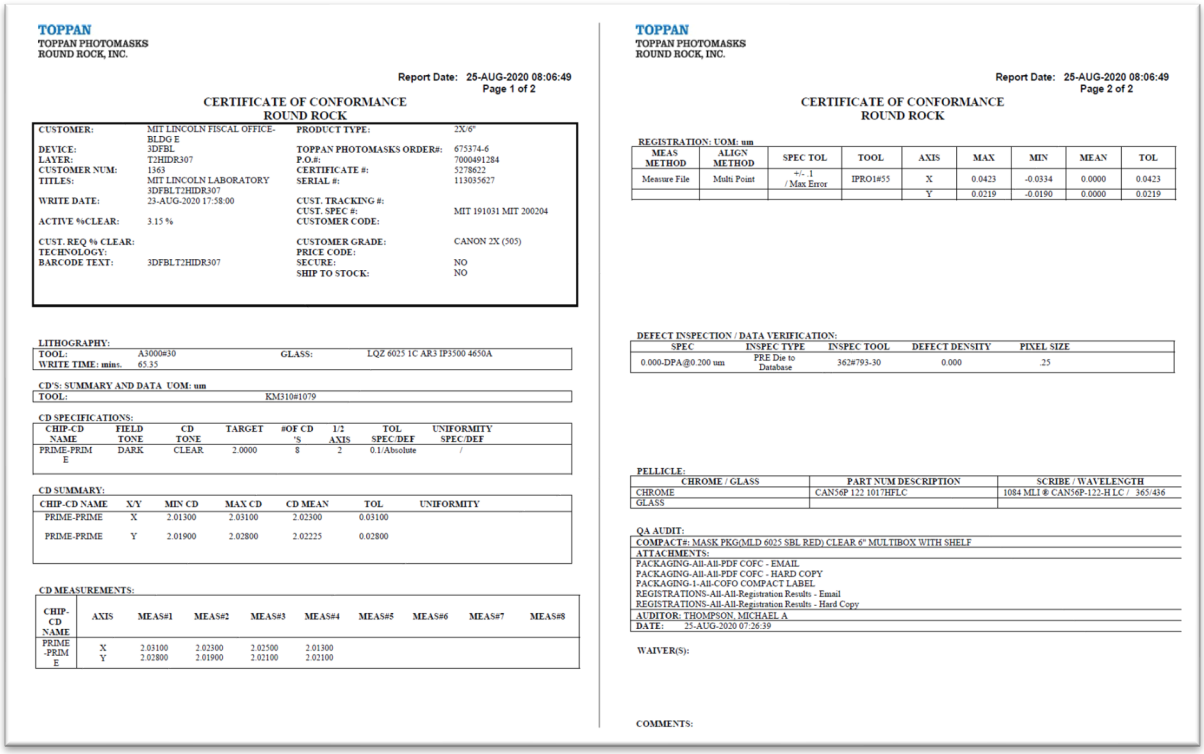
AUDITOR: LOPEZ, ALFREDO III (ALFRED)
DATE: 02-SEP-2020 07:26:48

WAIVER(S):

COMMENTS:

```
Processing
Die# ( 1 / 1 )
Alignment :     ALL
Ref.:   Design data
  1 :   J:\MIT\3DFBL\t2hicr306\5278621m1.NA0
        10:13AM, Tuesday, August 25, 2020
        Raw data Grid :          LMS IPRO
        Grid :  NIST


Mistec LMS IPRO Registration (dev)
08/25/2020  10:26 AM
MD : Running Automatically
Audit Trail : J:\Template\Default-41.adt


5278621m1.NA0
  Site#          X [nm]   Site#          Y [nm]
     1          -15.29        1            0.92
     2           -7.25        2          -12.45
     3           -7.63        3           -2.76
     4          -28.21        4            3.94
     5           -9.95        5           -6.77
     6           10.60        6           -8.96
     7           13.07        7           -6.73
     8           14.95        8           -0.83
     9            7.29        9            7.60
    10            1.08       10          -21.24
    11           -0.89       11           -9.57
    12            9.30       12            2.17
    13            2.08       13           22.17
    14           -2.19       14           11.44
    15           12.27       15           12.47
    16            0.78       16            8.62

Summary                  X [nm]                Y [nm]
Mean                       0.00                  0.00
Max 3 S.D.                35.05                 32.94
Min                      -28.21                -21.24
Max                       14.95                 22.17


Scales [ppm]
  1 :   -0.320   /      0.272


Orthogonality [10^-6 rad]
  1 :   -0.173
\\usrrrs01\common\mfg\rr\regis\rr_jobs_backup\mit\3dfbl\t2hicr306\5278621m1.NA0 Source File
```

Layer 307 – T3HID (Tier 2 Hybrid Interconnect D)



TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 25-AUG-2020 08:06:49
Page 1 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

CUSTOMER:	MIT LINCOLN FISCAL OFFICE-BLDG E	PRODUCT TYPE:	2X/6"
DEVICE:	3DFBL	TOPPAN PHOTOMASKS ORDER#:	675374-6
LAYER:	T2HIDR307	P.O.#:	7000491284
CUSTOMER NUM:	1361	CERTIFICATE #:	5278622
TITLES:	MIT LINCOLN LABORATORY 3DFBLT2HIDR307	SERIAL #:	113035627
WRITE DATE:	23-AUG-2020 17:58:00	CUST. TRACKING #:	
ACTIVE %CLEAR:	3.15 %	CUST. SPEC #:	MIT 191031 MIT 200204
CUST. REQ % CLEAR:		CUSTOMER CODE:	
TECHNOLOGY:		CUSTOMER GRADE:	CANON 2X (505)
BARCODE TEXT:	3DFBLT2HIDR307	PRICE CODE:	
		SECURE:	NO
		SHIP TO STOCK:	NO

LITHOGRAPHY:

TOOL:	A3000#30	GLASS:	LQZ 6025 1C AR3 IP3500 4650A
WRITE TIME: mins.	65.35		

CD'S: SUMMARY AND DATA UOM: um

TOOL:	KM310#1079

CD SPECIFICATIONS:

CHIP-CD NAME	FIELD TONE	CD TONE	TARGET	#OF CD 'S	1/2 AXIS	TOL SPEC/DEF	UNIFORMITY SPEC/DEF
PRIME-PRIME	DARK	CLEAR	2.0000	8	2	0.1/Absolute	/

CD SUMMARY:

CHIP-CD NAME	X/Y	MIN CD	MAX CD	CD MEAN	TOL	UNIFORMITY
PRIME-PRIME	X	2.01300	2.03100	2.02300	0.03100	
PRIME-PRIME	Y	2.01900	2.02800	2.02225	0.02800	

CD MEASUREMENTS:

CHIP-CD NAME	AXIS	MEAS#1	MEAS#2	MEAS#3	MEAS#4	MEAS#5	MEAS#6	MEAS#7	MEAS#8
PRIME-PRIME	X	2.03100	2.02300	2.02500	2.01300				
	Y	2.02800	2.01900	2.02100	2.02100				

TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 25-AUG-2020 08:06:49
Page 2 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

REGISTRATION: UOM: um

MEAS METHOD	ALIGN METHOD	SPEC TOL	TOOL	AXIS	MAX	MIN	MEAN	TOL
Measure File	Multi Point	+/- 1 / Max Error	IPRO1#55	X	0.0423	-0.0334	0.0000	0.0423
				Y	0.0219	-0.0190	0.0000	0.0219

DEFECT INSPECTION / DATA VERIFICATION:

SPEC	INSPEC TYPE	INSPEC TOOL	DEFECT DENSITY	PIXEL SIZE
0.000-DPA@0.200 um	PRE Die to Database	362#793-30	0.000	.25

PELLICLE:

CHROME / GLASS	PART NUM DESCRIPTION	SCRIBE / WAVELENGTH
CHROME	CAN56P 122 1017HFLC	1084 MLI @ CAN56P-122-H LC / 365/436
GLASS		

QA AUDIT:

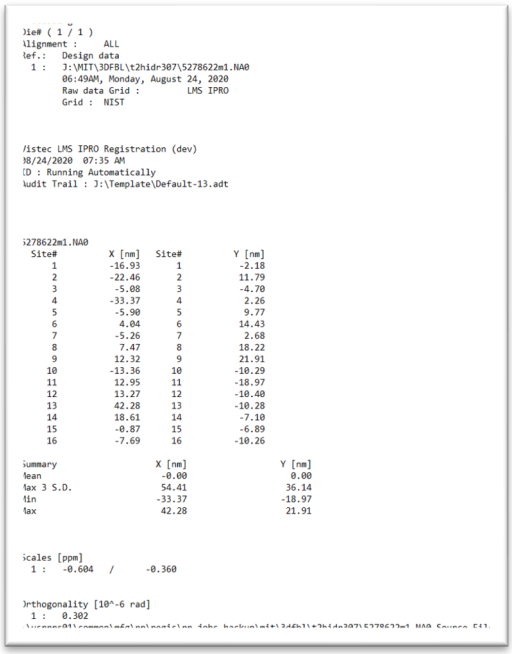
COMPACT#: MASK PKG(MLD 6025 SBL RED) CLEAR 6" MULTIBOX WITH SHELF

ATTACHMENTS:
PACKAGING-All-All-PDF COFC - EMAIL
PACKAGING-All-All-PDF COFC - HARD COPY
PACKAGING-1-All-COFO COMPACT LABEL
REGISTRATIONS-All-All-Registration Results - Email
REGISTRATIONS-All-All-Registration Results - Hard Copy

AUDITOR: THOMPSON, MICHAEL A
DATE: 25-AUG-2020 07:26:39

WAIVER(S):

COMMENTS:



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)ie# ( 1 / 1 )
\lignment :     ALL
lef.:   Design data
  1 :   J:\MIT\3DFBL\t2hidr307\5278622m1.NA0
        06:49AM, Monday, August 24, 2020
        Raw data Grid :          LMS IPRO
        Grid :  NIST


/istec LMS IPRO Registration (dev)
)8/24/2020  07:35 AM
)D : Running Automatically
\udit Trail : J:\Template\Default-13.adt

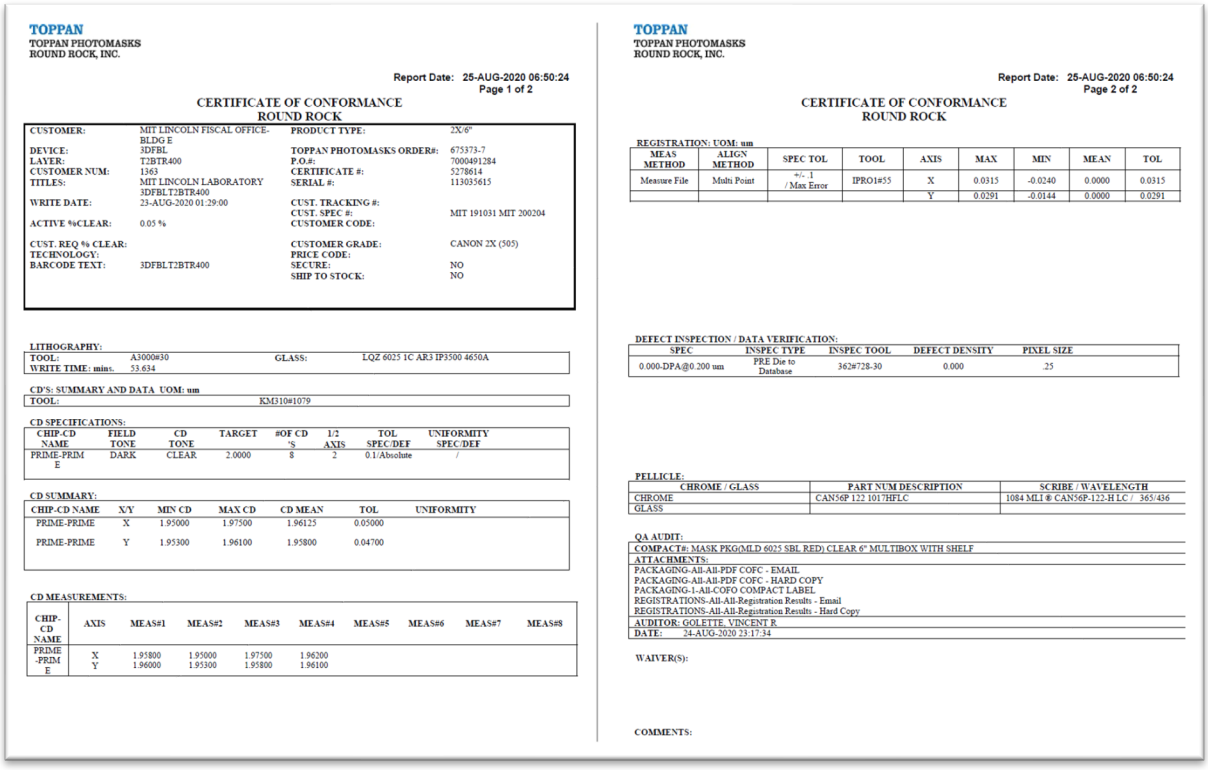

)278622m1.NA0
  Site#          X [nm]    Site#          Y [nm]
      1          -16.93        1          -2.18
      2          -22.46        2          11.79
      3           -5.08        3          -4.70
      4          -33.37        4           2.26
      5           -5.90        5           9.77
      6            4.04        6          14.43
      7           -5.26        7           2.68
      8            7.47        8          18.22
      9           12.32        9          21.91
     10          -13.36       10         -10.29
     11          12.95        11         -18.97
     12          13.27        12         -10.40
     13          42.28        13         -10.28
     14          18.61        14          -7.10
     15          -0.87        15          -6.89
     16          -7.69        16         -10.26

\ummary                  X [nm]                 Y [nm]
\lean                     -0.00                  0.00
\ax 3 S.D.                54.41                 36.14
\in                      -33.37                -18.97
\ax                       42.28                 21.91


)cales [ppm]
  1 :   -0.604   /      -0.360


)rthogonality [10^-6 rad]
  1 :   0.302
```

Layer 400 – T2BT (Tier 2 Backside Target)



TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 25-AUG-2020 06:50:24
Page 1 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

CUSTOMER:	MIT LINCOLN FISCAL OFFICE-BLDG E	PRODUCT TYPE:	2X/6"
DEVICE:	3DFBL	TOPPAN PHOTOMASKS ORDER#:	675373-7
LAYER:	T2BTR400	P.O.#:	7000491284
CUSTOMER NUM:	1363	CERTIFICATE #:	5278614
TITLES:	MIT LINCOLN LABORATORY 3DFBLT2BTR400	SERIAL #:	113035615
WRITE DATE:	23-AUG-2020 01:29:00	CUST. TRACKING #:	
		CUST. SPEC #:	MIT 191031 MIT 200204
ACTIVE %CLEAR:	0.05 %	CUSTOMER CODE:	
CUST. REQ % CLEAR:		CUSTOMER GRADE:	CANON 2X (505)
TECHNOLOGY:		PRICE CODE:	
BARCODE TEXT:	3DFBLT2BTR400	SECURE:	NO
		SHIP TO STOCK:	NO

LITHOGRAPHY:

TOOL:	A3000#30	GLASS:	LQZ 6025 1C AR3 IP3500 4650A
WRITE TIME: mins.	53.634		

CD'S: SUMMARY AND DATA UOM: um

TOOL:	KM310#1079

CD SPECIFICATIONS:

CHIP-CD NAME	FIELD TONE	CD TONE	TARGET	#OF CD 'S	1/2 AXIS	TOL SPEC/DEF	UNIFORMITY SPEC/DEF
PRIME-PRIME	DARK	CLEAR	2.0000	8	2	0.1/Absolute	/

CD SUMMARY:

CHIP-CD NAME	X/Y	MIN CD	MAX CD	CD MEAN	TOL	UNIFORMITY
PRIME-PRIME	X	1.95000	1.97500	1.96125	0.05000	
PRIME-PRIME	Y	1.95300	1.96100	1.95800	0.04700	

CD MEASUREMENTS:

CHIP-CD NAME	AXIS	MEAS#1	MEAS#2	MEAS#3	MEAS#4	MEAS#5	MEAS#6	MEAS#7	MEAS#8
PRIME-PRIME	X	1.95800	1.95000	1.97500	1.96200				
	Y	1.96000	1.95300	1.95800	1.96100				

TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 25-AUG-2020 06:50:24
Page 2 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

REGISTRATION: UOM: um

MEAS METHOD	ALIGN METHOD	SPEC TOL	TOOL	AXIS	MAX	MIN	MEAN	TOL
Measure File	Multi Point	+/- .1 / Max Error	IPRO1#55	X	0.0315	-0.0240	0.0000	0.0315
				Y	0.0291	-0.0144	0.0000	0.0291

DEFECT INSPECTION / DATA VERIFICATION:

SPEC	INSPEC TYPE	INSPEC TOOL	DEFECT DENSITY	PIXEL SIZE
0.000-DPA@0.200 um	PRE Die to Database	362#728-30	0.000	.25

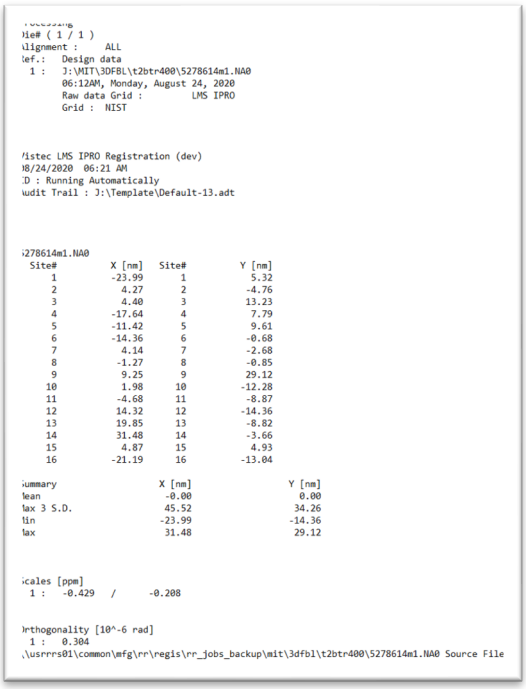
PELLICLE:

CHROME / GLASS	PART NUM DESCRIPTION	SCRIBE / WAVELENGTH
CHROME	CAN56P 122 1017HFLC	1084 MLI @ CAN56P-122-H LC / 365/436
GLASS		

QA AUDIT:
COMPACT#: MASK PKG(MLD 6025 SBL RED) CLEAR 6" MULTIBOX WITH SHELF
ATTACHMENTS:
PACKAGING-All-All-PDF COFC - EMAIL
PACKAGING-All-All-PDF COFC - HARD COPY
PACKAGING-1-All-COFO COMPACT LABEL
REGISTRATIONS-All-All-Registration Results - Email
REGISTRATIONS-All-All-Registration Results - Hard Copy
AUDITOR: GOLETTE, VINCENT R
DATE: 24-AUG-2020 23:17:34

WAIVER(S):

COMMENTS:



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Die# ( 1 / 1 )
Alignment :    ALL
Ref.:   Design data
  1 :   J:\MIT\3DFBL\t2btr400\5278614m1.NA0
        06:12AM, Monday, August 24, 2020
        Raw data Grid :          LMS IPRO
        Grid :  NIST


Vistec LMS IPRO Registration (dev)
08/24/2020  06:21 AM
JD : Running Automatically
Audit Trail : J:\Template\Default-13.adt


5278614m1.NA0
  Site#          X [nm]   Site#          Y [nm]
     1          -23.99       1           5.32
     2            4.27       2          -4.76
     3            4.40       3          13.23
     4          -17.64       4           7.79
     5          -11.42       5           9.61
     6          -14.36       6          -0.68
     7            4.14       7          -2.68
     8           -1.27       8          -0.85
     9            9.25       9          29.12
    10            1.98      10         -12.28
    11           -4.68      11          -8.87
    12           14.32      12         -14.36
    13           19.85      13          -8.82
    14           31.48      14          -3.66
    15            4.87      15           4.93
    16          -21.19      16         -13.04

Summary                  X [nm]                Y [nm]
Mean                      -0.00                 0.00
Max 3 S.D.                45.52                34.26
Min                      -23.99               -14.36
Max                       31.48                29.12


Scales [ppm]
  1 :   -0.429   /      -0.208


Orthogonality [10^-6 rad]
  1 :   0.304
.\usrrrs01\common\mfg\rr\regis\rr_jobs_backup\mit\3dfbl\t2btr400\5278614m1.NA0 Source File
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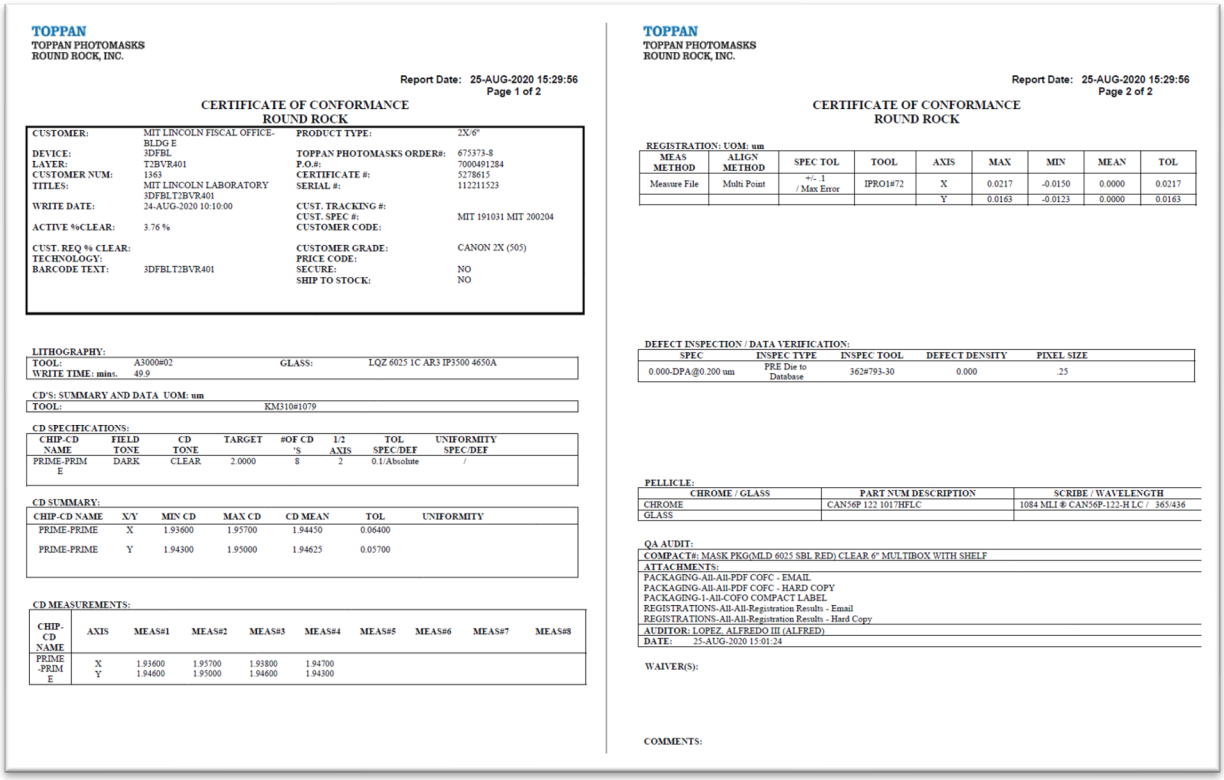
Layer 401 – T2BV (Tier 2 Backside Via)



TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 25-AUG-2020 15:29:56
Page 1 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

CUSTOMER:	MIT LINCOLN FISCAL OFFICE-BLDG E	PRODUCT TYPE:	2X/6"
DEVICE:	3DFBL	TOPPAN PHOTOMASKS ORDER#:	675373-8
LAYER:	T2BVR401	P.O.#:	7000491284
CUSTOMER NUM:	1363	CERTIFICATE #:	5278615
TITLES:	MIT LINCOLN LABORATORY 3DFBLT2BVR401	SERIAL #:	112211523
WRITE DATE:	24-AUG-2020 10:10:00	CUST. TRACKING #:	
		CUST. SPEC #:	MIT 191031 MIT 200204
ACTIVE %CLEAR:	3.76 %	CUSTOMER CODE:	
CUST. REQ % CLEAR:		CUSTOMER GRADE:	CANON 2X (505)
TECHNOLOGY:		PRICE CODE:	
BARCODE TEXT:	3DFBLT2BVR401	SECURE:	NO
		SHIP TO STOCK:	NO

LITHOGRAPHY:

TOOL:	A3000#02	GLASS:	LQZ 6025 1C AR3 IP3500 4650A
WRITE TIME: mins.	49.9		

CD'S: SUMMARY AND DATA UOM: um

TOOL:	KM310#1079

CD SPECIFICATIONS:

CHIP-CD NAME	FIELD TONE	CD TONE	TARGET	#OF CD 'S	1/2 AXIS	TOL SPEC/DEF	UNIFORMITY SPEC/DEF
PRIME-PRIME	DARK	CLEAR	2.0000	8	2	0.1/Absolute	/

CD SUMMARY:

CHIP-CD NAME	X/Y	MIN CD	MAX CD	CD MEAN	TOL	UNIFORMITY
PRIME-PRIME	X	1.93600	1.95700	1.94450	0.06400	
PRIME-PRIME	Y	1.94300	1.95000	1.94625	0.05700	

CD MEASUREMENTS:

CHIP-CD NAME	AXIS	MEAS#1	MEAS#2	MEAS#3	MEAS#4	MEAS#5	MEAS#6	MEAS#7	MEAS#8
PRIME-PRIME	X	1.93600	1.95700	1.93800	1.94700				
	Y	1.94600	1.95000	1.94600	1.94300				

TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 25-AUG-2020 15:29:56
Page 2 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

REGISTRATION: UOM: um

MEAS METHOD	ALIGN METHOD	SPEC TOL	TOOL	AXIS	MAX	MIN	MEAN	TOL
Measure File	Multi Point	+/- .1 / Max Error	IPRO1#72	X	0.0217	-0.0150	0.0000	0.0217
				Y	0.0163	-0.0123	0.0000	0.0163

DEFECT INSPECTION / DATA VERIFICATION:

SPEC	INSPEC TYPE	INSPEC TOOL	DEFECT DENSITY	PIXEL SIZE
0.000-DPA@0.200 um	PRE Die to Database	362#793-30	0.000	.25

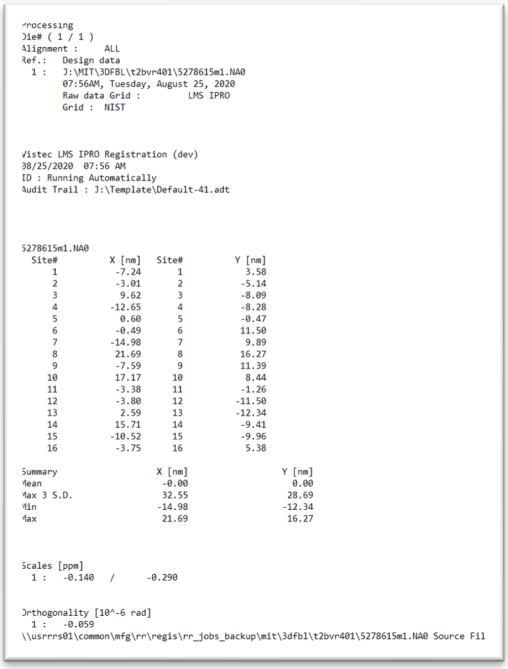
PELLICLE:

CHROME / GLASS	PART NUM DESCRIPTION	SCRIBE / WAVELENGTH
CHROME	CAN56P 122 1017HFLC	1084 MLI @ CAN56P-122-H LC / 365/436
GLASS		

QA AUDIT:
COMPACT#: MASK PKG(MLD 6025 SBL RED) CLEAR 6" MULTIBOX WITH SHELF
ATTACHMENTS:
PACKAGING-All-All-PDF COFC - EMAIL
PACKAGING-All-All-PDF COFC - HARD COPY
PACKAGING-1-All-COFO COMPACT LABEL
REGISTRATIONS-All-All-Registration Results - Email
REGISTRATIONS-All-All-Registration Results - Hard Copy
AUDITOR: LOPEZ, ALFREDO III (ALFRED)
DATE: 25-AUG-2020 15:01:24

WAIVER(S):

COMMENTS:



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Processing
Die# ( 1 / 1 )
Alignment :      ALL
Ref.:   Design data
  1 :   J:\MIT\3DFBL\t2bvr401\5278615m1.NA0
        07:56AM, Tuesday, August 25, 2020
        Raw data Grid :          LMS IPRO
        Grid :  NIST


Vistec LMS IPRO Registration (dev)
08/25/2020  07:56 AM
ID : Running Automatically
Audit Trail : J:\Template\Default-41.adt



5278615m1.NA0
  Site#          X [nm]    Site#          Y [nm]
      1           -7.24        1            3.58
      2           -3.01        2           -5.14
      3            9.62        3           -8.09
      4          -12.65        4           -8.28
      5            0.60        5           -0.47
      6           -0.49        6           11.50
      7          -14.98        7            9.89
      8           21.69        8           16.27
      9           -7.59        9           11.39
     10           17.17       10            8.44
     11           -3.38       11           -1.26
     12           -3.80       12          -11.50
     13            2.59       13          -12.34
     14           15.71       14           -9.41
     15          -10.52       15           -9.96
     16           -3.75       16            5.38

Summary                  X [nm]                Y [nm]
Mean                       -0.00                 0.00
Max 3 S.D.                 32.55                 28.69
Min                       -14.98                -12.34
Max                        21.69                 16.27


Scales [ppm]
  1 :   -0.140   /      -0.290


Orthogonality [10^-6 rad]
  1 :    -0.059
\\usrrrs01\common\mfg\rr\regis\rr_jobs_backup\mit\3dfbl\t2bvr401\5278615m1.NA0 Source Fil
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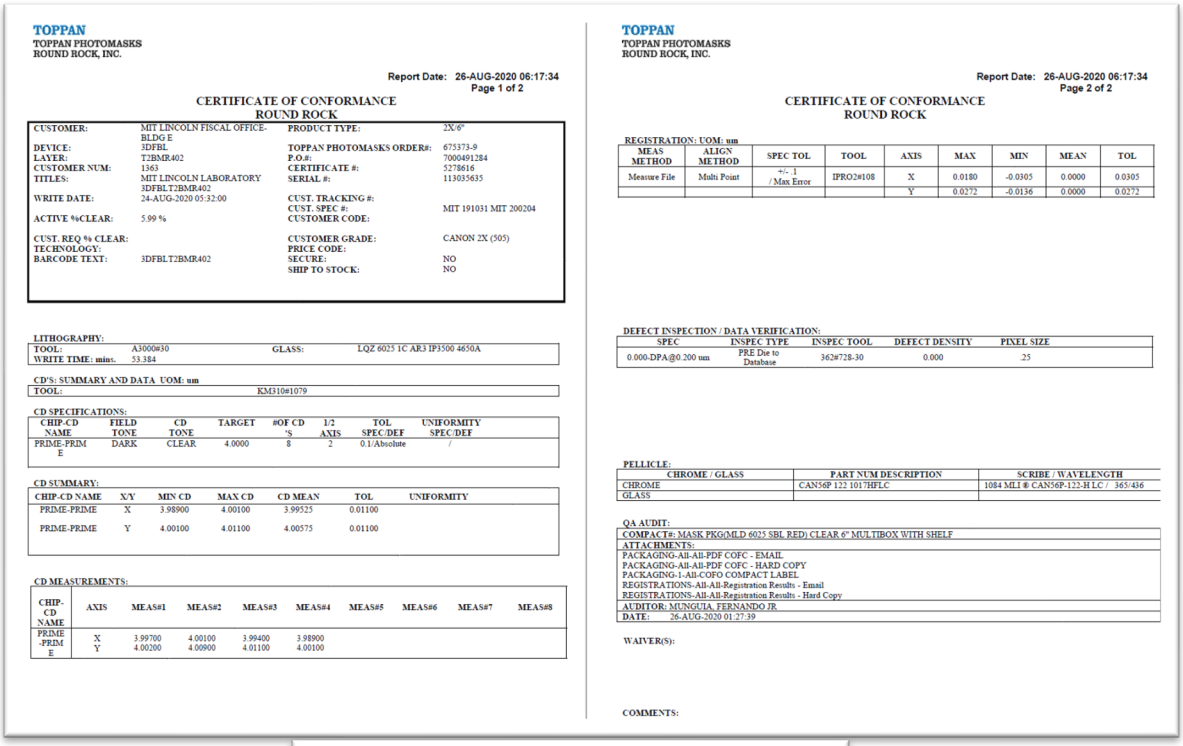
Layer 402 – T2BM (Tier 2 Backside Metal)



TOPPAN
TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 26-AUG-2020 06:17:34
Page 1 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

CUSTOMER:	MIT LINCOLN FISCAL OFFICE-BLDG E	PRODUCT TYPE:	2X/6"
DEVICE:	3DFBL	TOPPAN PHOTOMASKS ORDER#:	675373-9
LAYER:	T2BMR402	P.O.#:	7000491284
CUSTOMER NUM:	1363	CERTIFICATE #:	5278616
TITLES:	MIT LINCOLN LABORATORY 3DFBLT2BMR402	SERIAL #:	113035635
WRITE DATE:	24-AUG-2020 05:32:00	CUST. TRACKING #:	
		CUST. SPEC #:	MIT 191031 MIT 200204
ACTIVE %CLEAR:	5.99 %	CUSTOMER CODE:	
CUST. REQ % CLEAR:		CUSTOMER GRADE:	CANON 2X (505)
TECHNOLOGY:		PRICE CODE:	
BARCODE TEXT:	3DFBLT2BMR402	SECURE:	NO
		SHIP TO STOCK:	NO

LITHOGRAPHY:

TOOL:	A3000#30	GLASS:	LQZ 6025 1C AR3 IP3500 4650A
WRITE TIME: mins.	53.384		

CD'S: SUMMARY AND DATA UOM: um

TOOL:	KM310#1079

CD SPECIFICATIONS:

CHIP-CD NAME	FIELD TONE	CD TONE	TARGET	#OF CD'S	1/2 AXIS	TOL SPEC/DEF	UNIFORMITY SPEC/DEF
PRIME-PRIME	DARK	CLEAR	4.0000	8	2	0.1/Absolute	/

CD SUMMARY:

CHIP-CD NAME	X/Y	MIN CD	MAX CD	CD MEAN	TOL	UNIFORMITY
PRIME-PRIME	X	3.98900	4.00100	3.99525	0.01100	
PRIME-PRIME	Y	4.00100	4.01100	4.00575	0.01100	

CD MEASUREMENTS:

CHIP-CD NAME	AXIS	MEAS#1	MEAS#2	MEAS#3	MEAS#4	MEAS#5	MEAS#6	MEAS#7	MEAS#8
PRIME-PRIME	X	3.99700	4.00100	3.99400	3.98900				
	Y	4.00200	4.00900	4.01100	4.00100				

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ROUND ROCK, INC.

Report Date: 26-AUG-2020 06:17:34
Page 2 of 2

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REGISTRATION: UOM: um

MEAS METHOD	ALIGN METHOD	SPEC TOL	TOOL	AXIS	MAX	MIN	MEAN	TOL
Measure File	Multi Point	+/- 1 / Max Error	IPRO2#108	X	0.0180	-0.0305	0.0000	0.0305
				Y	0.0272	-0.0136	0.0000	0.0272

DEFECT INSPECTION / DATA VERIFICATION:

SPEC	INSPEC TYPE	INSPEC TOOL	DEFECT DENSITY	PIXEL SIZE
0.000-DPA@0.200 um	PRE Die to Database	362#728-30	0.000	.25

PELLICLE:

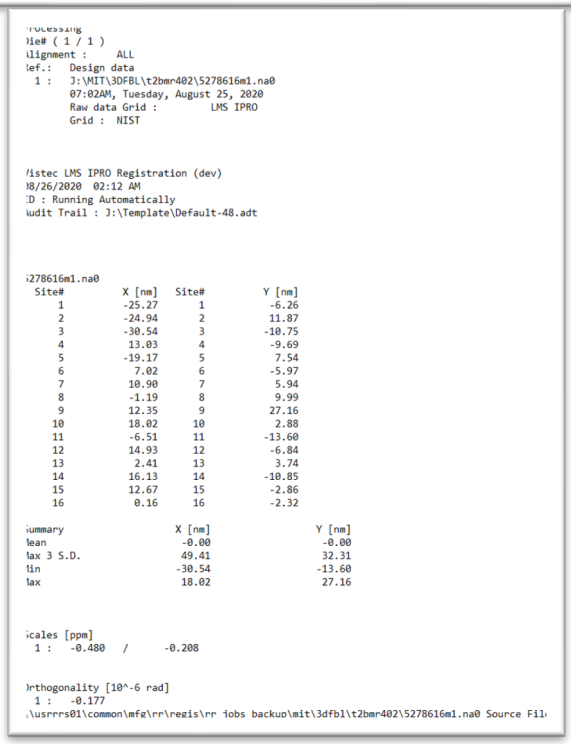
CHROME / GLASS	PART NUM DESCRIPTION	SCRIBE / WAVELENGTH
CHROME	CAN56P 122 1017HFLC	1084 MLI ® CAN56P-122-H LC / 365/436
GLASS		

QA AUDIT:

COMPACT#: MASK PKG(MLD 6025 SBL RED) CLEAR 6" MULTIBOX WITH SHELF
ATTACHMENTS:
PACKAGING-All-All-PDF COFC - EMAIL
PACKAGING-All-All-PDF COFC - HARD COPY
PACKAGING-1-All-COFO COMPACT LABEL
REGISTRATIONS-All-All-Registration Results - Email
REGISTRATIONS-All-All-Registration Results - Hard Copy
AUDITOR: MUNGUIA, FERNANDO JR
DATE: 26-AUG-2020 01:27:39

WAIVER(S):

COMMENTS:



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Processing
Die# ( 1 / 1 )
Alignment :    ALL
Ref.:   Design data
  1 :   J:\MIT\3DFBL\t2bmr402\5278616m1.na0
        07:02AM, Tuesday, August 25, 2020
        Raw data Grid :          LMS IPRO
        Grid :  NIST


Mistec LMS IPRO Registration (dev)
08/26/2020  02:12 AM
ID : Running Automatically
Audit Trail : J:\Template\Default-48.adt


5278616m1.na0
  Site#          X [nm]   Site#          Y [nm]
      1          -25.27       1           -6.26
      2          -24.94       2           11.87
      3          -30.54       3          -10.75
      4           13.03       4           -9.69
      5          -19.17       5            7.54
      6            7.02       6           -5.97
      7           10.90       7            5.94
      8           -1.19       8            9.99
      9           12.35       9           27.16
     10           18.02      10            2.88
     11           -6.51      11          -13.60
     12           14.93      12           -6.84
     13            2.41      13            3.74
     14           16.13      14          -10.85
     15           12.67      15           -2.86
     16            0.16      16           -2.32

Summary                  X [nm]                 Y [nm]
Mean                      -0.00                  -0.00
Max 3 S.D.                49.41                  32.31
Min                      -30.54                 -13.60
Max                       18.02                  27.16


Scales [ppm]
  1 :   -0.480   /      -0.208


Orthogonality [10^-6 rad]
  1 :   -0.177
.\usrrrs01\common\mfg\rr\regis\rr jobs backup\mit\3dfbl\t2bmr402\5278616m1.na0 Source Fil
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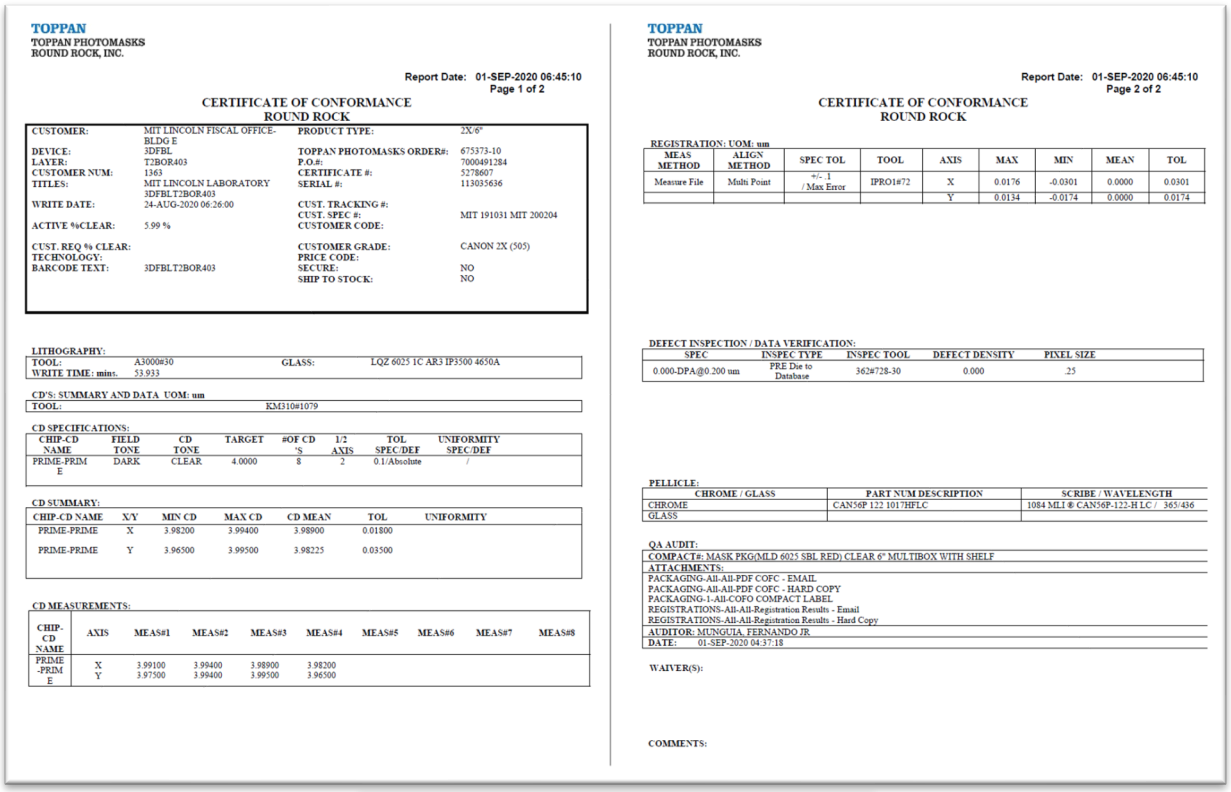
Layer 403 – T2BO (Tier 2 Backside Over-glass)



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ROUND ROCK, INC.

Report Date: 01-SEP-2020 06:45:10
Page 1 of 2

CERTIFICATE OF CONFORMANCE
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CUSTOMER:	MIT LINCOLN FISCAL OFFICE-BLDG E	PRODUCT TYPE:	2X/6"
DEVICE:	3DFBL	TOPPAN PHOTOMASKS ORDER#:	675373-10
LAYER:	T2BOR403	P.O.#:	7000491284
CUSTOMER NUM:	1363	CERTIFICATE #:	5278607
TITLES:	MIT LINCOLN LABORATORY 3DFBLT2BOR403	SERIAL #:	113035636
WRITE DATE:	24-AUG-2020 06:26:00	CUST. TRACKING #:	
		CUST. SPEC #:	MIT 191031 MIT 200204
ACTIVE %CLEAR:	5.99 %	CUSTOMER CODE:	
CUST. REQ % CLEAR:		CUSTOMER GRADE:	CANON 2X (505)
TECHNOLOGY:		PRICE CODE:	
BARCODE TEXT:	3DFBLT2BOR403	SECURE:	NO
		SHIP TO STOCK:	NO

LITHOGRAPHY:

TOOL:	A3000#30	GLASS:	LQZ 6025 1C AR3 IP3500 4650A
WRITE TIME: mins.	53.933		

CD'S: SUMMARY AND DATA UOM: um

TOOL:	KM310#1079

CD SPECIFICATIONS:

CHIP-CD NAME	FIELD TONE	CD TONE	TARGET	#OF CDS	1/2 AXIS	TOL SPEC/DEF	UNIFORMITY SPEC/DEF
PRIME-PRIME	DARK	CLEAR	4.0000	8	2	0.1/Absolute	/

CD SUMMARY:

CHIP-CD NAME	X/Y	MIN CD	MAX CD	CD MEAN	TOL	UNIFORMITY
PRIME-PRIME	X	3.98200	3.99400	3.98900	0.01800	
PRIME-PRIME	Y	3.96500	3.99500	3.98225	0.03500	

CD MEASUREMENTS:

CHIP-CD NAME	AXIS	MEAS#1	MEAS#2	MEAS#3	MEAS#4	MEAS#5	MEAS#6	MEAS#7	MEAS#8
PRIME-PRIME	X	3.99100	3.99400	3.98900	3.98200				
	Y	3.97500	3.99400	3.99500	3.96500				

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TOPPAN PHOTOMASKS
ROUND ROCK, INC.

Report Date: 01-SEP-2020 06:45:10
Page 2 of 2

CERTIFICATE OF CONFORMANCE
ROUND ROCK

REGISTRATION: UOM: um

MEAS METHOD	ALIGN METHOD	SPEC TOL	TOOL	AXIS	MAX	MIN	MEAN	TOL
Measure File	Multi Point	+/- 1 / Max Error	IPRO1#72	X	0.0176	-0.0301	0.0000	0.0301
				Y	0.0134	-0.0174	0.0000	0.0174

DEFECT INSPECTION / DATA VERIFICATION:

SPEC	INSPEC TYPE	INSPEC TOOL	DEFECT DENSITY	PIXEL SIZE
0.000-DPA@0.200 um	PRE Die to Database	362#728-30	0.000	.25

PELLICLE:

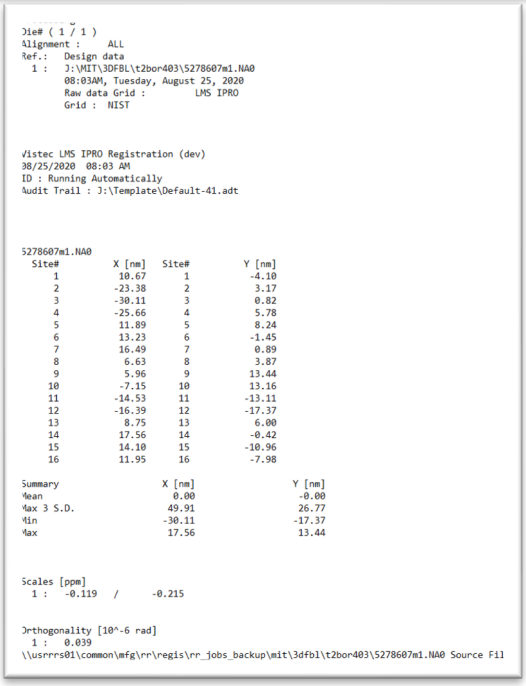
CHROME / GLASS	PART NUM DESCRIPTION	SCRIBE / WAVELENGTH
CHROME	CAN56P 122 1017HFLC	1084 MLI ® CAN56P-122-H LC / 365/436
GLASS		

QA AUDIT:

COMPACT#: MASK PKG(MLD 6025 SBL RED) CLEAR 6" MULTIBOX WITH SHELF
ATTACHMENTS:
PACKAGING-All-All-PDF COFC - EMAIL
PACKAGING-All-All-PDF COFC - HARD COPY
PACKAGING-1-All-COFO COMPACT LABEL
REGISTRATIONS-All-All-Registration Results - Email
REGISTRATIONS-All-All-Registration Results - Hard Copy
AUDITOR: MUNGUIA, FERNANDO JR.
DATE: 01-SEP-2020 04:37:18

WAIVER(S):

COMMENTS:



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Die# ( 1 / 1 )
Alignment :      ALL
Ref.:    Design data
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         08:03AM, Tuesday, August 25, 2020
         Raw data Grid :          LMS IPRO
         Grid :  NIST


Vistec LMS IPRO Registration (dev)
08/25/2020  08:03 AM
ID : Running Automatically
Audit Trail : J:\Template\Default-41.adt



5278607m1.NA0
 Site#          X [nm]   Site#          Y [nm]
     1           10.67       1           -4.10
     2          -23.38       2            3.17
     3          -30.11       3            0.82
     4          -25.66       4            5.78
     5           11.89       5            8.24
     6           13.23       6           -1.45
     7           16.49       7            0.89
     8            6.63       8            3.87
     9            5.96       9           13.44
    10           -7.15      10           13.16
    11          -14.53      11          -13.11
    12          -16.39      12          -17.37
    13            8.75      13            6.00
    14           17.56      14           -0.42
    15           14.10      15          -10.96
    16           11.95      16           -7.98

Summary                 X [nm]              Y [nm]
Mean                      0.00                -0.00
Max 3 S.D.               49.91                26.77
Min                     -30.11               -17.37
Max                      17.56                13.44


Scales [ppm]
  1 :   -0.119   /     -0.215


Orthogonality [10^-6 rad]
  1 :    0.039
\\usrrrs01\common\mfg\rr\regis\rr_jobs_backup\mit\3dfbl\t2bor403\5278607m1.NA0 Source Fil
```

APPENDIX D
PROBE SPECIFIC LOCATIONS FOR ELECTRICAL TEST

The following table includes chip level coordinates for the various chains and test devices on the 3DFBL reticle set.

1. **3D Kelvins** – Pad Frame 24 x 1 array of 100um pads at 150um pitch

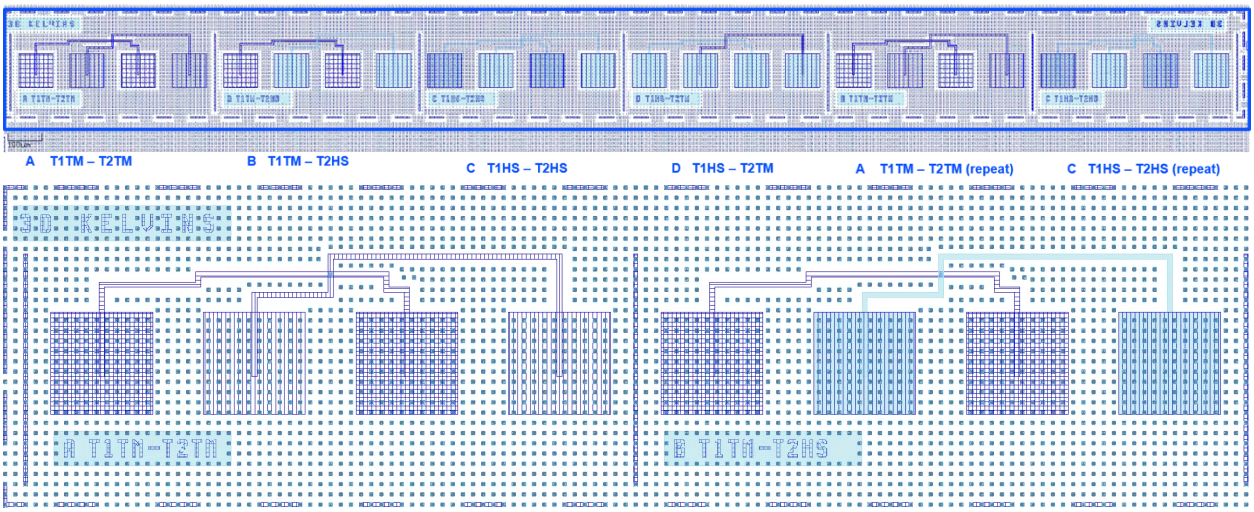
a. Device A: T1TM to T1-T2TM on pads 1-4, repeats on pads 17-20
- 1st and 3rd pad are T1TM
- 22nd and 4th pad are T2TM

b. Device B: T1TM to T1-T2HS on pads 5-8, repeates on pads 21-24
- 1st and 3rd pad are T1TM
- 22nd and 4th pad are T2HS

c. Device B: T1TM to T1HS-T2HS on pads 9-12
- 1st and 3rd pad are T1HS
- 22nd and 4th pad are T2HS

d. Device D: T1TM to T1HS-T2TM on pads 13-16
- 1st and 3rd pad are T1HS
- 22nd and 4th pad are T2TM

3D Kelvin Structures



3D Kelvin Locations (the coordinate given is for the center of the left-most pad)		
Site	**X (um)**	**Y (um)**
1	-3520	8630
2	-3520	9970
3	-3520	-10130
4	-3520	-8790

2. **CMOS Sheets** – Pad Frame 24 x 1 array of 100um pads at 150um pitch

a. Device MRS-A: T1TM on pads 1-4, for use in front side (if desired), also accessable after bonding

b. Device MRS-B: T1TM on pads 5-8, intended for use after bonding

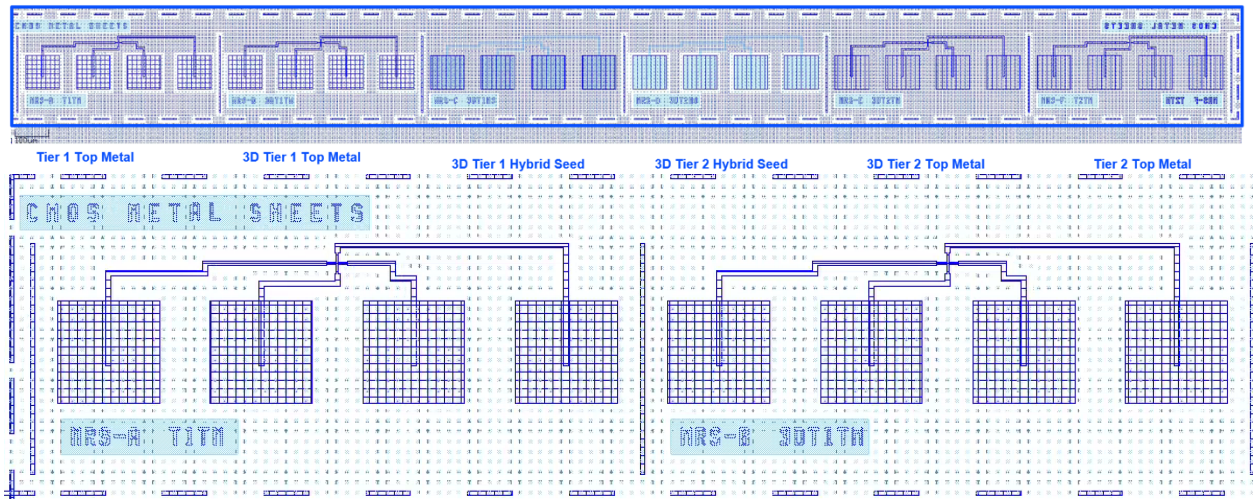
c. Device MRS-C: T1TM to T1HS-T2HS on pads 9-12, intended for use after bonding

d. Device MRS-D: T1TM to T1HS-T2TM on pads 13-16, intended for use after bonding

e. Device MRS-E: T2TM Rs on pads 17-20, intended for use after bonding

f. Device MRS-F: T2TM Rs on pads 21-24, for use in front side (if desired), also accessable after bonding

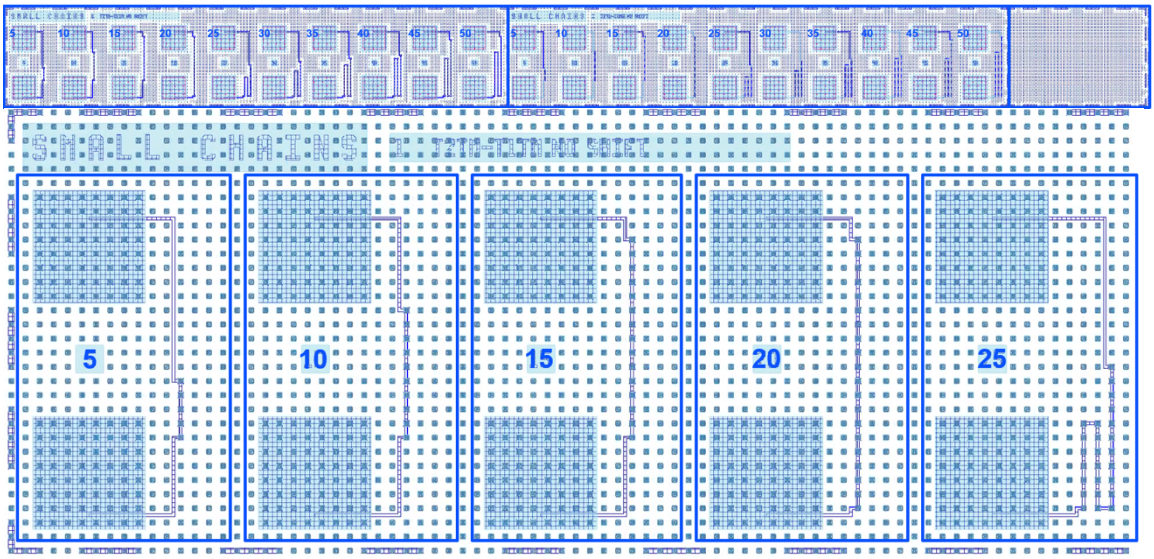
CMOS Sheet Resistance Structures



CMOS Sheets (the coordinate given is for the center of the left most pad)		
Site	**X (um)**	**Y (um)**
1	-3425	7455
2	-3425	7775
3	-3415	7455
4	-3415	7775
5	-5255	7455
6	-5255	7775
7	-1650	8095
8	-1650	9435
9	2045	-10665
10	2045	-9325

3. **Small Chains Type 1 (by 5's with partial compass shifts)** – Pad Frame 4 x 2 array of 80um pads at 160um pitch, five copies side by side, every FIVE steps on auto-prober equals TWENTY devices on the wafer. Each column of pads (2) has been wired to a separate chain.

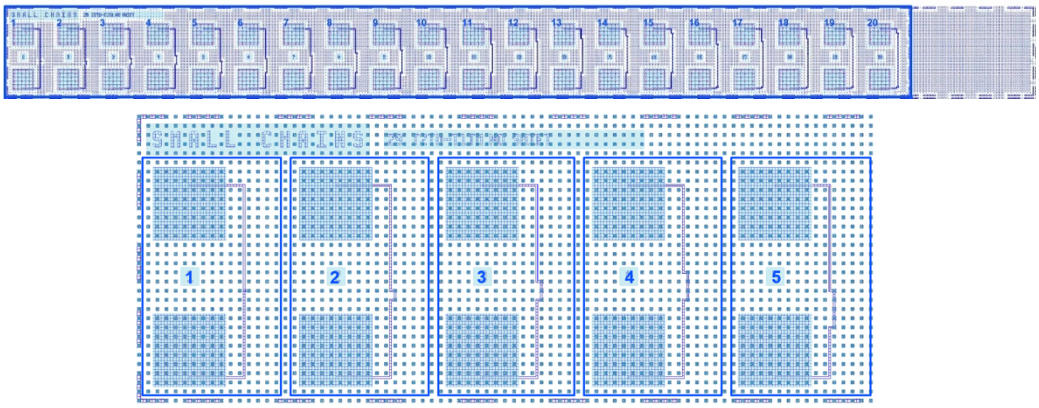
Small Chains Type 1 (Chain Length 5 to 50, increase by 5 at each set of pads)



Small Chains Type 1 (the coordinate given is for the center of the left bottom-most pad)				
Chain IDs ***(1st listed chains are on pad columns 1-10, 2nd listed chains are on pads 11-20)***	**Upper Array (Site 1)**		**Lower Array (Site 2)**	
	X (um)	**Y (um)**	**X (um)**	**Y (um)**
01 - T2TM to T2TM, no shift **&** 02 - T2TM to T1HS no shift	-5295	7055	-5295	-2335
03 - T2HS to T2HS no shift **&** 04 - T2HS to T1TM no shift	-5295	6735	-5295	-2655
05 - T2TM to T2TM shift N 1000nm **&** 06 - T2TM to T1HS shift N 1000nm	-5295	6415	-5295	-2975
07 - T2HS to T2HS shift N 1000nm **&** 08 - T2HS to T1TM shift N 1000nm	-5295	6095	-5295	-3295
09 - T2TM to T2TM shift NE 1000nm **&** 10 - T2TM to T1HS shift NE 1000nm	-5295	5775	-5295	-3615
11 - T2HS to T2HS shift NE 1000nm **&** 12 - T2HS to T1TM shift NE 1000nm	-5295	5455	-5295	-3935
13 - T2TM to T2TM shift E 1000nm **&** 14 - T2TM to T1HS shift E 1000nm	-5295	5135	-5295	-4255
15 - T2HS to T2HS shift E 1000nm **&** 16 - T2HS to T1TM shift E 1000nm	-5295	4815	-5295	-4575
17 - T2TM to T2TM shift N 2000nm **&** 18 - T2TM to T1HS shift N 2000nm	-5295	4495	-5295	-4895
19 - T2HS to T2HS shift N 2000nm **&** 20 - T2HS to T1TM shift N 2000nm	-5295	4175	-5295	-5215
21 - T2TM to T2TM shift NE 2000nm **&** 22 - T2TM to T1HS shift NE 2000nm	-5295	3855	-5295	-5535
23 - T2HS to T2HS shift NE 2000nm **&** 24 - T2HS to T1TM shift NE 2000nm	-5295	3535	-5295	-5855
25 - T2TM to T2TM shift E 2000nm **&** 26 - T2TM to T1HS shift E 2000nm	-5295	3215	-5295	-6175
27 - T2HS to T2HS shift E 2000nm **&** 28 - T2HS to T1TM shift E 2000nm	-5295	2895	-5295	-6495

4. **Small Chains Type 2 (by 1's with partial compass shifts)** – Pad Frame 4 x 2 array of 80um pads at 160um pitch, five copies side by side, every FIVE steps on auto-prober equals TWENTY devices on the wafer. Each column of pads (2) has been wired to a separate chain.

Small Chains Type 2 (Chain Length 1 to 20, increase by 1 at each set of pads)



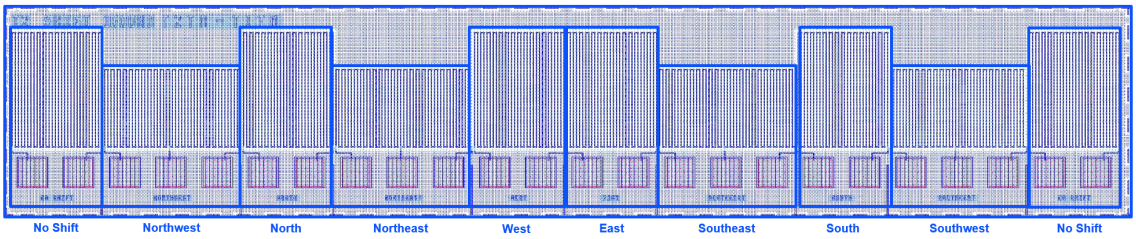
Small Chains Type 1				
Chain IDs	**Upper Array (Site 1)**		**Lower Array (Site 2)**	
	X (um)	**Y (um)**	**X (um)**	**Y (um)**
29 - T2TM to T2TM, no shift	-1645	7055	-1645	-2335
30 - T2TM to T1HS no shift	-1645	6735	-1645	-2655
31 - T2HS to T2HS no shift	-1645	6415	-1645	-2975
32 - T2HS to T1TM no shift	-1645	6095	-1645	-3295
33 - T2TM to T2TM N 1000nm	-1645	5775	-1645	-3615
34 - T2TM to T1HS N 1000nm	-1645	5455	-1645	-3935
35 - T2HS to T2HS N 1000nm	-1645	5135	-1645	-4255
36 - T2HS to T1TM N 1000nm	-1645	4815	-1645	-4575
37 - T2TM to T2TM NE 1000nm	-1645	4495	-1645	-4895
38 - T2TM to T1HS NE 1000nm	-1645	4175	-1645	-5215
39 - T2HS to T2HS NE 1000nm	-1645	3855	-1645	-5535
40 - T2HS to T1TM NE 1000nm	-1645	3535	-1645	-5855
41 - T2TM to T2TM E 1000nm	-1645	3215	-1645	-6175
42 - T2TM to T1HS E 1000nm	-1645	2895	-1645	-6495
43 - T2HS to T2HS E 1000nm	2005	7055	2005	-2335
44 - T2HS to T1TM E 1000nm	2005	6735	2005	-2655
45 - T2TM to T2TM N 2000nm	2005	6415	2005	-2975

46 - T2TM to T1HS N 2000nm	2005	6095	2005	-3295
47 - T2HS to T2HS N 2000nm	2005	5775	2005	-3615
48 - T2HS to T1TM N 2000nm	2005	5455	2005	-3935
49 - T2TM to T2TM NE 2000nm	2005	5135	2005	-4255
50 - T2TM to T1HS NE 2000nm	2005	4815	2005	-4575
51 - T2HS to T2HS NE 2000nm	2005	4495	2005	-4895
52 - T2HS to T1TM NE 2000nm	2005	4175	2005	-5215
53 - T2TM to T2TM E 2000nm	2005	3855	2005	-5535
54 - T2TM to T1HS E 2000nm	2005	3535	2005	-5855
55 - T2HS to T2HS E 2000nm	2005	3215	2005	-6175
56 - T2HS to T1TM E 2000nm	2005	2895	2005	-6495

5. **Small Chains Type 3 (Compass Shifts)** – Pad Frame 24 x 1 array of 100um pads at 150um pitch.

a. Left No Shift – Pads 1 & 2, 1140 HBI connections
b. Northwest Shift – Pads 3-5, 1144 HBI connections with central tap at the 574th HBI connections
c. North Shift – Pads 6-7, 1140 HBI connections
d. Northeast Shift – Pads 8-10, 1144 HBI connections with central tap at the 574th HBI connections
e. West Shift – Pads 11-12, 1140 HBI connections
f. East Shift – Pads 13-14, 1140 HBI connections
g. Southeast Shift – Pads 15-16, 1144 HBI connections with central tap at the 574th HBI connections
h. South Shift – Pads 17-19, 1140 HBI connections
i. Southwest Shift – Pads 20-22, 1144 HBI connections with central tap at the 574th HBI connections
j. Right No Shift – Pads 23 &24, 1140 HBI connections

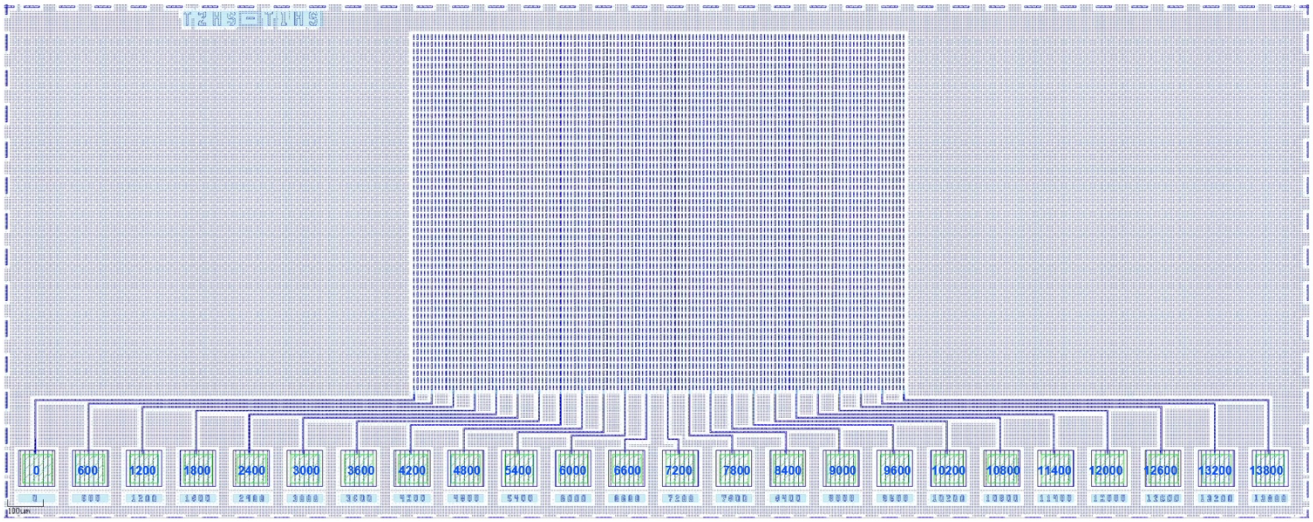
Small Chains Type 3 Compass Shifts



Small Chains Type 3 Compass Shifts (the coordinate given is for the center of the left most pad)								
Chain IDs	**Site 1**		**Site 2**		**Site 3**		**Site 4**	
Four Corner Arrays	**X**	**Y**	**X**	**Y**	**X**	**Y**	**X**	**Y**
T2 SHIFT T2TM-T1TM	-10715	10105	3285	10105	-	-8655	3285	-8655
T2 SHIFT T2TM-T1HS	-10715	9435	3285	9435	-	-9325	3285	-9325
T2 SHIFT T2HS-T1HS	-10715	8765	3285	8765	-	-9995	3285	-9995
T2 SHIFT T2HS-T1HS	-10715	8095	3285	8095	-	-10665	3285	-10665
T2 SHIFT T2TM_T1TM	-7075	10105	6925	10105	-7075	10105	6925	10105
T2 SHIFT T2TM-T1HS	-7075	9435	6925	9435	-7075	9435	6925	9435
T2 SHIFT T2HS-T1HS	-7075	8765	6925	8765	-7075	8765	6925	8765
T2 SHIFT T2HS-T1HS	-7075	8095	6925	8095	-7075	8095	6925	8095
Two Edge Arrays								
T2 SHIFT T2TM -T1TM	-10715	7425	-10715	7425	-	-615	-10715	-615
T2 SHIFT T2TM - T1TM	-10715	6755	-10715	6755	-	-1285	-10715	-1285
T2 SHIFT T2TM - T1TM	-10715	6085	-10715	6085	-	-1955	-10715	-1955
T2 SHIFT T2TM - T1TM	-10715	5415	-10715	5415	-	-2625	-10715	-2625
T2 SHIFT T2TM - T1TM	-10715	4745	-10715	4745	-	-3295	-10715	-3295
T2 SHIFT T2TM - T1TM	-10715	4075	-10715	4075	-	-3965	-10715	-3965
T T2 SHIFT 2TM - T1TM	-10715	3405	-10715	3405	-	-4635	-10715	-4635
T2 SHIFT T2TM -	-10715	2735	-10715	2735	-	-5305	-10715	-5305
T2 SHIFT T2TM - T1TM	-10715	2065	-10715	2065	-	-5975	-10715	-5975
T2 SHIFT T2TM - T1TM	-10715	1395	-10715	1395	-	-6645	-10715	-6645
T2 SHIFT T2TM - T1TM	-10715	725	-10715	725	-	-7315	-10715	-7315
T2 SHIFT T2TM - T1TM	-10715	55	-10715	55	-	-7985	6925	-7985

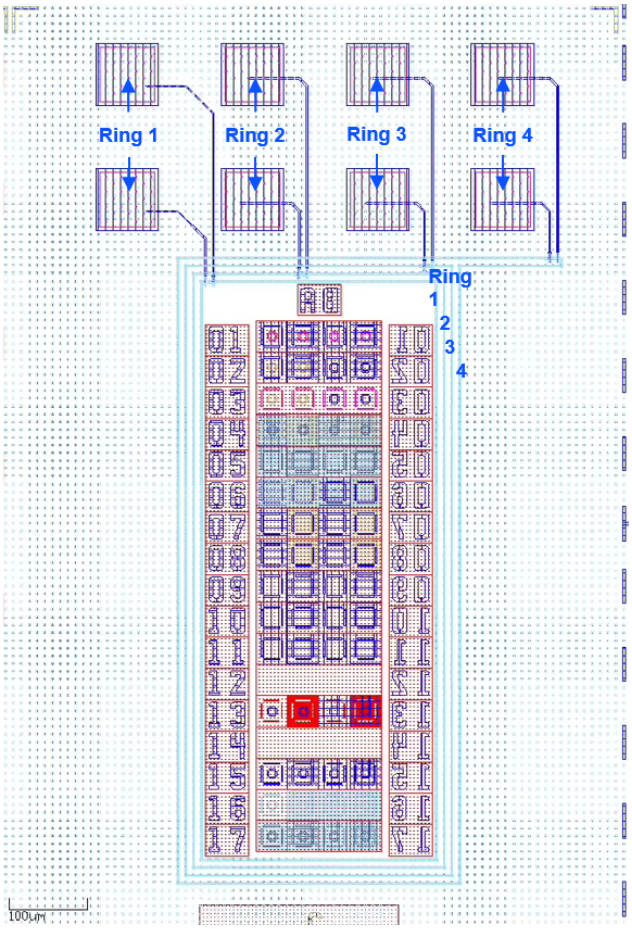
6. **Large Chains** (10K +) – Pad Frame 24 x 1 array of 100um pads at 150um pitch. There are 600 3D interconnections between each pair of pads for a total count of 13800 3D interconnections

Large Chains 13.8 K Tier 2 Hybrid Seed to 1 Hybrid Seed Interconnections (drops every 600 connections)



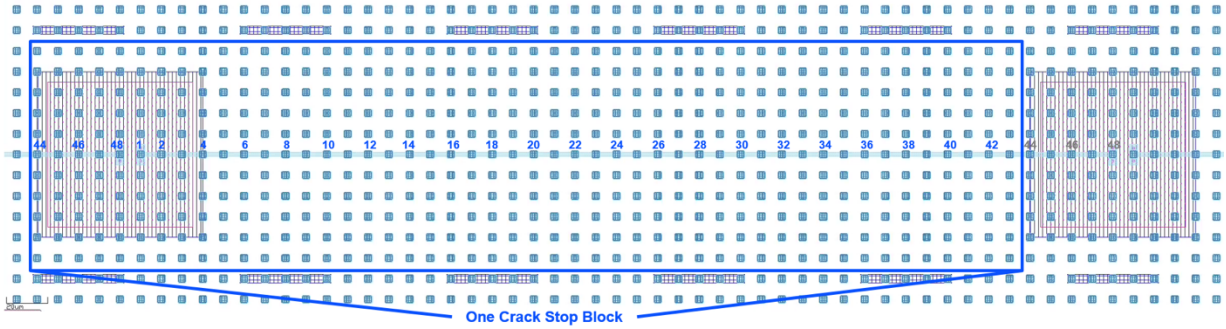
Large Chains - 600 HBI per each pad pair/13800 HBI total (the coordinate given is for the center of the left most pad)						
For 3 x 3 array of Large Chains	**Column 1 (Left)**		**Column 2 (Middle)**		**Column 3 (Right)**	
	X	**Y**	**X**	**Y**	**X**	**Y**
Row 1 (Top)	-5265	-1825	-1625	-1825	2015	-1825
Row 2 (Middle)	-5265	-395	-1625	-395	2015	-395
Row 3 (Bottom)	-5265	1035	-1625	1035	2015	1035

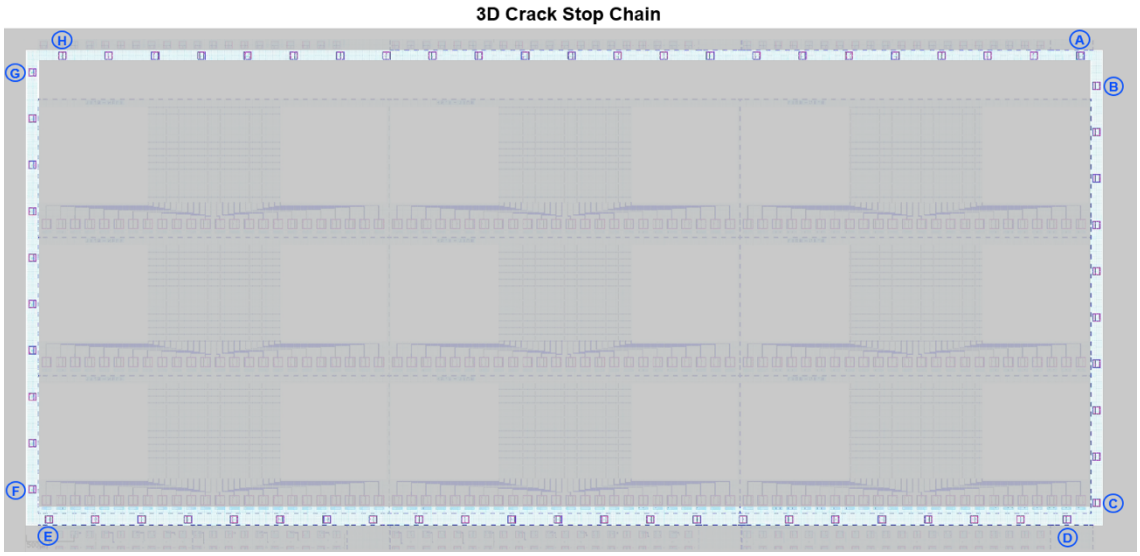
7. **Plasma Dice Chains** – Pad Frame 4 x 2 array of 80um pads at 160um pitch. Each column of pads has been connected to one ring.



Plasma Dice Chains (the coordinate given is for the center of the left most pad)								
Chain IDs	**Site 1** **(Top Left)**		**Site 2** **(Bottom Left)**		**Site 3** **(Top Right)**		**Site 4** **(Bottom Right)**	
four sites, near corners	**X**	**Y**	**X**	**Y**	**X**	**Y**	**X**	**Y**
Plasma Dice Chains	-7005	7705	-7005	-6795	6205	7705	6205	-6795

8. **3D Crack Stop Chains** – 80 um at 480um pitch. There are 48 3D interconnections between each pair of pads





3D Crack Stop Chains – 48 HBI per each pad pair, hand-probe only			
Site	**Array**	**X**	**Y**
A	Non-Applicable, unique cell	5460	2780
B	1 x 9 array, y step: -480um	5630	2470
C	Non-Applicable, unique cell	5630	-1850
D	22 x 1 array, x step -480um	-5320	-2020
E	Non-Applicable, unique cell	-5240	-2020
F	1 x 9 array, y-step: +480um	-5410	-1710
G	Non-Applicable, unique cell	-5410	2610
H	22 x 1 array, x-step 480um	-5100	2780

APPENDIX E
ASSOCIATED DOCUMENTS

The following list includes other relevant documents associated with the 3DFBL reticle set.

• 3DFBL_Ret_20200820.gds	Design GDS File
• PI_3DFBL.xls	Process Information sheet for Microelectronics Laboratory
• 3DFBL_Fab_Guide.ppt	Fabrication Guide for the | Microelectronics Laboratory

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