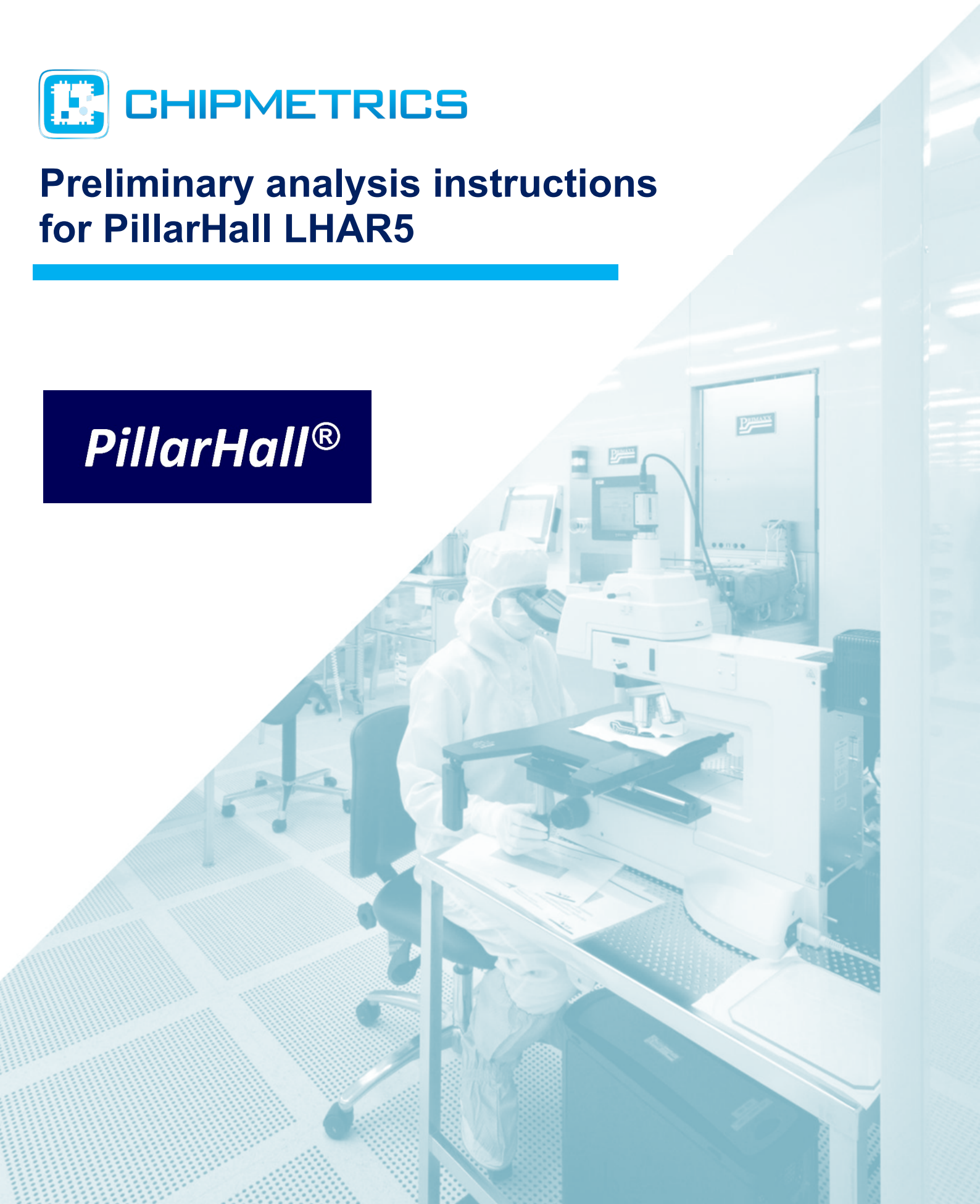
CHIPMETRICS

Preliminary analysis instructions for PillarHall LHAR5

PillarHall®



INTRODUCTION

This document highlights the differences between the LHAR5 and LHAR4 models. It is recommended to become familiar with these differences prior to utilizing the LHAR5 chips. For general procedures applicable to both LHAR5 and LHAR4, please refer to the LHAR4 analysis guide.

PillarHall® LHAR5 silicon test chip is an updated version from LHAR4 test chips, which contains Lateral High Aspect Ratio (LHAR) test structures for ALD and CVD thin film characterization. It is used as a measurement tool for thin film conformality and side wall coverage measurements in a high aspect ratio trench.

Chipmetrics product portfolio covers the PillarHall layout and model with the nominal 500 nm and 100 nm nominal gap height.

LHAR5 main features compared to LHAR4

1. LHAR5 Membrane is formed of 5µm thick single crystal silicon, membrane strength is better than LHAR4.
2. LHAR5 Pillars are made of SiO2, in contrast to the polysilicon used in previous models.
3. Both 100nm or 500nm gap heights are available, gap height accuracy is better than LHAR4.
4. Opening area extends to both sides of the lateral trench (cavity under the membrane).
5. Less surface roughness on the substrate.

LHAR5 Technical specifications

Technical specifications		Remarks
Product ID	PillarHall® LHAR5-βeta	
Material	Silicon	SiO_2 as pillars
Chip size	15 mm x 15 mm	
Test structures	8 LHAR in the main area 19 LHAR in the secondary area 2 stress test structures 1 chip edge LHAR	Layout next page
Aspect ratios (AR)	From 10:1 to 10000:1 See the table in the next pages.	For 500 nm gap height (AR= *L : H*)
Nominal gap height	*H (gap)* = 500 nm and *H (gap)* = 100 nm	With different gap height label
Opening width ($D_{(opening)}$)	$D_{(opening)}$= 2 - 100 µm	Illustrated in Figure
Later trench length (*L*) and width (*W*(gap))	L from 5 to 5000 µm $W_{(gap)}$ from 2 to 7000 µm	Layout next page
Temperature *	Up to 800°C	
Pressure *	From high vacuum to atmospheric	

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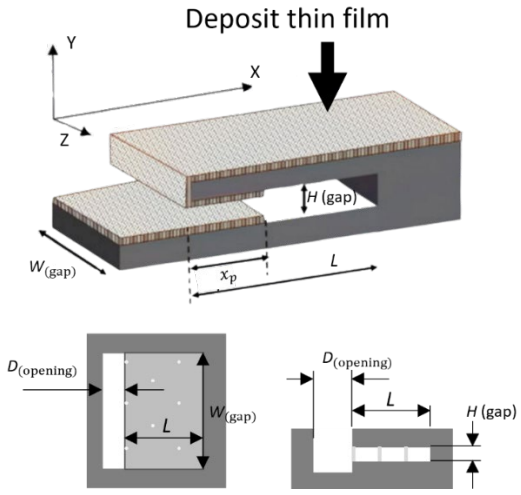


Figure 1. Geometry of the LHAR structure. *H* is the gap height. *L* is length (depth) of the lateral trench, $W_{(gap)}$ is width of the trench, and $D_{(\text{opening})}$ is the width of the vertical trench opening area, and $x_p$stands for film penetration depth.

LHAR5 chip Layout

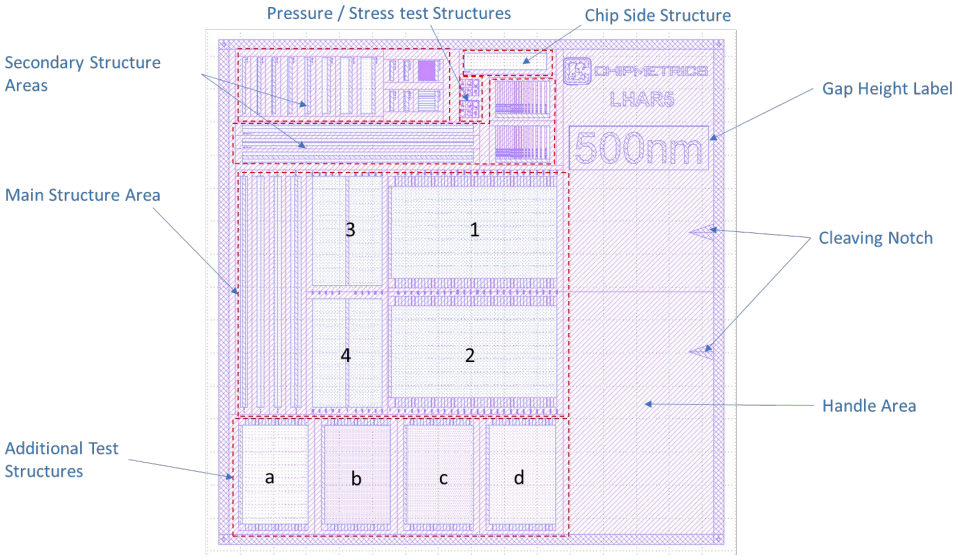
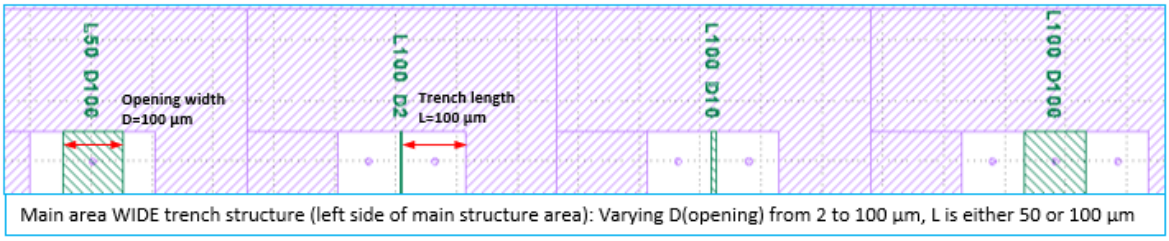
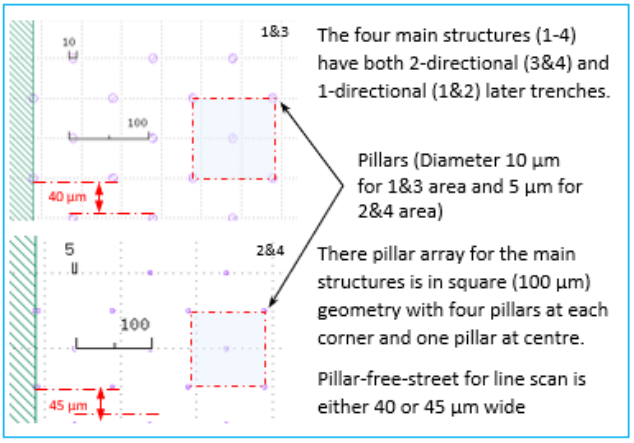


Figure 2. LHAR5 chip layout





LHAR Structure label	2-directional LHAR	Trench lenght (L), µm	Opening width (D), µm	Trench width (W), µm
L50 D100	Yes	50	100	7000
L100 D2	Yes	100	2	7000
L100 D10	Yes	100	10	7000
L100 D100	Yes	100	100	7000
1	No	5000	100	2800
2	No	5000	100	2800
3	No	1000	100	3300
4	No	1000	100	3300
a	No	2000	100	2000
b	No	2000	100	2000
c	No	2000	100	2000
d	No	2000	100	2000

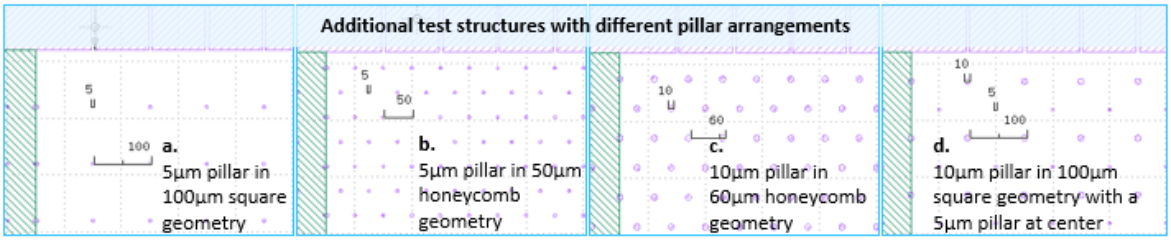


Figure 3. LHAR5 main and additional test structure detailed illustration and dimensions.

PRESSURE (STRESS) TEST STRUCTURES IN PILLARHALL® LHAR5-BETA TEST CHIP

These 2 sets of test structures are designed for ambient pressure measurement or thin film stress measurement. The circular membrane over the cavity (in both 100nm and 500nm gap height structures, either with or without ventilation channel) deforms against pressure difference (from under and above the membrane) or thin film (deposited on one side of the membrane) stress.

By measuring the membrane profile (bending altitude), the ambient pressure (membrane without ventilation channel) or thin film stress can be calculated. (a film stress calculation tool for this test structure is under development at Chipmetrics)

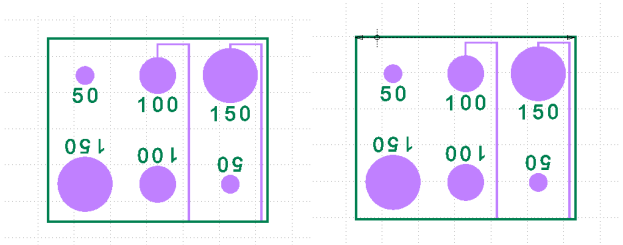
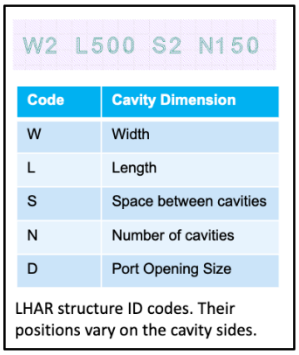


Figure 4. LHAR5 Pressure(Stress) test structure illustrations.

Secondary and chip side LHAR structures

Secondary and chip side area provides full amount of different LHAR dimensions that could be think of. Use them for your special test purpose.

Structure	2 Directional Port	Port Opening [µm]	Width [µm]	Length [µm]	Aspect Ratio 500nm Gap	Aspect Ratio 100nm Gap
W2800 L5000	No	100	2800	5000	10000	50000
W3300 L1000	Yes	100	3300	1000	2000	10000
L100 D100	No	100	7000	100	200	1000
L100 D2	No	2	7000	100	200	1000
L50 D100	No	100	7000	50	100	500
L2000 W3000 *	No	100	3000	2000	4000	20000
L100 W7000 D	No	2, 10, 100	7000	2	200	1000
W1700 L	No	100	1700	5 - 160	10 - 320	50-1600
W2 L S2 N150	No	100	2	10,50,500	20 - 1000	100-5000
W70 L S2 N8	No	100	70	10,50,500	20 - 1000	100-5000
W S50 L1000	No	100	1000	2 - 100	2000	10000
W S50 L1000	Yes	100	1000	2 - 100	2000	10000



Code	Cavity Dimension
W	Width
L	Length
S	Space between cavities
N	Number of cavities
D	Port Opening Size

LHAR structure ID codes. Their positions vary on the cavity sides.

CHARACTERIZATION PRACTICES

The characterization practices for the LHAR5 model are similar to those for the LHAR4 model. You can refer to the PillarHall LHAR4 analysis guide for detailed instructions.

.LHAR5 is similar to LHAR4, analyzing the penetration depth of deposited thin film in LHAR5 can be done through microscopy after the thin film deposition process. By examining a microscope image, you can potentially observe the extent of film growth based on color variations.

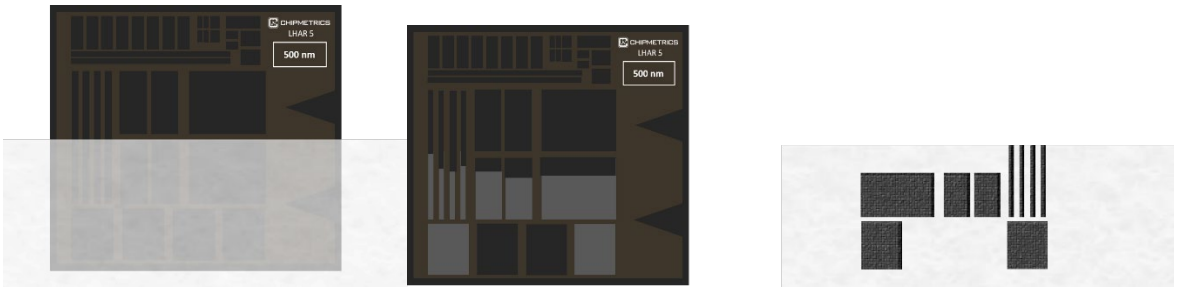
From the digitalized microscope image, one can measure film penetration simply visually or using distance indicators in the PillarHall LHAR structures..

While this method offers a simple and high-throughput approach, the resolution for measuring film penetration depth profile is limited. To improve the visibility of the penetration depth effect, users can leverage optical modelling tools to design the experiment beforehand.
For further details and a more in-depth explanation of the characterization practices, including measurement techniques, it's recommended to refer to the PillarHall LHAR4 analysis guide.

MEMBRANE PEELING

PillarHall® LHAR test chips have been designed so that one should easily be able to detach the membrane by applying adhesive tape. We recommend Scotch® Magic Tape, the Scotch® Brand's matte-finish invisible tape uses 3M adhesive technology to bond tightly and disappear without a trace.

Removing the LHAR5 membrane is easy and straightforward requiring minimal training.
Procedure to remove membrane is illustrated in figures below.



As illustrated in figure 5 the membranes from test areas **2, 4**, and **a** are easier to remove due to design variations in the current LHAR5 chips.

In the future LHAR5 products, only designs same as areas **2, 4** and **a** remain, so that all the test structure membranes are easy to peel.

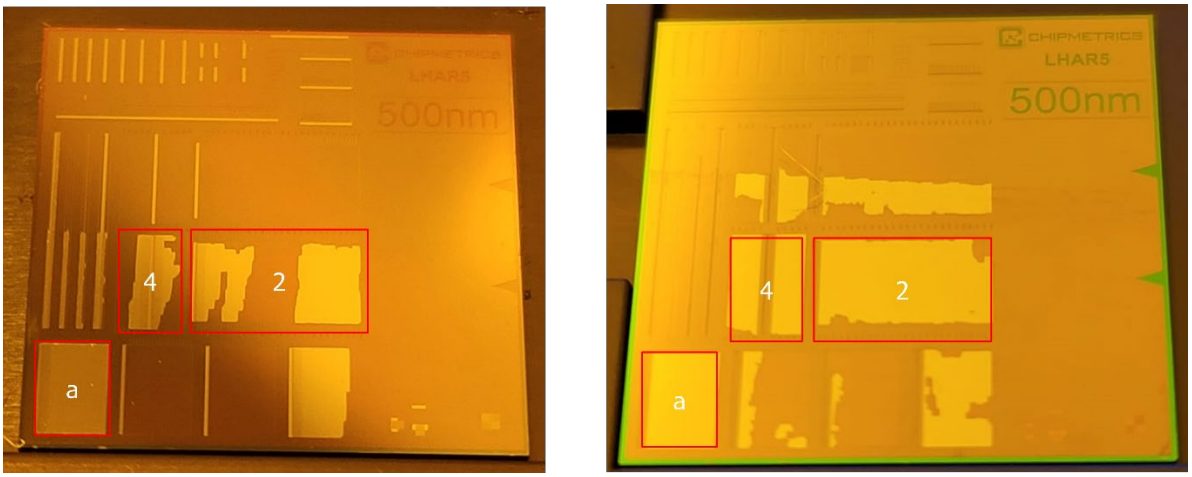


Figure 5. Microscope images of LHAR5 test chips after removing the membrane.

The figure below shows microscope images of both the PillarHall LHAR4 and LHAR5 models, illustrating that after the removal of the top membrane, the thin film becomes visible in a similar manner across both models.

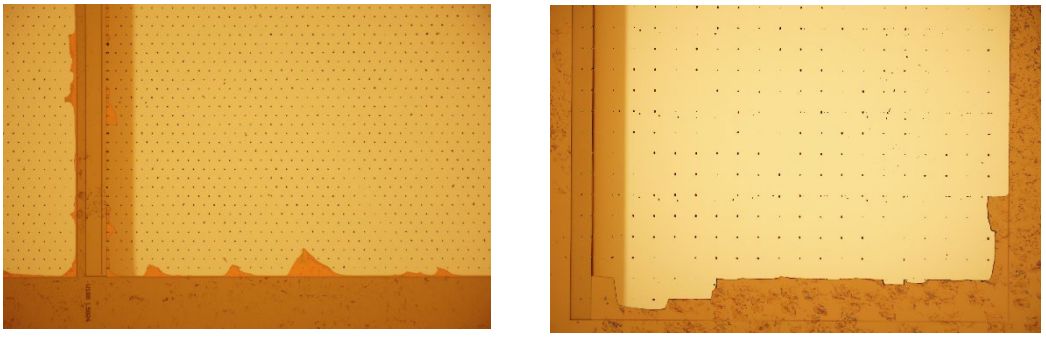


Figure 6. Left: Microscope image of PillarHall LHAR4 with visible thin film after removing the membrane; Right: Microscope image of LHAR5 that shows the visible thin film following the peeling of the top membrane in PillarHall LHAR5 model.

PILLARHALL LHAR5 DELIVERY

Chipmetrics provides PillarHall LHAR5 test chips in a box with 5 pcs of LHAR5 test chips (default number of chips is 5 pcs in a BTXF box).

Note: PillarHall LHAR5 model is not currently available in a wafer size.

List of further readings:

1. PILLARHALL LHAR5 CHIP HANDLING GUIDELINES

This Document includes general handling guidance, storage conditions, shipment types, inspecting the shipment box, handling the box, transferring chips out from the box, inspecting and handling wafers, and transferring chips out from the wafer's shipper box.

2. PILLARHALL TEST CHIP ANALYSIS GUIDE

Various development versions, product models and other information of the PillarHall® Test Chips as well as information of their typical use in analysis are described in this PillarHall® Analysis Guide.

3. Application Note PILLARHALL LHAR4 – STANDARD PROCEDURE IN PROCESS MONITORING

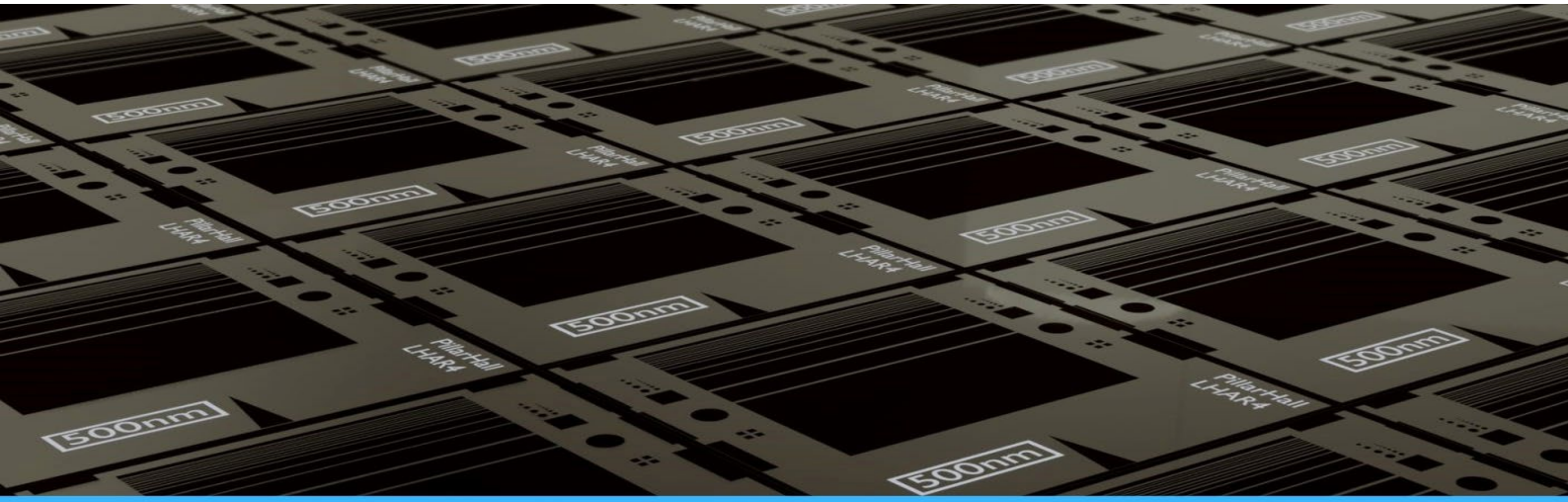
This application note describes the standard procedure of PillarHall LHAR4 test chip use in 3D thin film deposition process monitoring.

4. Application Note PILLARHALL LHAR4 – COMPARING THE CONFORMALITY PERFORMANCE TO OTHER HIGH ASPECT RATIO STRUCTURES

This application note describes how the PillarHall LHAR4 film penetration depth profile results can be used to predict conformality in any high aspect ratio structure, when the dimensions of these structures are known.

5. Application Note PILLARHALL LHAR4 – COMPATIBILITY WITH PE-CVD

This application note assesses PillarHall LHAR4 measurement tool compatibility with PE-CVD.



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