

## **Blu-ray Disc stamper physical characteristics**

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## **BD Stamper Physical Characteristics**

### **Introduction**

Sony DADC and Singulus Technologies are co-operating closely to make BD stamper making and replication available for the industry quickly.

For successful replication of BD25 and BD50, stampers to be used should have a number of physical characteristics.

Sony and Singulus have taken the initiative to come to a well defined set of characteristics for stampers that can be used as guidance to ensure high quality BD-ROM disc manufacturing.

To ensure quick availability of an appropriate document, a working group consisting of staff members of a small number of companies leading in their specific fields of expertise was formed. Experts from these companies have co-operated closely and shared their knowledge openly to identify and evaluate “best practices” in the worldwide production of BD optical discs and summarize the collective wisdom as it is available in the industry in this document. Next to Sony and Singulus, experts from Sibert and technotrans participated to cover BD Mastering, Galvanic processing of Masters and finishing of BD stampers.

As the BD format and the evaluation tools matures and the industrial experience grows, the insights may evolve, but at this point in time, adhering to the stamper characteristics as described is likely to produce the best results.

This stamper characteristics document gives recommendations for the properties stampers need to have at successive stages of production and in the final state, with some explanations of why and the relevance of these characteristics for high quality BD-ROM production.

This document does not detail explicit manufacturing procedures to achieve these characteristics; alternative equipment suppliers may reach the required results in different manners.

Therefore, additional information from companies supplying specific operations to prepare stampers in such a way that they comply with the recommendations in this document will be made available separately by different equipment suppliers. Examples of such information can be found in the reference section of this document.

### **Disclaimer**

The information in this document can be used freely, but the contributors cannot be held responsible in any way for the results or any damages incurred.

## Stamper Thickness variation

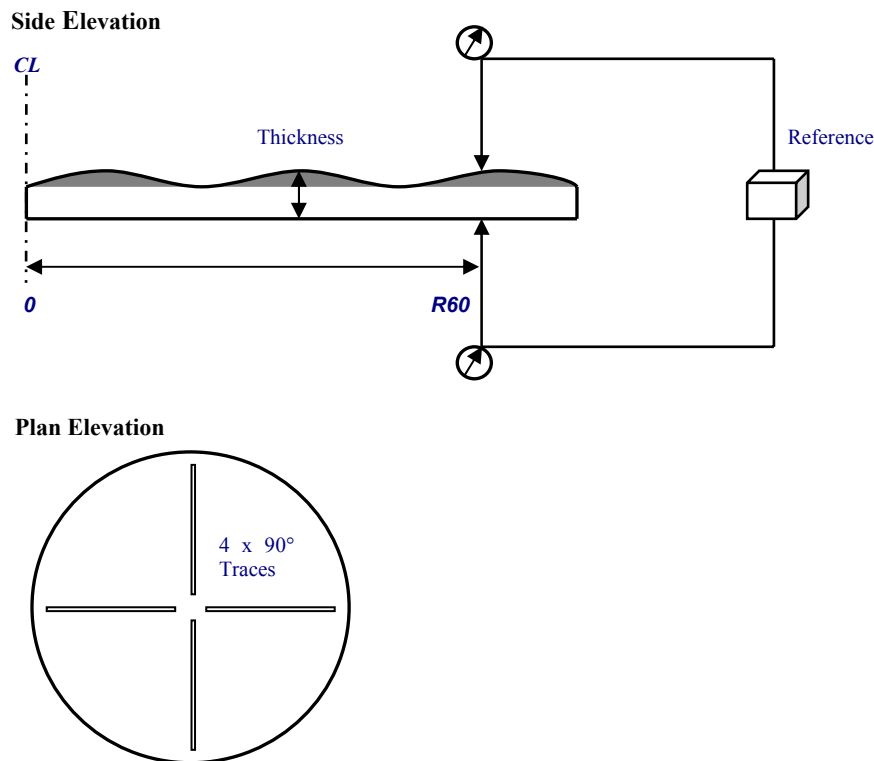
After considering current practices in replication worldwide (molds used by various replicators on different replication lines), it was decided to standardize on an allowable stamper thickness variation of  $297 \pm 3$  micrometer both for BD25 and BD50 stampers.

The stamper thickness can be measured for instance with a regular double sided capacitive probe based thickness measurement system. Measurement should be carried out to cover ideally a trace from the center of the stamper out to a radius of 60 mm.

As a minimum two, but preferably 4 traces should be measured, each trace under 90 degrees angle of each other to capture wedge and saddle type of shape effects on thickness variation of the stamper.

In practice, the capability of measurement instruments to measure all the way to the center is limited. Therefore, contact less thickness measurements over part of the surface (including at least the data area) can be combined with measurement of the center part of the stamper after punching with for instance a micrometer to get a good indication of the stamper thickness.

Control of the thickness variation is by adjusting the galvanics plating procedure and keeping bath conditions the same.



## Stamper Flatness

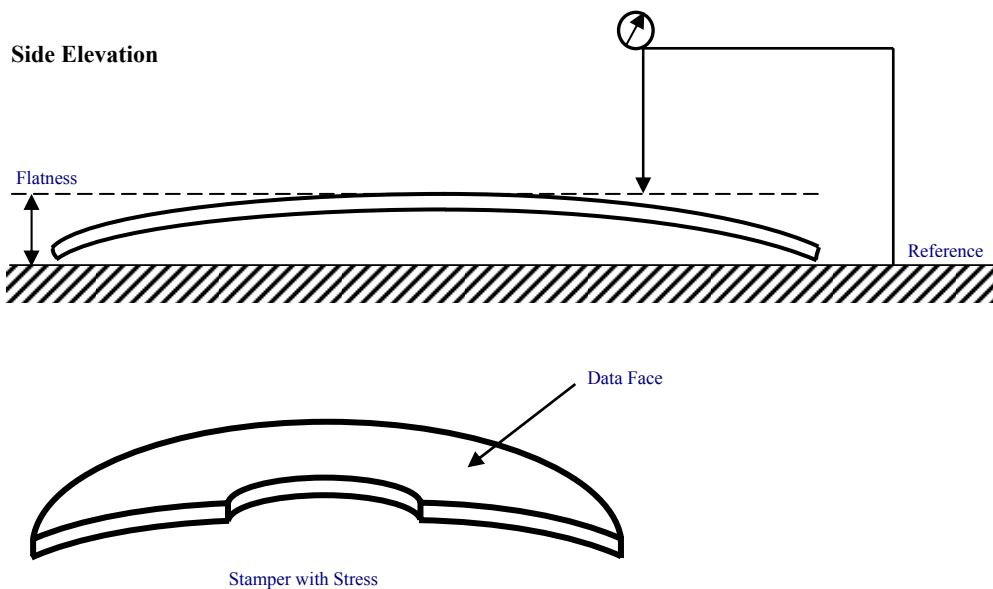
For BD25 and BD50 Layer 0, a flatness of less than 3 mm Peak to Valley (PV) is required. For BD50 Layer 1 the flatness should be better than 1 mm PV.

The more stringent requirement for BD50 Layer 1 is needed for replication by wet embossing. The holding force of the stamper during the processing of L1 is generated by vacuum and this holding force reduces while wet embossing since this takes place under vacuum conditions as well. When the stamper is too curved, this could result in the stamper coming loose when wet embossing the Layer1.

Due to L1 being embossed and not being subject to the same pressure as molding for L0, the 1 mm deflection PV can be achieved by a less intense stamper back finishing compared to the L0 stamper back finishing.

Evaluation can be done using a mechanical or optical stylus device or a gauge clock. Care has to be taken not to damage the sensitive area of the stamper by the measurement device.

Stamper flatness is determined by the amount of stress in the stamper, which is in turn determined both by the metallization step after recording the master and the subsequent plating and finishing operations.



## Hardness of the stamper surfaces

The data side of BD25 and BD50 stampers should ideally be 200 +10% HV0.3. The backside hardness should be 200 -10% HV0.3. The HV0.3 indicates testing to be done using a micro-Vickers hardness tester with a load of 0.3 kgf (3 N) on the diamond tip. A typical galvanics bath in steady state operation will typically produce stampers with such hardness.

The hardness as stated was found experimentally to be desirable for the following reasons:

- To allow finishing of the stamper with minimum bowing.
- The center hole size after punching will be more consistent to the tooling specified.
- To achieve reasonable stamper lifetime.

For electro-chemical reasons, when a completely new plating bath is started, the stamper hardness will initially typically be lower than the desired values (from 150 HV0.3 upward values are likely). Finishing and punching conditions in such cases may have to be adapted and results need to be monitored carefully to check the bowing and center hole size of the stamper after punching.

The hardness measurement can be done on the center piece that is punched out of the stamper. (The deformation caused by the measurement with a loaded diamond is unacceptable on a sensitive part of the stamper).

## Backside roughness of unfinished stamper (after plating)

The roughness requirements are captured by the following values:

$R_{max} < 10$  micrometer

$R_z < 5$  micrometer

$R_a < 0.8$  micrometer

These values apply for BD25 and BD 50 L0 and L1 stampers. The purpose of these requirements is to ensure that the stamper surface after plating is of sufficient quality that during finishing with the regular methods, an appropriate result can be obtained. Measurements can be done using a mechanical or optical measurement.

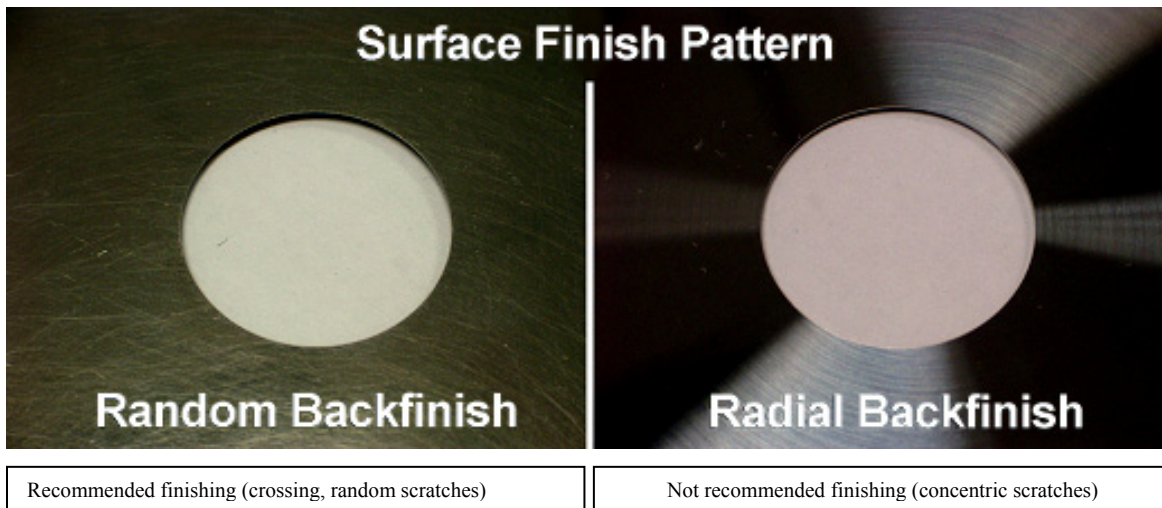
## Backside roughness of finished stamper

$0,5 < R_{max} < 1,5$  micrometer

$0,3 < R_z < 1,5$  micrometer

$0,04 < R_a < 0,15$  micrometer

Roughness values for BD25 and BD 50 L0 and L1 stampers in this range have been shown to produce adequate replication results. The lower limits are necessary to avoid sticking of the stamper to the mirror surface of the mold and ensure good transcription of the pit geometry during molding. Measurements can be done using a mechanical or optical measurement. Finishing can be one by wet abrasion.



A random scratch pattern on the backside of the stamper (crossing scratches), uniform over the whole surface of the disc (uniform reflectivity also), has proven to give optimum RSER and replication yield.

## Outer diameter

For BD25, BD50 Layer 0 and 1 the stamper diameter should be 138 mm +/- 0,1 mm. The punching tool diameter shipped with the equipment or refurbished will be verified by the equipment manufacturer and can be checked on a coordinate measuring machine if needed.

## Center Hole Diameter

In view of the differences in punching equipment and molds used by various replicators, the nominal diameter of stampers ( $D_{nom}$ ) can be different as indicated in table1, but basically, the diameter variation must be kept to  $D_{nom} +0,005 -0,000$  mm.

The accuracy of the punching tool is a critical factor to maintain diameter variation in spec, also over lifetime of the punching tool.

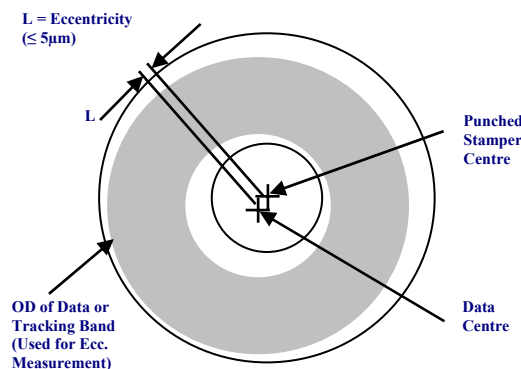
Measurements of the center hole diameter should be done on a freshly punched stamper.

To avoid damaging the stamper while inspecting it, a non contacting optical measurement probing method is used by the finishing equipment manufacturer to check the diameter of the center hole punch tool.

### Centre Hole Eccentricity

Eccentricity of the punched centre hole to data area outer diameter or punch band diameter should be less than 5 micrometers. 5 micrometers eccentricity or 10 micrometers RRO (radial run out), is a reasonable portion of the total BD radial run out budget of the final product, to which many process steps contribute. This can be realized using an optical centering optimisation procedure on the punching equipment.

Verification can be done using an off line optical scanner.



### Punch band eccentricity

The punch band eccentricity with respect to the tracks in the data area should be less than 1 micrometer on the stamper. Since this is written on the Laser beam recorder, where the required track pitch accuracy is in the nm regime, this should not be a problem.

### Punching and center hole burr size

Punching direction recommended differs for layer 0 and Layer 1 stampers. In any case, the punching tool quality and execution must be such that the burr size does not exceed a



height of 10 micrometer (BD25 and also BD50 layers 0 and 1). This limit is critical in order to avoid problems in replication with for instance the cover layer formation process.

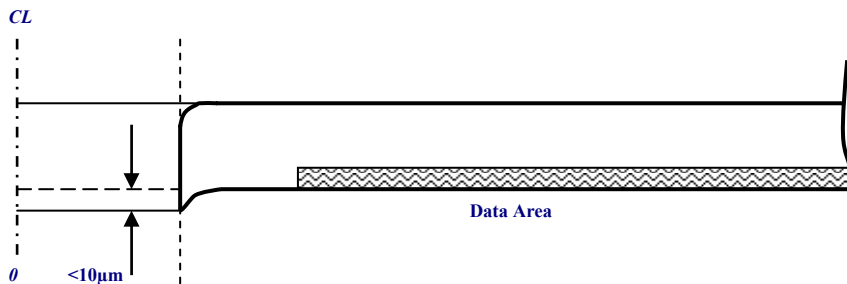
For Layer 0, punching from the backside is better to ensure a continuous lacquer flow from the stacking ring all the way out radially, covering all of the metallised area. This is important to prevent the risk of corrosion of the metal longer term under severe atmospheric conditions.

Punching from the front side would hamper the flow of the lacquers and also would potentially leave some area of the metalized layer between the stacking ring and the burr uncovered.

For Layer 1, punching from the front side is recommended. This results in a burr on the backside of the stamper that is not transferred in the Layer 1 embossing operation.

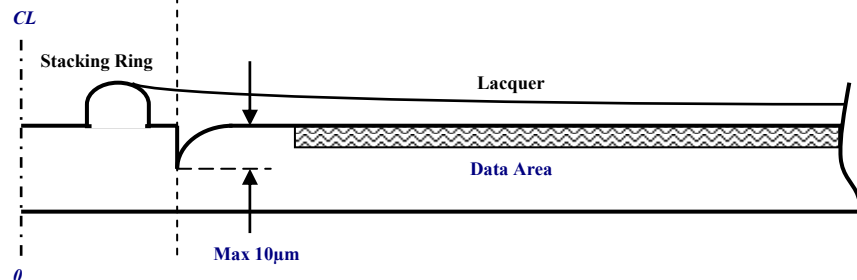
#### L0 Stamper – Reverse Punched

Side Elevation



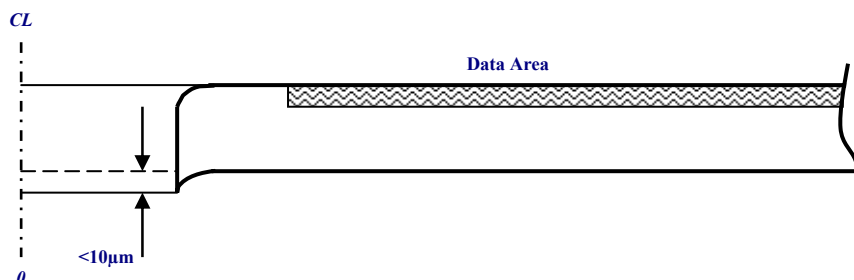
#### L0 Replica

Side Elevation



#### L1 Stamper – Standard Punched

Side Elevation



Although punching a stamper covered with protective tape or uncovered with such tape is irrelevant for replication, it is better to do so without covering present. If punching with protective tape or coating, tool life and center hole size will be affected negatively.

Reverse punching with protective coating or tape will not give the correct center hole size and acceptable burr size.

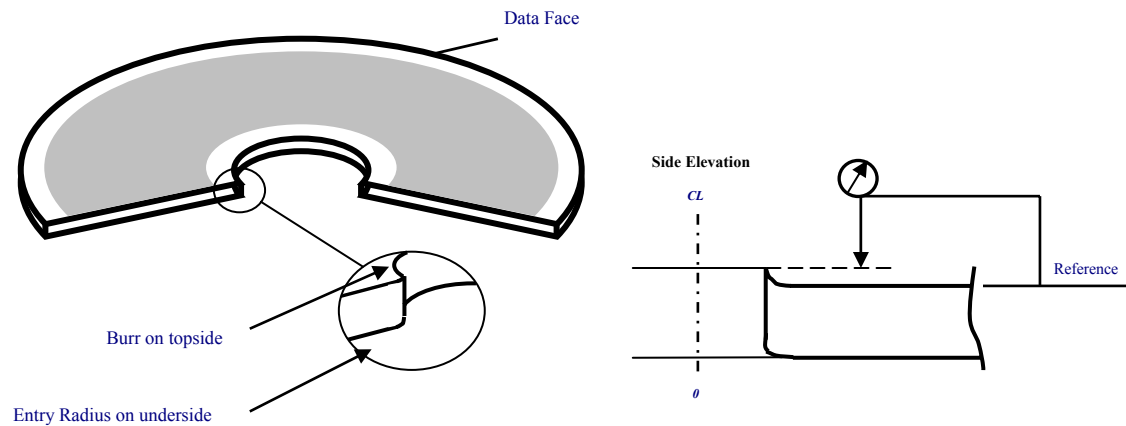
In case the center hole is punched from the front side of the stamper, the entry radius of the punched hole should be minimum.

Cleanliness of the punching tools and mounting surfaces are crucial for reliable punching operation without introducing defects on the stamper.

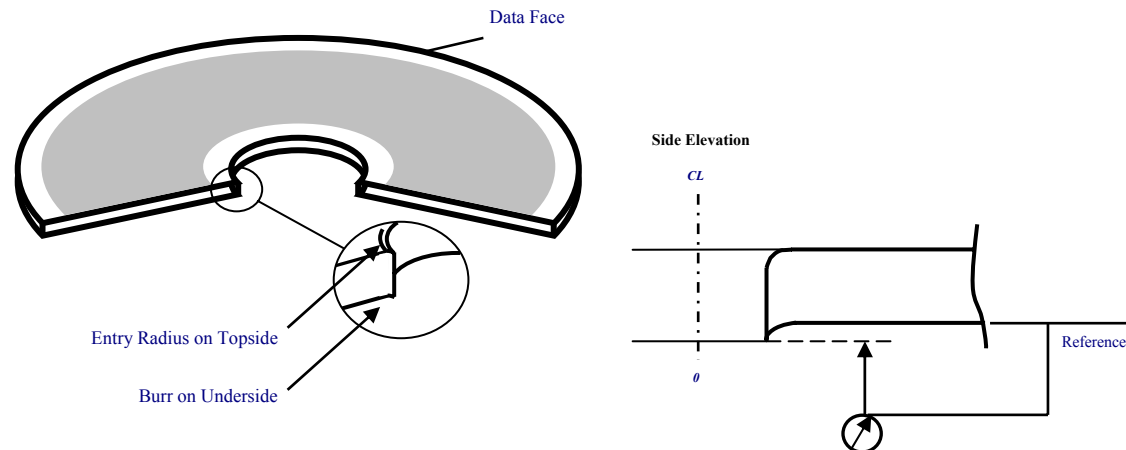
The reference plane for the burr size measurement is the backplane of the stamper. Measurement can be mechanical or using an optical microscope to determine the focus shift needed to focus on the reference plane and on the top of the burr.

Measurement of burr size and center hole size should be done on a freshly punched stamper.

**Reverse Punching L0**



**Standard Punching L1**

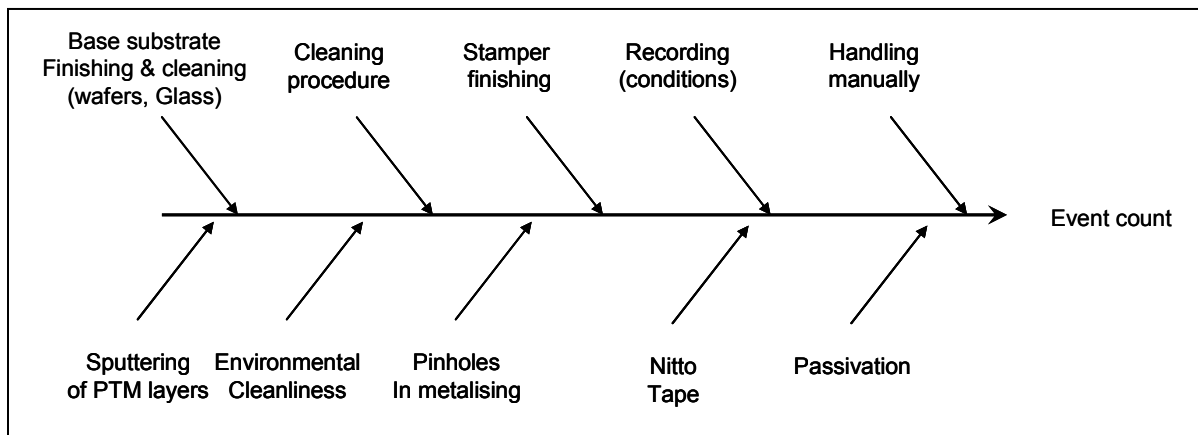


### Visual Appearance (Data Side)

< 15 defects < 50 micrometer,  
 < 5 defects < 100 micrometer,  
 No defects larger than 100 micrometer.

These defects can be observed visually or using an appropriate stamper line camera based scanner. Various optical scanners have been used (adapted to make them fit for use on stampers) to make the measurements quantitative and more objective than visual inspection by an operator. A stamper with less than 100 defect counts on such scanners has been shown to be likely to produce replicas without RSER problems.

Debris and defects on the stamper can come from a variety of steps in the manufacturing process, as indicated in the following influence diagram as a help to identify the cause of high numbers of event counts. If manual handling of stampers takes place, care has to be taken to use “clean” clothing, for instance gloves that do not contain powder that can contaminate the stampers.



### Visual Appearance (Backside)

No visible bumps and or scratches allowed. Inspection can be done looking at the reflection coming from the stamper surface using high intensity light source to illuminate it. Any deformation or intensity variation of the reflected image of the light source is an indication of a defect on the stamper surface.

## Summary of stamper requirements

Document Section	BD25 L0 / BD50 L0	BD50 L1	Unit	Manufacturing Equipment	Measurement Instrument
Thickness avg.	297±3		µm	plating console	capacitive detector
Backside Roughness R <sub>max</sub> unfinished	< 10		µm	plating console	mechanical roughness measurement
Backside Roughness R <sub>z</sub> unfinished	< 5		µm	plating console	mechanical roughness measurement
Backside Roughness R <sub>a</sub> unfinished	< 0,8		µm	plating console	mechanical roughness measurement
Punch band Eccentricity	<1		µm		non contact measurement
Backside Roughness R <sub>max</sub> finished	0,5 < R <sub>max</sub> <1,5		µm	wet finishing	mechanical roughness measurement
Backside Roughness R <sub>z</sub> finished	0,3 < R <sub>z</sub> <1,5		µm	wet finishing	mechanical roughness measurement
Backside Roughness R <sub>a</sub> finished	0,04 < R <sub>a</sub> < 0,15		µm	wet finishing	mechanical roughness measurement
Backside Pattern	Random Pattern		N/A	wet finishing	Visual Inspection
Backside Characteristic	Uniform Finish		N/A	wet finishing	Visual inspection
Data Side Macro-Hardness finished	200 +10%HV0.3		HV	plating console	micro Vickers Hardness Tester
Backside Macro-Hardness finished	200 -10%HV0.3		HV	plating console	micro Vickers Hardness Tester
Punch direction	Fom back to frontside	From front to backside			
Center Hole Diameter	21.990 -0.000/+0.005		mm	punch	non contact measurement
	21.995 -0.000/+0.005		mm	punch	non contact measurement
	22.000 -0.000/+0.005		mm	punch	non contact measurement
	22.005 -0.000/+0.005		mm	punch	non contact measurement
Center Hole Burr on backside	< 10		µm	punching tools	interferometer or microscope
Center hole Eccentricity	< 5		µm	optical centering	Optical inspection
Outer Diameter	138 ± 0.1		mm		
Flatness	< 3mm	< 1mm	mm	plating console, finishing	mechanical stylus or gauge clock
Visual Inspection - Data Side	<15 defects <50µm <5 defects <100µm		#	wet cleaning	line camera inspection system
Visual Inspection - Backside	no bump no scratch			plating console wet abrasion	high intensity light

## **Working group contact points**

The members of the working group invite feedback on the recommended practices and stamper characteristics described.

Companies involved with industrial equipment or processes for BD manufacturing, that have practices that result in stamper characteristics in line with this document and would like documentation about that referenced below are encouraged to contact the working group.

Regular evaluation meetings will be held, for instance coincident with MediaTech events.

### **For further information, please contact:**

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Info@Singulus.nl

BluRay@technotrans.de

## **References**

1. Technotrans PTM stampers manufacturing galvanics application note ([www.technotrans.de](http://www.technotrans.de))
2. Sibert BD stamper preparation application note ([www.sibert.co.uk](http://www.sibert.co.uk))