

Producing – testing Super Audio CD (SACD)

SACD Hybrid Disc

Developed by Sony and Philips, the Super Audio CD or SACD is the next generation music format that provides ultra-high sound quality. Additional features like multi-channel sound, text and graphics, plus backward compatibility with the installed base of CD and DVD players, become reality. The Scarlet Book published by Philips and Sony in March 1999 describes the SACD format and all its specifications, allows three different disc configurations: single-layer SACD, dual-layer SACD and the SACD Hybrid.

This latter version fulfils all the requirements specified by the Recording Industry's three major associations as originally defined by the Steering Committee (ISC). One of these wishes is full compatibility with the CD. Therefore, Philips recommends the replication industry to adopt the SACD Hybrid Disc.

Description of the Hybrid Disc Structure.

The SACD Hybrid Disc consists of a CD and a High Density (HD) layer. The CD layer of a SACD Hybrid Disc is fully compliant to the 'Red Book' CD specifications. The HD layer can contain up to 4,7 Gigabytes of Direct Stream Digital (DSD) data. As can be seen in figure 1 the logical structure of the HD layer is relatively simple and as straight forward as for the CD content layer.

An optional feature is the use of the Extra Data area in the HD layer. This Extra Data area can contain enrichments such as lyrics, visuals and graphics. Robust copyright protection and anti-piracy measures are strongly interwoven throughout the whole SACD Hybrid Disc.

SACD Hybrid physical requirements: comparison CD/DVD.

All properties of the CD layer in the SACD Hybrid Disc must comply with the 'Red Book' CD Specifications. The High Frequency (HF) and servo properties of the HD SACD layer as well as its mechanical and optical parameters are the same as those specified for DVD 5. Only the logical

layout of the content, the data format, and the copy protection measures are typical for SACD Hybrid.

SACD Hybrid Manufacturing – Process Overview

Masters & Stampers

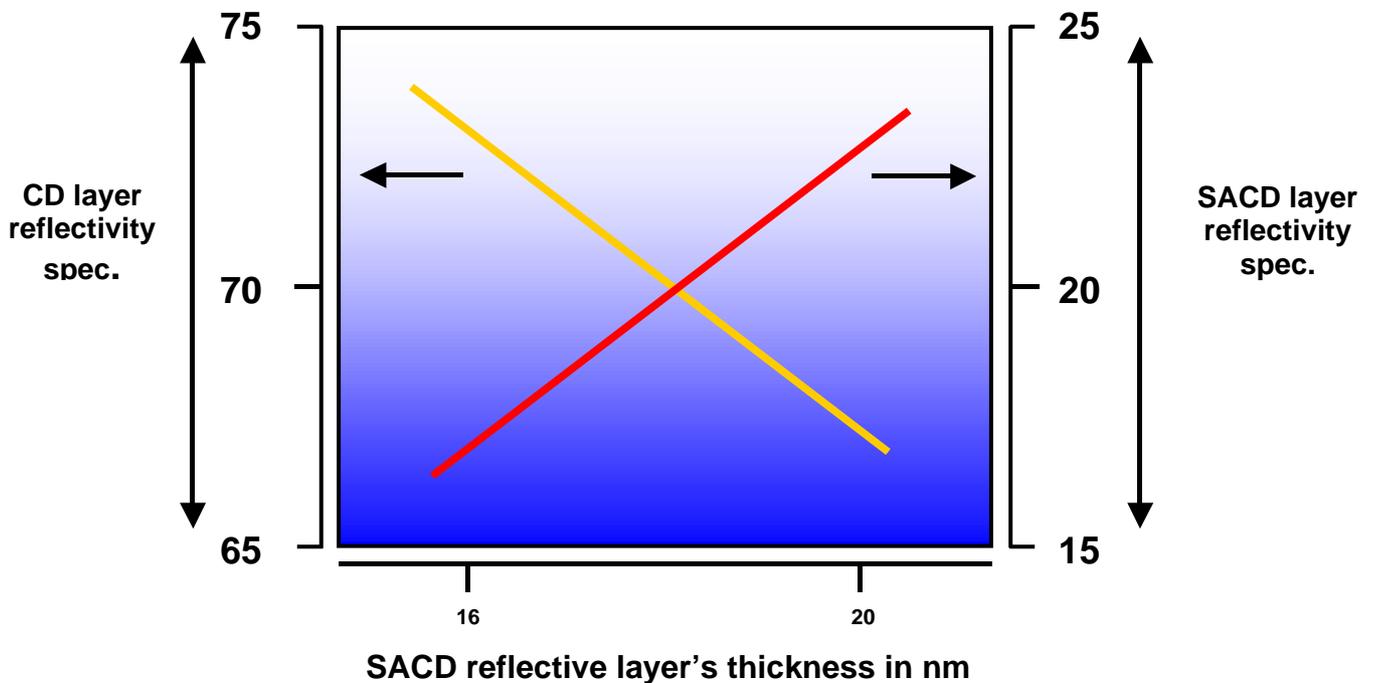
A set of two stampers is required for SACD Hybrid Disc manufacturing. These are a CD and a HD stamper both of which are mastered with a 413 nm (DVD) Laser Beam Recorder. Copyright and anti-piracy features are implemented during the glass mastering process. Further treatment of the masters and stampers is the same as for the DVD replication process.

Substrates

The CD and HD stampers are used for the replication of the SACD Hybrid Disc substrates. For both content layers, the replication is done with conventional 0,6 mm substrate (DVD) moulds and injection moulding or compression injection equipment.

Reflective Layer Deposition

The optical properties of the reflective materials for the HD and the CD layers in the SACD Hybrid disc need to be adjusted carefully in order to satisfy all physical and functional disc requirements. A sufficiently wide manufacturing window for the deposition of both layers is achieved by using silver for the CD layer and silicon-based material for the semi-transparent HD layer. This wide margin provides a relatively straightforward deposition process.



Bonding of the Hybrid Disc

The SACD Hybrid Disc is based on a two layer structure like DVD 9. However, the used bonding process is the same as for DVD 5. For DVD 9, the specified 50 µm separation of the two layers leads to a critical and narrow process window.

SACD Hybrid Disc in production

The manufacturing of the SACD Hybrid Disc resembles that of DVD, with only minor differences:

New formatter for the HD layer

New sputtering equipment for the semi-transparent HD layer

Adapted testing equipment for HF and Servo signals

For manufacturing, a few new tools are unavoidable. However, an existing DVD manufacturing line can be converted in a reversible way into a SACD line.

The involved processes of DVD and SACD are reasonably comparable and therefore the same personnel that operate DVD5 lines can operate SACD lines. As well one can expect a similar process cycle time as for DVD5

Test Criteria and Equipment

For manufacturing of SACD Hybrid discs, conventional in-line inspection systems can be used with similar criteria as for DVD. The same holds for off-line parameter testing. For the measurements of the HF and servo signals of both the CD and HD layer, commercial SACD test equipment can be procured from the major test equipment manufacturers. DaTARIUS has come up with a package called SACD Test Tandem, which consists of:



DVD Stamper and Replica Test player

- Scarlet and DVD book conform
- SACD and DVD stampers and replicas
- Pulstec DVD Pick-up head
- Patented Stamper Adapter

CD Multi format Test Player

- Red Book Conform
- CD Stampers, master and replicas
- Calibration for each media type,
- Patented Stamper Adapters

Double speed analysis

The test players mentioned above are SACD modified.

The test criteria for these signals are, in general, the same as for DVD (HD layer) and CD (CD layer in the SACD Hybrid). Nevertheless, there are light differences in specification.

In the case of Hybrid SACD, the signals used for CD and DVD can be applied for SACD testing. Some signals have seen their limits modified for the Hybrid SACD. As you can see in the table below, the modifications are not that tremendous.

	Scarlet Book	DVD Book	Red Book
Radial error	Max 0,02 µm	Max 0,022 µm	-
Radial noise	Max 0,014 µm	Max 0,016 µm	-
Reflectivity (CD)	Min 65 %	-	Min 70%
Reflectivity(HD)	15-30 %	18-30%	-
I14H variation over a revolution	Max 0,10	Max 0,15	-
I14H variation over the whole disc	Max 0,20	Max 0,33	-

Additional to this list, the jitter for the HD layer has also a different limit as the one specified for DVD. Philips and Sony have specified jitter differently as specified by the DVD forum for DVD. With DVD, the best jitter or "bottom jitter" is searched and can be achieved by optimising parameters such as Slicing Level, Tilt or Focus.

The Scarlet book defines jitter as to be measured without optimisation that cannot be executed by consumer players. Therefore, the jitter limit for SACD Hybrid is 9 % and not 8 % as specified for DVD.

The thickness of the bonding layer is not specified as it is for DVD 9. The technology used for DVD 5 can be used for SACD.

In the Scarlet book, birefringence is specified to be measured at the 2 different wavelengths: 650 nm (DVD/HD) and 780 nm (CD). Till now, optical testers use only one wavelength. Calculation based on the results can offer a value for the second wavelength, but this has to be considered with tolerance. In practice, birefringence will be measured with only one wavelength.

The semi-transparent layer is a silicon-based material. This High Density layer acts as colour filter:

- Reflective for 650 nm light,



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- Transparent for 780 nm light.

Because of this optical property, the light, which can be reflected, is not so intense as the light reflected on a DVD 9. Therefore, the reflectivity's lower limit in the case of the HD layer is lower than the specified DVD limit. The reflectivity limit of the CD layer is also lowered. The reason for this is the adaptation of the Redbook limit to the "DVD-like" structure of the Hybrid SACD.

As we have seen, there are no major differences between SACD and CD/DVD. As hybrid SACD shows up as new audio format with backwards compatibility with installed base of CD player. This is also the case for most of the production equipment (replication-testing).

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