Thermally Balanced Writing for High Speed CD-R recording

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1. Introduction

Directly after the introduction of CD-recordable (CD-R) in 1990, the tendency towards higher recording speeds started to develop. The "X-factor", indicating the overspeed with respect to the default speed of CD-audio, has been increased to over 12X. At higher linear velocities, in-track thermal interference becomes more important and restricts the suitability of the so-far used write strategies. To improve recording at high speeds, thermal balancing is proposed to diminish thermal interference to a great extend. In this paper, we report on the write performance of such thermally balanced write strategies.

2. Pre-heat and post-heat: thermal interference

The recording process for CD-R discs is based on irreversible deformation of the thin recording layer by heating the dye. The deformed area is called a pit and has lower reflection. Between these pits, unmodified areas of higher reflection remain, referred to as "lands". Variation of the land and pit lengths in a predetermined sequence enables the storage of binary data. The quality of bit-detection during readout of data is mainly determined by the jitter in the position of pit-edges. At low recording speeds, the accuracy of placing the pit-edges depends mainly on the steepness of the temperature gradient in the recording layer (dye). Therefore, the proposed write strategy for low speed CD-R [1] starts with an increased power level "ΔP" during 1.5 clock cycle (see figure 1). A pulse shortening of $\theta = 0.5$ to $\theta = 1.0$ is used to compensate for the spot size.

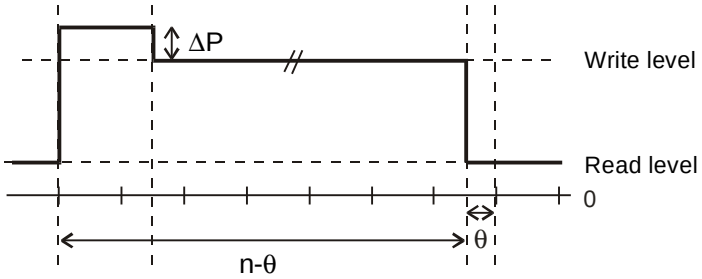

Figure 1 : Write strategy suitable for CD-recording from 1X up to 4X [1]

When a similar write strategy is used for recording at speeds higher than 8X, the thermal properties of the disc will affect the writing behaviour since the huge amount of power injected to write the neighbour pits diffuses towards the pit to be written. The positioning of pit-edges is no longer determined solely by the laser pulse, but also by the in-track thermal crosstalk in the disc due to the writing of adjacent pits.
There are two directions of in-track thermal crosstalk as visualised in figure 2. When a pit is written, the heat injected in the disc to write the previous pit will diffuse towards the position where the current pit has to start. This residual amount of heat is referred to as "pre-heat" and results into pit expansion at the leading edge.

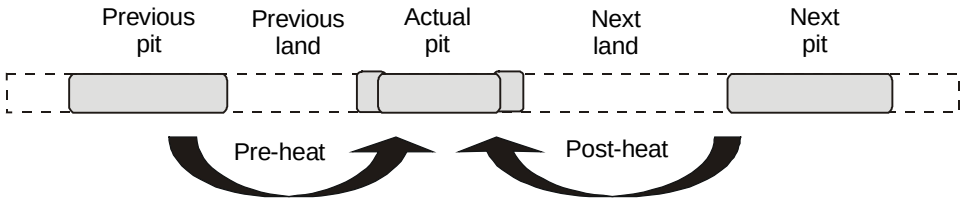

Figure 2:In-track thermal interference: the effect of pre-heat and post-heat

The amount of pre-heat encountered depends mainly on the length of the previous land. Therefore, pits will be expanded with a random magnitude since the length of the previous land is random. The second type of thermal crosstalk is caused by writing the next pit. When the actual pit is written, the next pit does not exist yet. However, when the next pit is written, the injected heat will diffuse back towards the actual pit and cause pit expansion at

the trailing edge. This phenomenon is called post-heat and has a stochastic level due to the variations in the next land length.

3. Results: Thermally balanced write strategy

Thermal interference between consecutive pits is more severe for short intermediate lands. To compensate for both types of in-track thermal crosstalk, the residual heat in the stack when writing a pit has to be taken into account. Therefore, the leading edge of a write pulse should be delayed when the previous land is short (a 3T land). A write strategy facilitating such thermal balancing by using as a thermal compensation delay τ is proposed in the Multi-Speed CD-R standard [2] and is repeated in figure 3. In addition, this write strategy involves write equalisation for the 3T pits by means of a ΔP. The restriction of the ΔP to 3T effects only results into an improved controllability of the write performance to anticipate to disc to disc variations.

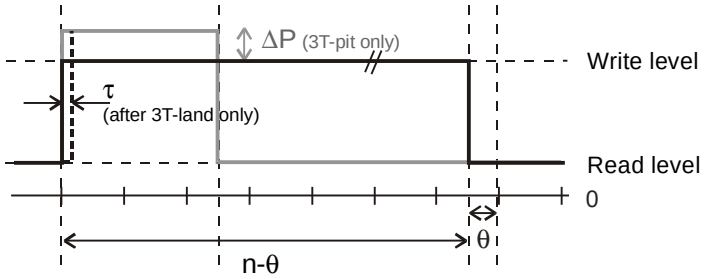

Figure 3 : Thermally balanced write strategy [2]

A thermally balanced write strategy was successfully applied to many discs at recording speed ranges from 8X up to 32X. Figure 4 shows the increased system margins as observed when stepping from the strategy of figure 1 to a thermally balanced strategy with 3T boost. Figure 5 is the eye pattern of a thermally balanced recording at 32X.

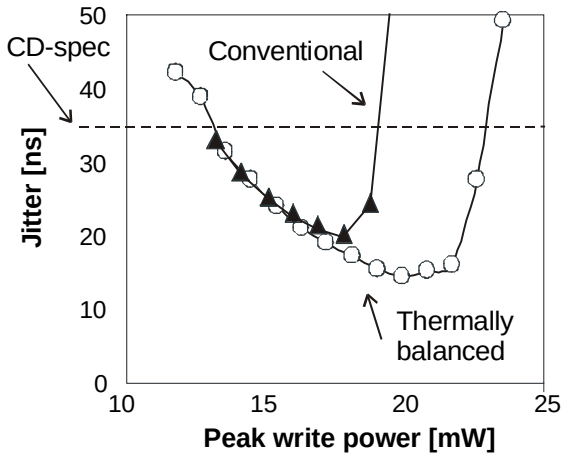

Figure 4 :Power margins when using a thermally balanced write strategy for 8X CD-R recording

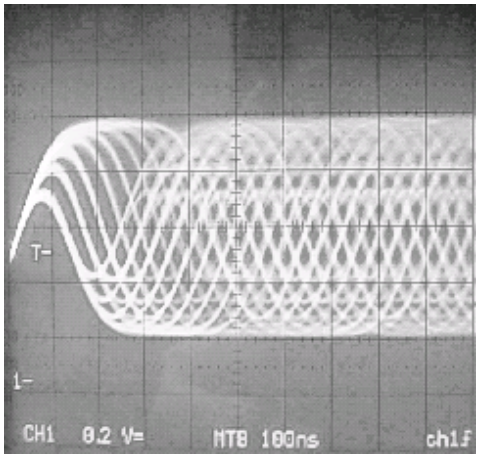

Figure 5 : CD-R Recording at 32X using a thermally balanced write strategy on a phthalocyanine disc

4. Conclusion

Conventional write strategies used for low-speed CD-R fail for higher recording speeds due to in-track thermal interference between written pits. To enable recording at higher speeds a thermally balanced strategy for CD-R was developed and experimentally tested on a large variety of CD-R discs. It was adopted as mandatory write strategy for media testing in the Multi-Speed CD-R standard. In the full paper, numerous measurements will be presented and substantiated using thermal modelling of the write process.

5. References

[1] Recordable Compact Disc Systems, Part II: CD-R, Volume 1: 1x/2x/4x, Version 3.1, System description, December 1998
[2] Recordable Compact Disc Systems, Part II: CD-R, Volume 2: Multi-speed CD-R, Tentative version 0.9, December 2000