Recording CD-R up to 56x

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ABSTRACT

The most important performance parameter for CD-R recording is the recording speed. We have achieved recording speeds of up to 56X on CD-R with a data-to-data jitter of 25 ns that is well within Orange Book specification. This jitter is achieved at zero asymmetry and with a write power margin of 20% of the optimum recording power. In this paper, we present results on a number of CD-R media. Furthermore, we discuss the influence of write strategy parameters, such as laser power level, laser pulse length, pulse shape, etc., on the recording performance of high speed CD-R.

1. INTRODUCTION

Recording/reading speeds are an important parameter and unique selling point of optical discs and drives. Since CD-Recordable was introduced to the market at the beginning of 1990's, efforts to increase its recording speed have never stopped. The compatibility enforced by the standardization policy plays an important role to make CD-R have a strong position in the optical removable storage market. CD-R recording at up to 40x and 48x speed has been covered by the Multi-Speed CD-R standard. At such high recording speed, a drive can almost write as fast as it can read.
In this paper, we report how to write CD-R discs up to 56x and the factors influencing the writing performance at the high speed.

2. THERMALLY BALANCED WRITE STRATEGY FOR HIGH-SPEED CD-R

One of the most important quality parameters of CD-R data recording is the jitter in the pit-length and land-length. The pit-length and land-length are determined by the positions of pit-edges. At low recording speed, the in-track thermal interference can be neglected. The neighbor laser pulses to burn previous and next pits hardly affect the edge position of the pit to be written. The main concern of a write strategy is how to make a steep temperature gradient in the recording layer so that the position of the pit-edge can be burnt accurately. Therefore the proposed write strategy for low speed CD-R [1] starts with an increased power level "ΔP" during the first 1.5 clock cycles. A pulse shortening of θ=0.5 to θ=1.0 is used to compensate for the spot size.
However, the same write strategy cannot be applied at higher speed (>8x) because the in-track thermal interference will become very serious at high-speed recording. Huge heat from the neighbor pits will diffuse towards the pit that is to be written. In such a situation, the position of the edge-pit is not only determined by the laser pulse imposed on the pit to be written but also affected by the so-called pre-heat and post-heat which are shown in figure 1. The lengths of the previous land and next land mainly determine the amount of the pre-heat and post-heat diffused to the pit to be written. Because the lengths of the previous land and next land are random, the pits to be written will be expanded with a random magnitude. This will cause unacceptably high jitter.

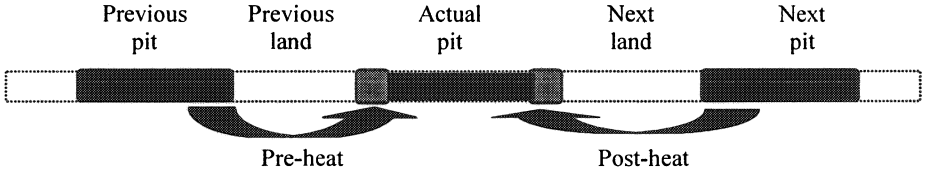

Figure 1: In-track thermal interference: the effect of pre-heat and post-heat

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To compensate for the in-track thermal interference, a thermally balanced writes strategy has been developed to cover the speed range from 4x to 48x. It has been included in the Multi-Speed CD-R standard as media testing condition. It is shown in figure 2 [2, 3, 4]. In the thermally balanced write strategy, the leading edge of a write pulse is delayed (τ) when the previous land is 3T. In addition, write equalization for 3T pits is applied by means of a ΔP.

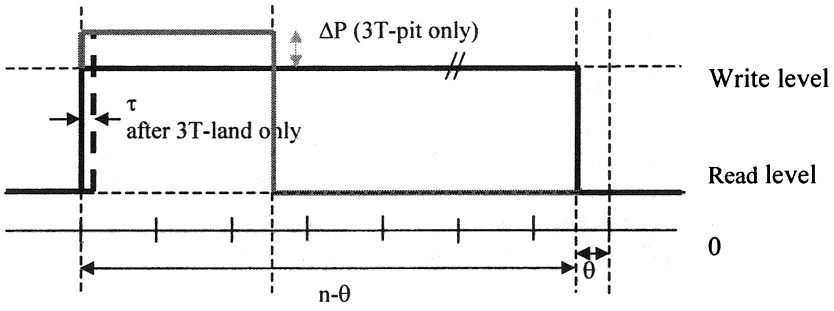

Figure 2: Thermally balanced write strategy

3. WRITING CD-R AT 48X

A lot of CD-R discs including phthalocyanine, cyanine and azo CD-R were experimentally written at 48x using the thermally balanced write strategy. Figure 3 and figure 4 depict the power margin for 48x writing of a phthalocyanine CD-R disc and EFM eyepattern respectively. All jitters are below 35ns (CD-spec). Asymmetry is between –5% and 6%. In addition, modulation is bigger than 66%. The power margin is 9mW (16%). Generally, the power margin for 48x writing is bigger than 15% if the thermally balanced write strategy is used. Large power margins are achieved also for cyanine and azo CD-R discs at 48x writing. Of course, the writing performance strongly depends on the CD-R quality as well as the write strategy.

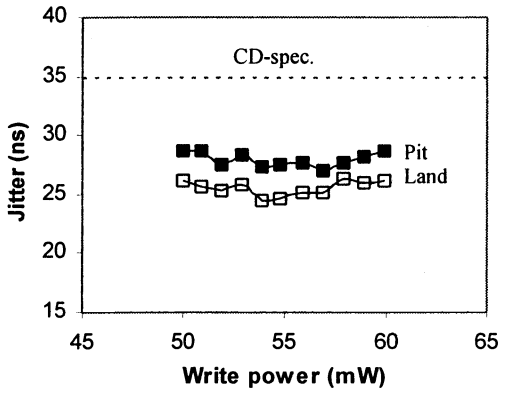

Figure 3: Power margin for 48x writing (phthalocyanine CD-R)

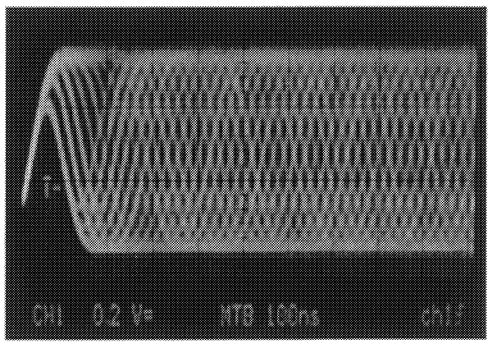

Figure 4: EFM eye pattern of 48x writing (phthalocyanine CD-R)

In order to achieve a large power margin for 48x CD-R writing, write parameters of the thermally balanced write strategy must be optimized because recording performance strongly depends on them. τ mainly influences pit jitter. ΔP mainly affects land jitter. Figure 5 depicts an example. In this case, 2T/16 and 4% are the optimum parameters for τ and ΔP respectively.

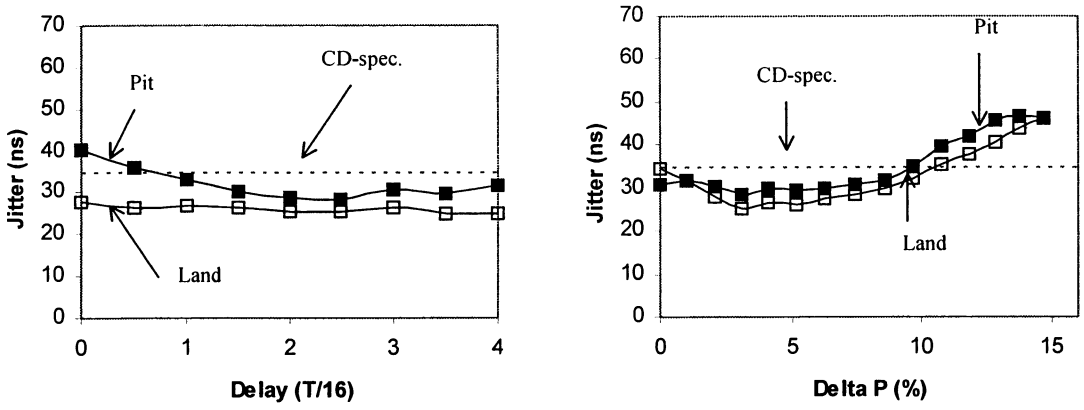

Figure 5: The influence of τ (delay) and ΔP on the jitter of a CD-R disc

Another factor influencing the writing performance of 48x CD-R recording is the laser pulse length (θ). Pulse length has a big influence on the write power and jitter. Figure 6 depicts an example. Long pulses have the advantage of low power, but too long pulses can affect the jitter. Therefore, depending on a disc characteristic, a compromise between power and jitter has to be found.

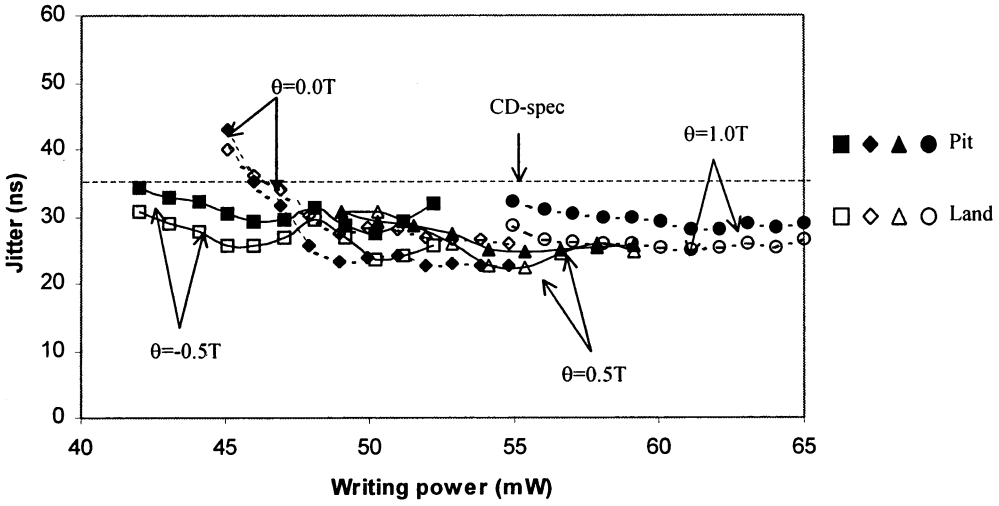

Figure 6: The influence of laser pulse length on the power margin of an azo CD-R

Overall, the thermally balanced write strategy can be used to write CD-R at 48x. All parameters after recording are well within CD and CD-R specification. A large power margin can be achieved if optimum writes parameters are used. The Multi-Speed CD-R standard has been upgraded to 48x successfully. The thermally balanced write strategy was adopted as the mandatory write strategy for media testing in the standard. 48x will be the final speed specified in CD-R standardization because it approaches to the mechanical limit of drive motor and CD-R substrate. This result suggests that the speed race for Recordable DVD's will also continue to such a final speed of 67m/s (16 to 20x DVD).

4. ACHIEVING RECORDING SPEED HIGHER THAN 48X

Although 48x will be the final speed for CD-R standard, it is very interesting to see what will occur at recording speed higher than 48x. In Philips Research-Shanghai laboratory, we successfully demonstrated the 56x CD-R recording with thermally balanced write strategy. The power margin and jitter-asymmetry curves of 56x recording of an azo CD-R are depicted in figure 7. Figure 8 shows the power margin of an azo CD-R disc from 4x to 56x written by thermally balanced write strategy. In every speed, the power margin is bigger than 20%.

This result shows that the recording speed of the dye layer is not limited by the write strategy but only by other factors such as the max motor speed or available laser power.

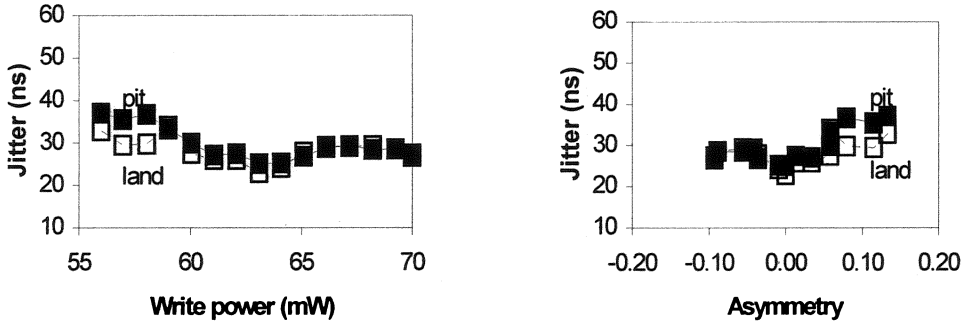

Figure 7: Power margin for 56x CD-R recording and jitter-asymmetry curves

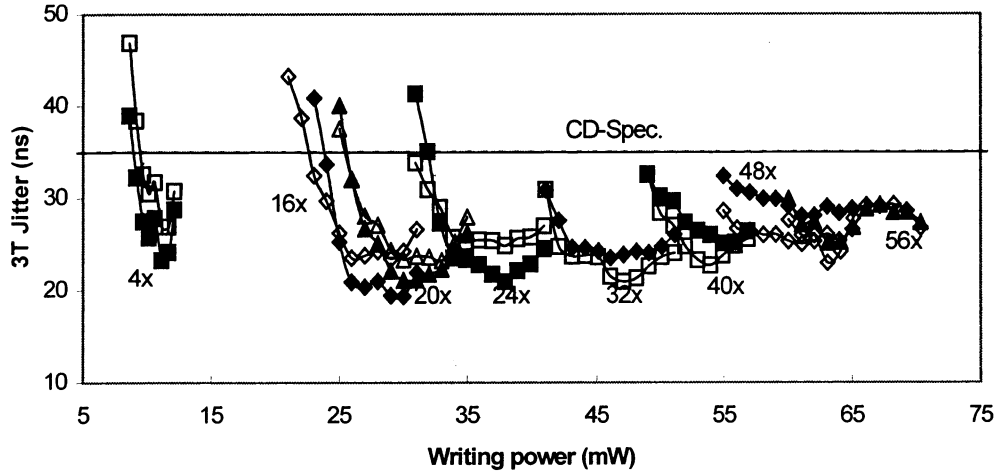

Figure 8: Power margins of a CD from 4x to 56x

5. CONCLUSIONS

Recording CD-R at 56x was successfully achieved by using the thermally balanced write strategy invented by Philips Research. All parameters after recoding are within the CD-R standard. A large power margin of bigger than 15% is achievable if optimum writes parameters are used. 67m/s maybe the final speed of organic dye as write-once optical recording media because other factors will limit a further increase of recording speed.

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