READ SPACING LOSS IN PERPENDICULAR MAGNETIC RECORDING

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Introduction

In perpendicular magnetic recording, an increase in the mechanical spacing between the magnetic head and the recording medium affects spacing loss because it weakens the magnetic coupling between the head and the medium [1][2]. In this report, we will discuss the results of measurements we made on the read spacing loss of both single-pole and ring heads on Co-Cr single-layer and Co-Cr/Ni-Fe double-layer recording media.

Experimental Procedure

Table 1 gives the characteristic values for the head and medium used in the measurements. After completing the saturation recording of the NRZI All 1's signals in the contact condition using a single-pole head, these recorded signals were played back with the insertion of a titanium foil (film thickness d 0.9 - 1.9 μm) as a spacer between the various types of read heads and the medium. In the recording wavelength (λ) region of 10 μm or above, the reproduced signals were analyzed in a spectrum analyzer to measure the attentuation corresponding to the spacing of each harmonic component for each individual recording density. In the wavelength region below 10 μm, the above measurement technique presents difficulties due to the deterioration of the signal to noise ratio so that a fast Fourier conversion was introduced for a Fourier analysis of the reproduced waveform with a 2 kFRPI recording density to measure the spacing loss from the attenuation due to the spacing of the higher harmonics ranging up to the 19th harmonic [3].

Results

For the region up to 2 μm spacing, it is possible to use the following expression by way of approximation:

Reproduction spacing loss =

$$K \cdot (d/\lambda) \text{ dB} \qquad (1)$$

The coefficient K is called the spacing loss coefficient and its dependence on the recording wavelength is shown in Fig. 1. It has been established that: (1) For the single-layer media (a) and (b), the loss coefficient is roughly equal to the

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longitudinal recording value 54.6 [4] at a wavelength under 50 μm
(2) For the double-layer medium (c) and (d), there is a particularly pronounced dependence of the loss coefficient on the wavelength, especially for ring heads (c); that is, at long wavelengths it is extremely high and at short wavelengths it is even smaller than 54.6.

For single-layer media, the head field distribution is virtually unaffected by the presence of the medium whereas for double-layer media the distribution range and the amplitude of the reproduction sensitivity change, since the strength with which the head and medium interact magnetically varies depending on their spacing.

For single-pole heads and double-layer media, the magnetic interactions between the main pole and the medium are skillfully exploited to achieve optimum recording density characteristics. In this context it has been established that the spacing loss is the greater; that is, the stronger the magnetic interactions between the head and the medium, the thicker the main pole, the thinner the Co-Cr layer, and the greater its saturation magnetization. It is therefore desirable to keep the spacing between the head and medium as small as possible in order to exploit the mutual magnetic interactions between the two to the fullest possible extent.

Editor's Note

This "read spacing loss," which includes read efficiency changes as well as spacing loss, should not be confused with the usual reproduce spacing loss of the form exb(-kd) or 54.6 d/λ dB.

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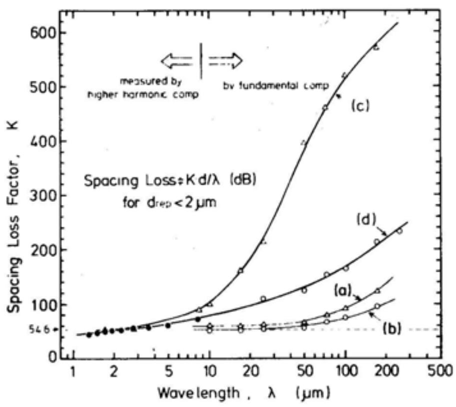
Table 1 Characteristics of the head and medium used for the spacing loss measurements

Head	Type	Tm or g, (μm)	W, (mm)
SPT-1	Single-Pole	1	2
SPT-2	Single-Pole	0.4	2
SPT-3	Single-Pole	0.9	2
RT-1	Ring	0.6	2

Medium	Layer	δ_{Co-Cr}, (μm)	$Hc_{\perp}$ (Oe)	Ms, (emu/cc)	δ_{BL}, (μm)
DL-1	Double	0.26	750	710	0.5
DL-2	Double	0.26	570	710	0.5
SL-1	Single	0.25	750	450	—
SL-2	Single	0.21	570	450	—



(a): Ring Head & Single Layer Medium [Rec: SPT-1, Rep: RT-1, Med: SL-1]

(b): Single Pole Head & Single Layer Medium [Rec, Rep: SPT-3, Med: SL-2]

(c): Ring Head & Double Layer Medium [Rec: SPT-1, Rep: RT-1, Med: DL-1]

(d): Single Pole Head & Double Layer Medium [Rec, Rep: SPT-2, Med: DL-2]

Fig. 1 Read spacing loss coefficient versus recording wavelength