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RECORD SPACING LOSS MEASUREMENT FOR D1 TAPE

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Abstract - Measurements of the record spacing loss have been made using D1 cobalt doped-gamma-ferric-oxide tape. The measured values at 1 micron wavelength range from 10 dB/wavelength at a spacing of 0.05 microns to 30 dB/wavelength at 0.20 microns spacing.

Introduction

Head-to-tape separation results in the well known 55 dB/wavelength playback loss[1] which is independent of gap length, head geometry, and the magnetic properties of the tape. A head-to-tape separation during record produces a loss because the record depth is reduced (for a fixed record current) and the magnetic transition width, which is determined at record time by the magnetic field distribution, is increased. At short wavelengths the record loss is dominated by the demagnetization effects[1] which determine the transition width.

Measurement Method

The record loss was measured using a longitudinal recorder[2] with single crystal manganese zinc ferrite heads with gap length of 0.33 microns. First reference recordings were made on a 13-micron thick Sony D1K tape at 1 and 2 micron wavelength with record current optimized for the 1 micron wavelength. Then the head contour was "spoiled" using 25-micron thick Fuji H621 tape (abrasivity = 0.03 μm/hour) as a lapping tape. This lapping with thick tape produced a head-to-tape spacing at the gap when the thinner 13-micron tape was again run on the transport. The magnitude of the head-to-tape spacing, which depended upon the amount of lapping, was then measured from the playback signal loss of the reference recordings. With a given head-to-tape spacing new test recordings were then made and compared with the reference recordings upon playback. The record current for all the test recordings was held constant at the same value as used for the reference recording. The new recordings were found to have a weaker playback as a result of both record and playback loss. The 13-micron tape was then run for a long enough time to remove the head-to-tape spacing, leaving only the record loss of the test recordings. The signal from original reference recordings was observed to make a complete recovery, and the amount by which the test recordings recovered was, in general, in good agreement with the amount by which the reference recording recovered. The abrasivity of the 13-micron tape Sony D1K tape was measured[2] and found to be 0.02 μm/hour at 60% relative humidity so that about 12 hours of running was needed to completely restore the head for another measurement.

This note was prepared for publication, but was not submitted to a journal. The note summarizes work reported in several earlier VLBA Acquisition memos.

Results

The results of the record spacing loss measurements are shown in the figure. The errors are estimated from the r.m.s. spread of many measurements made along the length of the tape. The spacing was estimated from the reproduce loss of the reference recordings (assuming 55 dB/wavelength) and the measured record loss is divided by the spacing in the wavelengths.

From the results it is clear that the record spacing loss is a function of the record spacing ranging from about 10 dB/wavelength at 0.05 micron spacing to 30 dB/wavelength at 0.20 microns spacing. For zero spacing, values of 0.35 microns and 0.15 microns were obtained for the record depth and effective spacing respectively, by fitting the wavelength dependence of the reproduce signal to the theoretical expression given by equation 59 of Bertram[1]. The effective spacing is the sum of the magnetic transition length and any dead layer which produces a residual spacing. The record current optimization was quite broad and a separate test showed that re-optimization of the recordings with head-to-tape spacing would have made little difference in the results. However, a constant record depth of about 0.3 microns could not have been maintained at large spacing owing to saturation of the head pole tips. As a result the record depth is inevitably reduced at the larger spacings. Because of the reduced record depth not all the signal reduction with spacing in the figure is the result of increased magnetic transition length. The measurements at 1 and 2 microns wavelength have been combined to separate the signal loss from reduced record depth from that of increased magnetic transition length "thickness loss" term in equation 59 of Bertram[1]. The solid squares in the figure are estimates of signal loss due to transition length alone. Errors are uncertain, owing to the model dependency, but are at least as large as those shown for the measurements. With the record depth correction the trend of increased record spacing loss with increased spacing is still significant.

Comparison with Theory and other Measurements

Middleton[3] gives an expression for the transition length of

$$\alpha = -\frac{\delta}{4} + \left(\frac{\delta^2}{16} + \frac{M_r \delta (d + \delta/2)}{\pi H_c}\right)^{1/2}$$

giving α = 0.09 μm
for δ = record depth = 0.3 μm
d = head-to-tape spacing = 0
M_r/H_c = 1220 Gauss/830 Oersted ~1.5
(for Sony D1K gamma ferric oxide tape)

and a record loss of 20 dB/wavelength at 0.05 μm from the dependency of a on d. The increase of record loss with increased spacing seen in the measurements is not predicted from the expression above. Computer modelling an array of magnetic particles in a manner similar to that of Miles and Middleton[4] has been attempted. The model was extended from 2- to 3-

dimensions and used the Karlquist head field. The model does show an increase in transition width with increased spacing, but needs more work and will not be described in this paper.

Bertram and Niedermeyer[5] have made measurements of record spacing loss by depositing a thin non-magnetic film on the head and obtained values from about 35 to 45 dB/wavelength at a spacing of about 0.25 microns. Given the range of magnetic materials and the larger spacing used, their results are consistent with the results presented here.

Conclusion

The measured record spacing loss using D1 tape at small spacing, is considerably lower than previously reported measurements, with other tapes at larger spacing. In practice, this result means that a small mechanical spacing, due to head flying or other causes, is more tolerable at short wavelengths during record than during reproduce.

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References

[1] Bertram, H. N., "Fundamentals of the Magnetic Recording Process", Proc. IEEE, pp 1494-1512, Nov. 1982

[2] Hinteregger, H.F., Rogers, A.E.E., Cappallo, R.J., Webber, J.C., Petrachenko, W.T., Allen, H., "A High Data Rate Recorder for Astronomy", IEEE Trans. Magn. Vol. 27, No. 3, pp 3455-3465, May 1991.

[3] Middleton, B.K., "Magnetic Recording" Vol. 1 Edited by Mee, C.D. and Daniel, E.D., Chapter 2, pp 62 Equation 2.52, McGraw-Hill, N.Y., 1987

[4] Miles, J.J. and Middleton, B.K., "Transition Structure in Longitudinal Thin Film Magnetic Media", IEEE, Trans. Magn. MAG-26, pp 204-206, June 1990.

[5] Bertram, H.N. and Niedermeyer, R., "The Effect of Spacing on Demagnetization in Magnetic Recording" IEEE Trans. Magn. MAG-18, pp 1206-1208, Nov 1982.

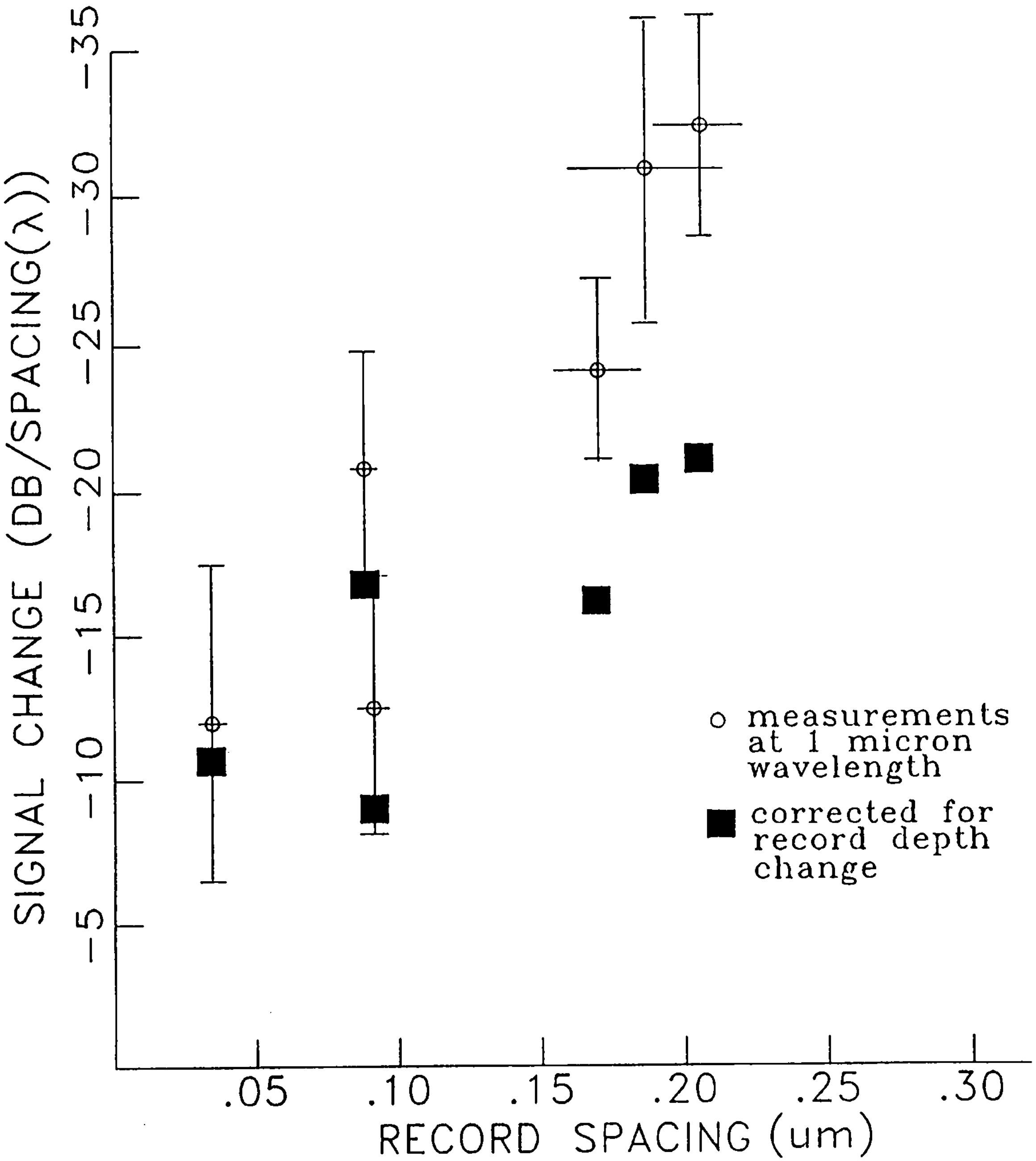

Fig. Measurements of record spacing loss at 1 micron wavelength. Corrections for record depth reduction shown are derived by combining measurements at 1 and 2 microns wavelength.