# DEVELOPMENT OF BARIUM FERRITE TAPE MEDIA WITH HIGH SNR AND THERMAL STABILITY

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## I. INTRODUCTION

The total volume of digital data is increasing at an explosive pace and is projected to reach 44 zetabytes (ZB) by 2020—10 times the volume of data estimated for 2013 [1]. Particulate media-based tape storage systems are widely used for data backup and archiving applications because of their low cost, stability of the recording media for long-term data retention, and the reliability of information retrieval and reproduction. Therefore, it is important to continuously increase the storage capacity of magnetic tapes. Achieving a higher areal recording density, requires the volume size of magnetic particles to be reduced. However it is a cause of deterioration of thermal stability. In this study, we investigated whether high thermal stability can be obtained with magnetic tapes in fine barium ferrite (BaFe) particles.

## II. EXPERIMENTS AND RESULTS

We have developed a magnetic tape medium (test tape) using BaFe particles as small as 1360 $nm^3$, which is approximately 30% smaller than those used in LTO7 tape. In addition, we improved the KuV/kT (by increasing the Ku) by adjusting the amount of substitution element.

***(i) Parametric properties:*** The recording performance of the test tape and LTO7 tape was evaluated using a loop tester at a linear velocity of 2 m/s with an enhanced field tape write head (described in reference [2]), consisting of conventional $Ni_{45}Fe_{55}$ poles with an additional 200-nm-thick liner layer of CoFe deposited between the write gap and the trailing pole, and a giant magnetoresistive head. The broadband SNR was calculated from the root mean square voltage of the read-back signal corresponding to a written data pattern of a period of $2T$ (where $T$ is the channel bit period) and the noise, which was the integral value of the power spectral density from 0 to $1/T$ Hz, as measured with a spectrum analyzer.

Fig.1 shows the dependence of the output of the test tape and LTO7 tape on the recording linear density. The test tape exhibited a higher output and an improved frequency response than the LTO7 tape. The higher output of the test tape is attributed to both the high degree of perpendicular orientation (perpendicular squareness ratio: 0.79, 0.66 for test tape and LTO7 tape respectively) and a reduction in the surface roughness (AFM Ra: 1.7 nm, 2.0 nm for test tape and LTO7 tape respectively).

Fig.2 shows the signal and modulation noise spectrum at a linear density of 350 kfci (kfci = 1000 flux changes per inch). Since the surface roughness is smooth, it is conceivable that the media noise of the test tape increases with the output as compared with the LTO7 tape, but the same media noise as the LTO7 tape is obtained. This is primarily thought to result from the reduction in the magnetic particle volume from 1950 $nm^3$ to 1360 $nm^3$. As a result, the BB-SNR of the test tape was 4.0 dB higher than that of the LTO7 tape at a linear density of 350 kfci.

***(ii) Thermal stability:*** In order to investigate the effect of enhancing the thermal stability by improving the KuV/kT, we compared the decay rates of the test tape both before and after KuV/kT improvement of the test tape. Fig.3 shows the signal degradation of the test tape and that of the tape before KuV/kT improvement. The decay rate of the test tape was 0.029 dB/decade. This value was lower than that of the tape before KuV/kT improvement (0.071 dB/decade) and corresponds to maintaining the bit error rate, which is permitted to be less than $1 \times 10^{-4}$ when using the GPR4ML-AR model that is implemented in an actual tape drive after $10^9$ seconds (approximately 30 years) storage at 24 °C [3-5].

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## III. SUMMARY

We successfully developed a BaFe particulate tape of which the BB-SNR was 4.0 dB higher than that of a commercially available LTO7 tape at a linear density of 350 kfci and of which the thermal stability was acceptable for long-term archiving over approximately 30 years. We believe this advanced BaFe particulate tape is a promising candidate for next-generation magnetic particulate tapes. Furthermore, we expect tape-storage systems using BaFe particulate media to continue to provide sufficient storage capacity at a low total cost of ownership for many years to come.

## REFERENCES


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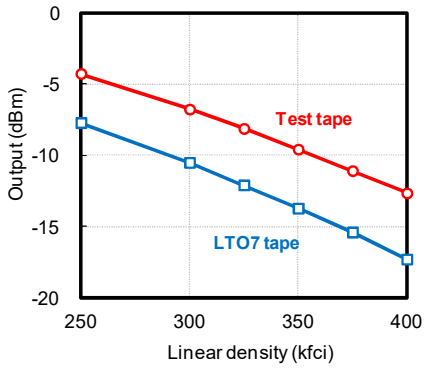


Fig. 1 Recording linear density vs. 2T output.

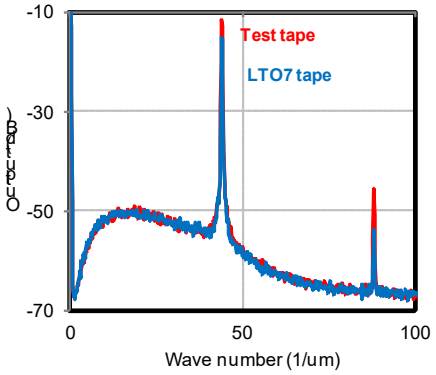


Fig. 2 Signal and modulation noise spectrum at a linear density of 350 kfci.

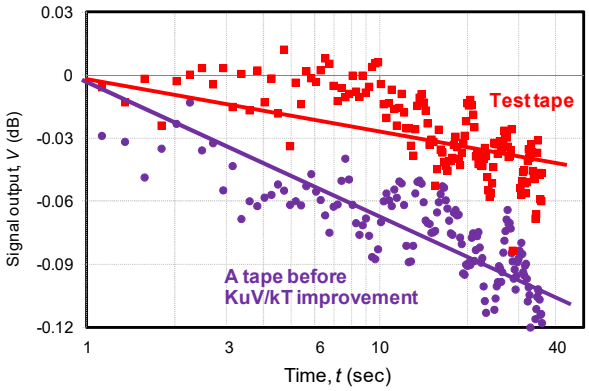


Fig. 3 Signal decay of test tape and the tape before KuV/kT improvement. Solid lines are results fitted with 0.029 [dB/decade] (test tape), and 0.071 [dB/decade] (tape before KuV/kT improvement).