MMM 2022 Conference

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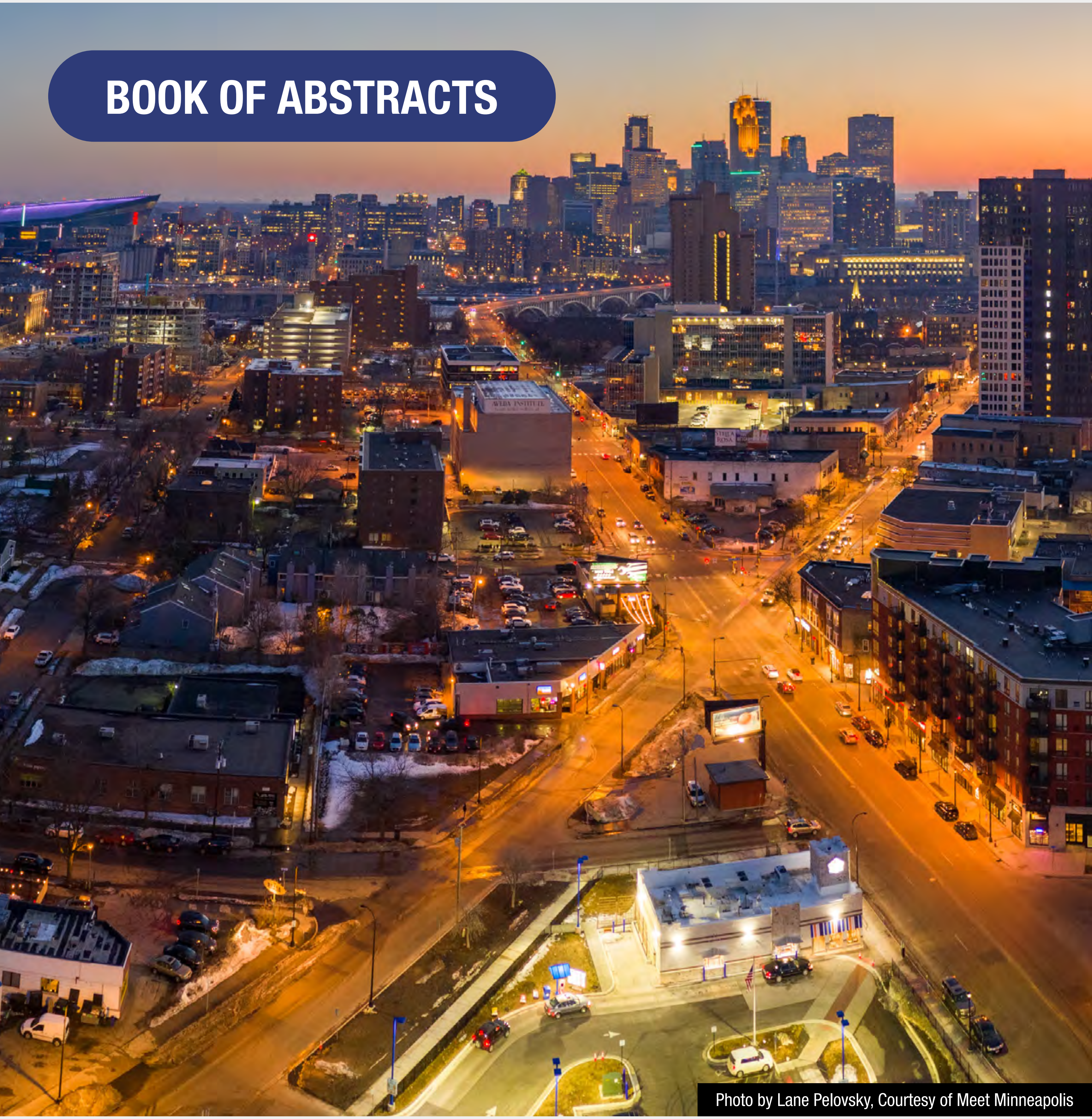
BOOK OF ABSTRACTS



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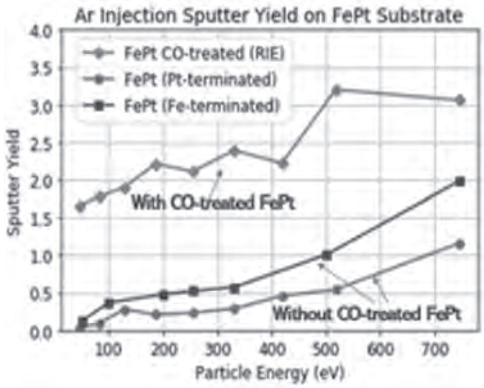

Figure 2. FePt sputter yield (with Ar ions) comparison on CO/H_2-treated and non-treated surface

IOB-05. FePt-BN Granular HAMR Media with High Grain Aspect Ratio and High $L1_0$ Ordering on Corning Lotus™ NXT Glass.

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The key to realizing high area recording density capability (ADC) for heat assisted magnetic recording (HAMR) is to achieve small grain size (and pitch) in the granular $L1_0$ FePt media with a sufficiently high grain aspect ratio [1]. Media such as FePt-C, FePt-SiO_x, and FePt-TaO_x, or multilayers made of a combination of them, appear not able to reach the desired goal because of their failure to achieve either high grain aspect ratio, small grain size, or high $L1_0$ ordering, respectively [2, 3]. In this study, using the co-sputtering technique, we demonstrate the fabrication of FePt-BN granular media with much reduced FePt grain size and high grain aspect ratio. In particular, an underlayer stack of Ta(5nm)/Cr(50)/MgO(9) is first deposited on Corning Lotus™ NXT glass followed by co-sputtering of FePt and BN at an elevated substrate temperature along. A RF bias is applied to the substrate during the FePt-BN deposition with a short and optimized delay. Figure 1C shows the order parameter as a function of substrate temperature for the FePt-BN granular film media, calculated from XRD measurements. The volumetric concentration of BN is at 38%. Figure 1A on the left of the figure shows a cross-section TEM micrograph of the FePt-BN layer formed at a substrate temperature of 725 °C. Figure 1B shows a cross-section TEM picture of FePt-BN/FePt-SiO_x multilayer granular film with temperature and composition graded over the grain height for producing tall grains [4] for comparison. The grain size of single layer FePt-BN film (Figure1 A) is around 4 nm with an aspect ratio of 2 while the grain size of the FePt-BN/FePt-SiO_x multilayer film is around 7nm and grain height 11nm. The small grain size with a relatively high grain aspect ratio in the single layer FePt-BN film is promising for enabling high area recording density capability.

[1]Y. Kubota et al., "Heat-Assisted Magnetic Recording's Extensibility to High Linear and Areal Density," IEEE Transactions on Magnetics, vol. 54, no. 11, Nov. 2018. [2] A. Perumal, Y.K. Takahashi, K. Hono, "L10 FePt-C Nanogranular Perpendicular Anisotropy Films with Narrow Size Distribution", Appl. Phys. Express 1 101301 (2008). [3] B. S. D. C. S. Varaprasad, M Chen, YK Takahashi, K Hono "L1-Ordered FePt-Based Perpendicular Magnetic Recording Media for Heat-Assisted Magnetic Recording" IEEE transactions on magnetics 49 (2), 718-722 (2013) [4] C. Xu, B. Zhou, T. Du, B.S.D.C.S. Varaprasad, D.E. Laughlin, J.-G. Zhu, Understanding the growth of high-aspect-ratio grains in granular L10-FePt thin-film magnetic media, APL Materials. 10 (2022).

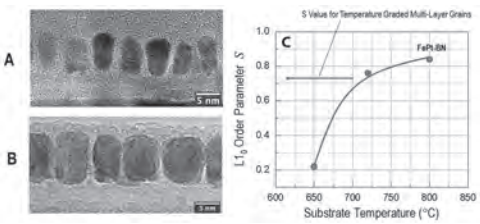

Figure 1 (A) Out of plane micrographs of FePt-BN (8 nm) (B) Out of plane micrographs of FePt-BN/FePt-SiO 2 (11 nm) and (C) Order parameter Vs set temperature of FePt-BN sample

IOB-06. A Rate-7/8 Modulation Code for Double-Track Reading Scheme in BPMR Systems.

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To increase an areal density (AD) of magnetic recording technology, bit-patterned media recording (BPMR) is one of the promising candidates for the next generation of hard disk drive [1]. To achieve a high AD, the track pitch and bit length must be greatly reduced. Because the reader's sensitivity response has a wider coverage area than the width of a written track, the inter-track interference will be unavoidable [2,3]. To improve the performance of a double-track reading (DTR) scheme in a staggered BPMR system as shown in Fig. 1; therefore, we propose a rate-7/8 two-dimensional (2-D) modulation code, which guarantees that the BPMR readback signal will not be corrupted by severe interference. To do so, we first analyze the peak amplitude of all possible $2^8 = 256$ data patterns in a matrix form of 2×4 bits, which are arranged as a staggered array BPMR, where the peak amplitude of each data pattern is obtained by the 2-D convolution between its magnetization and the readhead sensitivity response as shown in Fig. 1. Consequently, we found that when the 2×4 data pattern contains many 1's and -1's, the readback signal amplitude will be degraded which easily causes an error in the data recovery process. Therefore, this condition is utilized as a criterion for codeword designing to avoid such destructive data patterns. The encoding process easily operates based on a look-up table, while the Euclidean distance concept is applied in the decoding process. We evaluate the performance of 1) the proposed DTR system with a rate-7/8 2-D modulation code, 2) the DTR system without coding [4], and 3) the conventional system which uses one reader. The user density (UD) is defined as UD = AD×R, where R is a code rate. We define SNR = $10\log_{10}(1/\sigma^2)$ in dB, where σ is a standard deviation of AWGN. As depicted in Fig. 2, it is clear that at BER = 10^{-5} the proposed coded system at UD = 2.6 Tb/in^2 performs better than the uncoded system of about 1.0 dB and is superior to the conventional system.

[1] Y. Shiroishi et al., IEEE Trans. Magn., vol. 45, no. 10, pp. 3816-3822, Oct. 2009. [2] S. Nabavi and B. V. K. V. Kumar, in Proc. of ICC, pp. 6249–6254, Jun. 2007. [3] H. Muraoka and S. J. Greaves, IEEE Trans. Magn., vol 51, no.11, pp. 3002404, Nov. 2015. [4] C. Buajong and C. Warisarn, in Proc. of iEECON 2017, pp. 457-460, Mar. 2017

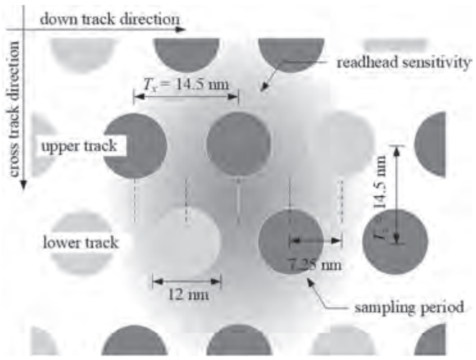

Fig. 1. Configuration of the proposed DTR systems at AD = 3.0 Tb/in^2 under the readhead sensitivity response that is positioned between the desired upper and lower tracks.

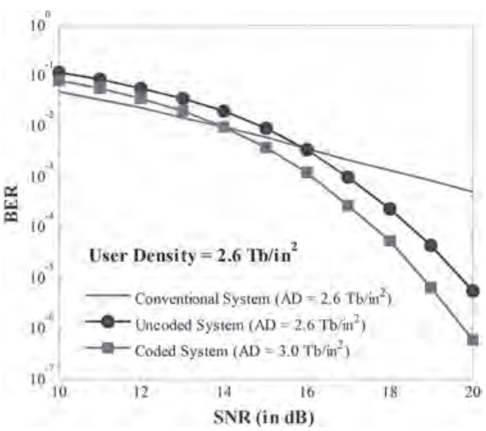

Fig. 2. Performance comparison of various systems at UD = 2.6 Tb/in^2.

IOB-07. Double-Layer Magnetic Recording with Multilayer Perceptron Decoder for Single-Reader/Two-Track Reading in BPMR Systems. *N. Rueangnetr*[1], S. Koonkarnkhai[2], P. Kovintavewat[2] and C. Warisarn[1] *1. College of Advanced Manufacturing Innovation, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand; 2. Nakhon Pathom Rajabhat University, Nakhon Pathom, Thailand*

The distance between islands must be reduced to increase an areal density (AD) in bit-patterned media recording (BPMR) [1]-[2], which means both inter-symbol interference (ISI) and inter-track interference (ITI) effects are avoidably increased. Therefore, BPMR system performance is effortlessly degraded [3]. In prior work [4], constrained code working with a multilayer perceptron (MLP) decoder in a staggered-array BPMR system was proposed. However, to get more improvement in the overall system performance of the magnetic recording system, we propose to apply the three-dimensional (3-D) magnetic recording that has double recording layers [5] with the constrained code performing with the MLP decoder. Here, a double recording layer medium is designed as a staggered pattern as shown in Fig. 1. Each layer is arranged as a regular array. Both of them are then arranged in a staggered pattern. The proposed double recording layer not only avoids the significant signal degradation from inter-layer interference (ILI) but also mitigates ISI and ITI effects. An input sequence, $u_k \in \{\pm 1\}$, is encoded by LDPC code and the rate-3/5 constrained encoder to obtain two encoded data sequences, $[x_{k,0}, x_{k,1}]$ as shown in Fig. 2. The odd, $x_{k,0}$, and even, $x_{k,1}$, data sequences are recorded in the upper and lower layers, respectively. A single reader is always positioned between two desirable tracks to retrieve the readback signal, which is then oversampled at time $t = kT_x/2$ to obtain a data sequence, r_k, where T_x is a bit period. The 1-D equalizer and 1-D modified-soft output Viterbi algorithm (m-SOVA) are used to equalize and determine a log-likelihood ratio (LLR), λ_k, respectively. Then, it is decoded and produced the improved LLR values, respectively, with the rate-3/5 decoder and LLR estimator based on MLP, λ''_k. Finally, the estimated user bit, $\hat{u}_k$, is produced using an LDPC decoder. Simulation results indicate that, at the same user density (UD), the proposed system (AD = 5 Tb/in^2) provides BER performance over the previous system [4].

Y. Shiroishi et al., IEEE Trans. Magn., vol. 45, pp. 3816-3822 (2009) R. L. White, R. M. H. New, and R. F. W. Pease, IEEE Trans. Magn., pp. 990-995 (1997) P. W. Nutter et al., IEEE Trans. Magn., vol. 41, pp. 3214-3216 (2005) N. Rueangnetr et al., 19th ECTI-CON 2022, pp. 1-4 (2022) Y. Nakamura et al., IEEE Trans. Magn., vol. 58, pp. 1-5 (2022)

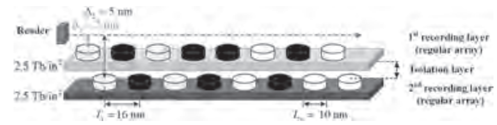

Fig. 1. Cross-section of head-media geometry for double recording layer medium.

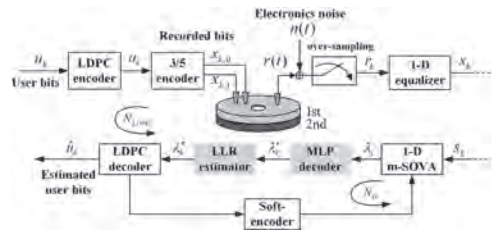

Fig. 2. A code BPMR channel model with the rate-3/5 constrained code.

IOB-08. A Study of Bit Island Spacing Optimization of Staggered Patterned Media-based SRTR Scheme in BPMR Systems.
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Many promising recording technologies have been introduced for hard disk drives to increase an areal density (AD), this paper considers the bit-patterned magnetic recording (BPMR) technology because it can achieve AD beyond 4 Tb/in^2 [1]. To increase an AD in BPMR, which unavoidably leads to a problem of two-dimensional (2D) interference. To combat this difficulty, several techniques have been proposed based on modulation codes [2] and iterative processing [3]. Additionally, the BPMR system performance can be further enhanced by the proper island placement [4]. In this paper, we propose to optimize the bit-length (T_x) and track pitch (T_z) of BPMR under a single reader/two-track reading (SRTR) technique, which leads to getting greatly improved BER performance. Here, we arrange the island in a staggered pattern. The single reader was then employed to read both desired data tracks simultaneously. The signal waveforms from the upper and lower tracks, and the readback signal, that correspond to the data bits stored in the staggered medium through our proposed system are illustrated in Fig. 1. Here, we then investigate five cases under an iterative partial response maximum likelihood (PRML) system as follows: Case 1: T_x = 13.0 nm and T_z = 16.2 nm, Case 2: T_x = 14.0 nm and T_z = 15.0 nm, Case 3: T_x = 14.5 nm and T_z = 14.5 nm, Case 4: T_x = 15.0 nm and T_z = 14.0 nm, and Case 5: T_x = 16.2 nm and T_z = 13.0 nm, to obtain AD of 3 Tb/in^2. Its data samples that were obtained from the over-sampling technique will then be processed through iterative PRML detection. Simulation results indicate that a system that has a larger bit-length distance, T_x, (Case 5) can provide the highest system performance when compared to other cases as shown in Fig. 2. In addition, the proposed system that encountered media noise still provides the highest system performance. It means that choosing proper T_x and T_z spacing can increase the efficiency of the staggered SRTR BPMR system.

[1] M. Mehrmohammadi et al., IOPscience, pp. 1-8 (2010) [2] C. Warisarn, A. Arrayangkool, and P. Kovintavewat, IEICE Trans. Electronics, vol. E98-C, pp. 528-533 (2015) [3] M. Tuchler, R. Koetter, and A. C. Singer,