MMM 2022 Conference

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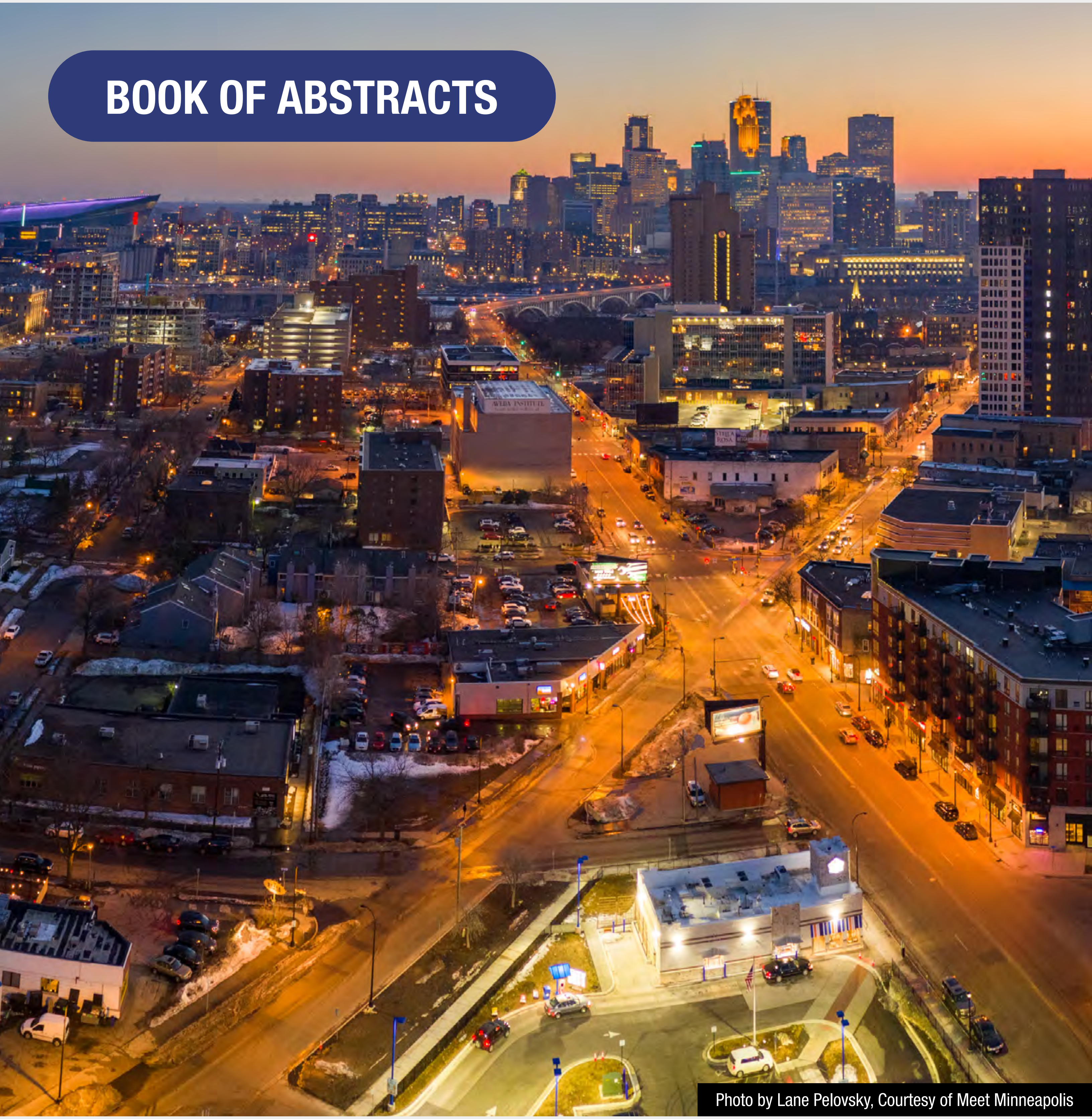
BOOK OF ABSTRACTS



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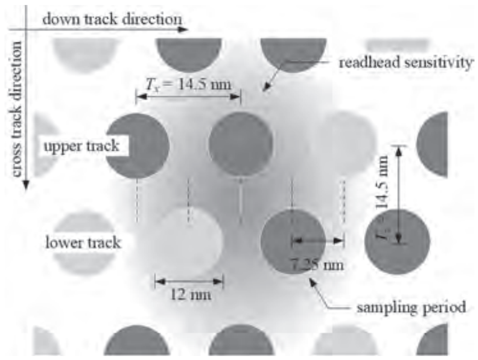

Fig. 1. Configuration of the proposed DTR systems at AD = 3.0 Tb/in^2 under the readhead sensitivity response that is positioned between the desired upper and lower tracks.

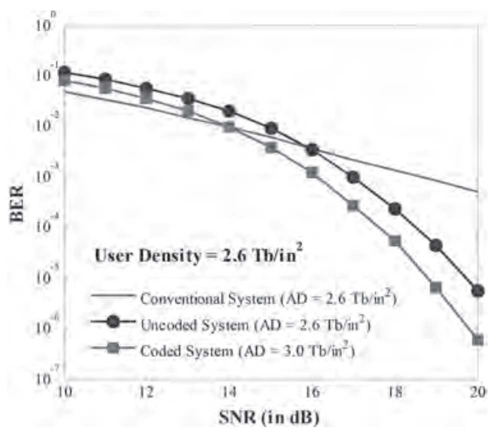

Fig. 2. Performance comparison of various systems at UD = 2.6 Tb/in^2.

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)

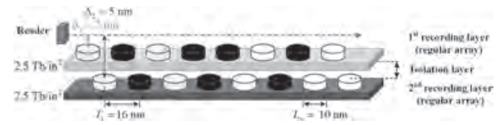

Fig. 1. Cross-section of head-media geometry for double recording layer medium.

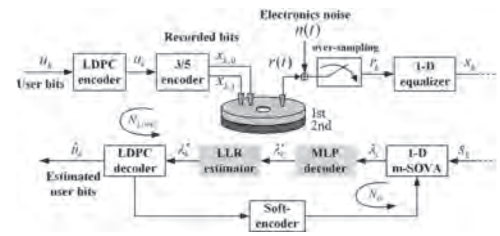

Fig. 2. A code BPMR channel model with the rate-3/5 constrained code.

IOB-08. A Study of Bit Island Spacing Optimization of Staggered Patterned Media-based SRTR Scheme in BPMR Systems.
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1. King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand; 2. Nakhon Pathom Rajabhat University, Nakhon Pathom, Thailand

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,

IEEE Trans. Commun., vol. 50, pp. 754-767 (2002) [4] S. Jeong, J. Kim, and J. Lee, Trans. Magn. vol. 54, pp. 1-4 (2018)

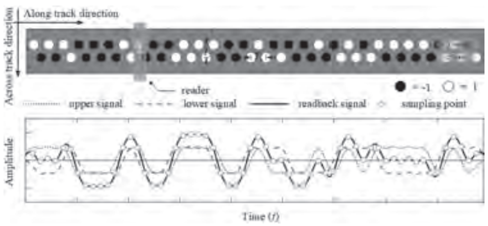

Fig. 1. Position of a single reader between two desired tracks over the staggered island pattern and its readback signal.

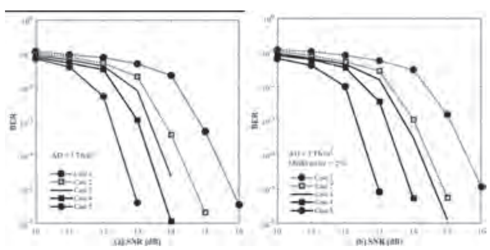

Fig. 2. BER performances of different cases of SRTR BPMR system (a) without and (b) with 5% media noises.

IOB-09. Dependence of User Density on System and Media Parameters for Shingled Heat Assisted Magnetic Recording (HAMR).

K. Hosen[1] and R.H. Victora[1] *1. Department of Electrical and Computer Engineering, University of Minnesota, Minneapolis, MN, United States*

We predict how design aspects of the HAMR system such as media properties, thermal profile, and the geometry of the magneto-resistive (MR) reader affect user density through micromagnetic simulation [1]. It is found that maximum user density is achievable by optimizing the track pitch. Fig 1. shows dependence on track pitch for a small grain pitch, fly height, and thermal spot size: Fig 2. shows corresponding data for large values. User density increases when the value of shield-to-shield spacing (SSS) of the reader is reduced owing to improved resolution, even though SNR often decreases [2]. Moreover, the impact of the shield-to-shield spacing is much stronger in case of small grain size compared to larger grain size because the limit to resolution becomes the transition broadening induced by the grain pitch. It is also evident that higher full width at half maximum (FWHM) of the temperature profile reduces user density owing mostly to increased track pitch, but also owing to increased erase after write. Transition curvature in combination with shingled recording is predicted to yield asymmetric transitions with respect to the track center [3]. Therefore, to adequately match the curvature of these asymmetrical curved transitions, we employed a rotated read head rotation: a single rotated head ($\theta_{opt} = 35^0$) results in a 9% improvement in user density over a single non-rotated head at 5.8 nm grain pitch, 15 nm reader width, 30 nm FWHM, 16 nm SSS, and 15 nm track pitch. Finally, we also demonstrate that media T_c variation impacts density more severely at high densities, but anisotropy field variation is the more significant effect at lower densities.

[1] R. H. Victora and P.-W. Huang, *IEEE Trans. Magn.*, vol. 49, no. 2, pp. 751–757, (2013) [2] Z. Liu, Y. Jiao, and R. H. Victora, *Appl. Phys. Lett.*, vol. 108, no. 23, p. 232402, (2016) [3] W.-H. Hsu and R. H. Victora, *Appl. Phys. Lett.*, vol. 118, no. 7, p. 72406, (2021)

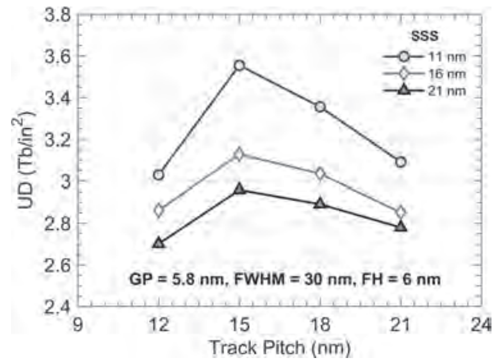

Fig. 1. User density as a function of track pitch for different shield-to-shield spacing (SSS) of ECC (FePt) media for optimal bit length = 9nm and reader width =15nm.

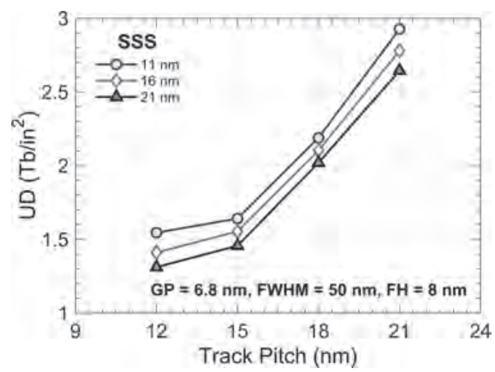

Fig. 2. User density profile as a function of track pitch for different shield-to-shield spacing (SSS) of ECC (FePt) media for optimal bit length = 9nm and reader width =15nm.

IOB-10. Effectiveness of a Pulsed Laser in Heat Assisted Magnetic Recording.

Y. Chen[1] and R.H. Victora[1] *1. University of Minnesota, Minneapolis, MN, United States*

Recently, much effort has been directed towards increasing the areal density of Heat-Assisted Magnetic Recording (HAMR) [1-2]. Here, we use our HAMR recording simulation [3] that employs renormalized media parameters to examine the potential use of a pulsed laser instead of a continuous laser. By carefully tuning parameters such as peak temperature, decay rate and inter-granular exchange, the pulsed laser is shown to have better recording performance. It also produces less average heat in the media and thus improves near field transducer lifetime. We employ the thermal profile of the discontinuous laser described in our previous work [4]. Optimization yields a peak temperature of around 950K and a time constant for heat dissipation of about 0.5 nS. This is fortunate because 0.5 nS also appears to be the experimental value of time constant for at least some media stacks. Inter-granular exchange of 10% is found to be optimal for both the continuous and pulsed laser configurations. Our results show that the optimized pulsed laser reduces Adjacent Track Erasure (ATE) relative to the continuous laser. For example, Fig. 1 shows that the pulsed laser system shows a lower decay rate with write number than the continuous laser. This could be understood from Fig. 2, where the averaged thermal activation is calculated. Here, the pulsed laser has a narrower distribution along the cross-track direction, which means the signals written on track 1 are less affected by the signals written on the adjacent track. We believe that the effectiveness of our pulsed laser approach relies on properly synchronizing the pulse with the magnetic field change: 0.1 nS delay works best. This allows the gradient at the edge of the writing bubble to almost double when transitions are initiated.

[1] McDaniel, Terry W. Journal of Physics: Condensed Matter 17.7 (2005): R315. [2] Weller, Dieter, et al. IEEE transactions on magnetics 50.1 (2013):