Potential of Rotary Stage Electron Beam Mastering System for Fabricating Patterned Magnetic Media

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In order to fabricate high density master patterns of patterned magnetic media, we have developed a rotary stage electron beam mastering system (EBR)[1]. We have established a Continuous r-theta Stage Movement Flyback Lithography (CSMFL) including BlankingLess Beam Shift (BLBS) write function using the following components:

1. a new PC-controlled Electron Optical Column (EOC) provided with a pre-condenser lens to realize a smaller beam spot size at a larger beam current such as 5nm diameter at 5nA,
2. a radial direction movement stage equipped with a friction drive mechanism with twisted rollers to obtain high positional resolution of 0.28nm,
3. a dynamic focus function by a control between an electrostatic lens and height sensor to correct a focus position within a dynamic range of +/-50 micrometer.

We here present current performances and functions of the EBR with respect to a resolution, a placement accuracy, servo pattern elements.

(Resolution) The both track and bit pitches of 35nm bit array for Bit Patterned Media (BPM) fabricated by the CSMFL function is shown in Fig.1. Its bit rate is 1.22 MHz/bit.

(Placement Accuracy) SEM image analysis results of placement accuracies for 50nm period bit array by the CSMFL are indicated in Fig.2. In the Y direction deviations, the difference of 4.7nm (3 sigma) between r and theta rows would be caused by some jitter noises of a rotary stage. We have measures for improving the placement accuracy by means of reducing jitter noises of a rotary stage and correcting relative position errors between stages and beam positions.

(Servo Pattern Element) The CSMFL and BLBS write functions are very effective to write various servo pattern elements such as grooves and dots, grooves and right-angled grooves, grooves and half pitch shift dot array, various pit length patterns which details are shown in Fig.3.

We will improve to obtain master patterns for 25nm pitch bit array and beyond with a placement accuracy of better than 5nm (3 sigma) for all the directions.

[1] H.Ohyi, K.Hayashi, K.Kobayashi, T.Miyazaki, Y.Kuba, H.Morita, EIPBN 07

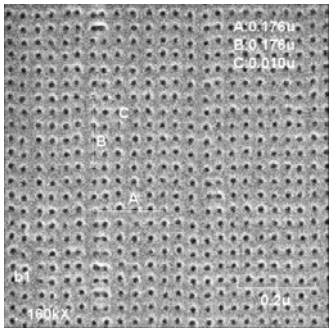


Fig.1 A 35nm track pitch x 35nm bit pitch bit array for bit patterned media (BPM)

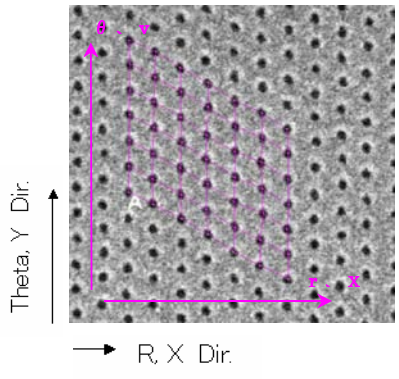
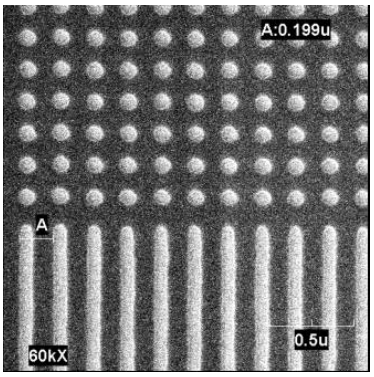
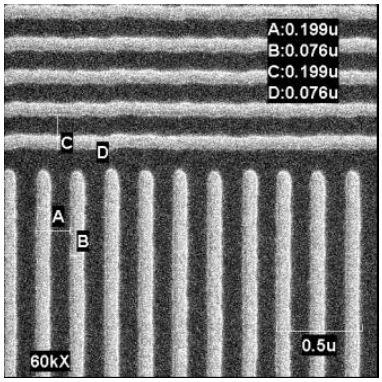


Fig.2 SEM image analysis of placement accuracy for 50nm period bit array

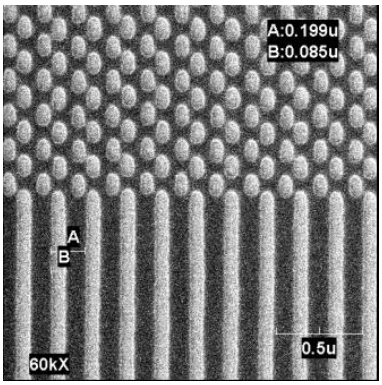
Placement Accuracy		
Deviation		3 Sigma (nm)
X. Dir	Theta Row	4.77
	R. Row	5.74
Y. Dir	Theta Row	3.93
	R. Row	8.63



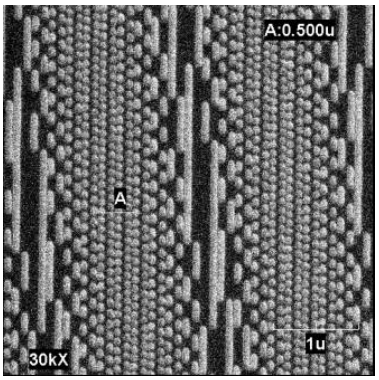
(a) Theta direction flyback lithography (TP(Track Pitch) =200nm)



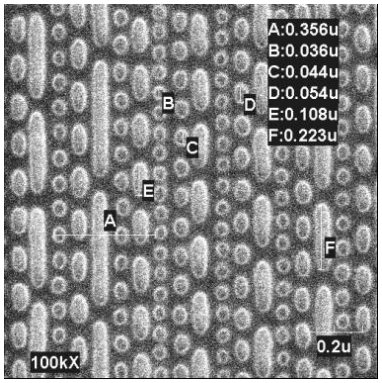
(b) R + Theta direction flyback lithography (TP=200nm)



(c) R direction half pitch shift blankingless write (TP=200nm)



(d) R direction half pitch shift blankingless write with frequency modulation (TP=200nm)



(e) Theta Flyback lithography with asynchronous frequency modulation (TP=70nm)

Fig.3 The write results for servo pattern elements using the continuous r-theta stage movement flyback lithography and blankingless beam shift write functions

(Short summary)
A rotary stage EB mastering system has been developed to fabricate patterned magnetic media. A 35nm period bit array was fabricated using a continuous r-theta stage movement flyback lithography (CSMFL) function. Placement accuracies within 5nm (3 sigma) for theta rows were realized. The CSMFL and blankingless beam shift write functions to write various servo patterns are demonstrated.