High Resolution Electron Beam Lithography Systems for the Next Generation Optical and Hard Disk

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We develop two types of new Electron Beam Lithography (EBL) for nanofabricating high density optical and hard disk patterns with feature sizes of sub-50nm or less.

A XYZ stage Gaussian round beam EBL system equipped with a Circular Pattern Write Function (CPWF) designed for a laboratory use within nanofabrication applications for concentric or spiral grooves and pits is developed [1]. Sample disks with well-defined fine groove or bit patterns as data areas and servo patterns are necessary to develop signal read/write techniques aiming at break through the optical diffraction limit, etc. As shown in Fig.1, each field of 1,200 micrometer maximum on a circular zone to be patterned is positioned under the E-Beam axis by x and y motions of the stage. At the same time, the E-Beam scan direction, i.e., the field direction is rotated by a proper angle theta corresponding to the position on the circle. A whole circular patterns can be written by field stitch write processes from (1) to (7) in order of number shown in the figure which is one of the best way to prevent any stitching errors caused by the thermal fluctuation of the main system including an Electron Optical Column (EOC), the XYZ stage, etc. for the EBL system.

Fig.2 shows a Discrete Track Media (DTM) test pattern including data patterns with both lands and grooves of 80nm width and several kinds of servo patterns as a demonstration and performance evaluations of the Circular Pattern Write Function (CPEF). Fig.3 shows SEM photomicrographs of the write results of the DTM test patterns at eight directions in the test band width of 100 micrometer on 10mm in diameter.. The over all stitching accuracy of 13nm peak to peak was evaluated in the stitchings of 600 times. This Function can afford to nanofabricate not only high resolution data patterns but also any kinds of complex servo patterns such as DTM and BPM (Bit Patterned Media) hard disks using the dedicated CAD software without a formatter for an EBR (Electron Beam Recorder) system. One more advantageous feature of the proposed function is freedom from problems associated with a large quantity of divided pattern data file as a conventional rectangular coordinate pattern division method, because if there are many sector servo patterns in a DTM disk, the same data file can be employed for fabricating the same servo patterns in every sector servo unit.

A novel X-Theta stage EB mastering system (EBR) which enables to fabricate nano order finer and denser patterns of an optical or hard disk as a production use with high throughput. This machine can fabricate random pit master patterns for the 3rd generation of a 25GB class to be commercialized, and the 4th generation of 100GB class with a track pitch of 160nm and minimum pit length of 80 nm in a diameter 120mm disk within several hours thanks to accomplish a beam current of 400nA at a beam spot size of 64nm by introducing a pre-condenser electrostatic lens right below a TFE emitter shown in Fig.4, a radial transition fluctuation within +/-10nm (3 sigma) at a line velocity of 6m/sec, a radial transition speed of 16 micrometer/sec using a slider stage with a twisted roller friction drive and a dynamic focus correction control technology to realize a just focus pattern write in the whole area of an optical disk during 20-60mm radii shown in Fig.5.

[1] N.Atoda, M.Kuwahara, C.Mihalcea, J.Tominaga, K.Hayashi, K.Kobayashi, T.Miyazaki and H.Ohyi, 27th International MNE Conference, 2001

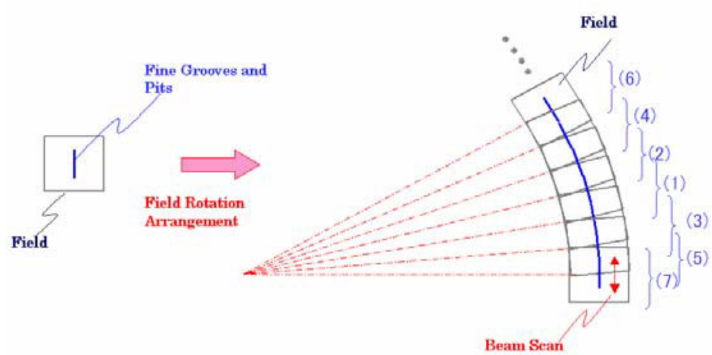


Fig.1 Principle of Circular Pattern Write Function (CPWF)
The CPWF is realized with synchronized movements between a stage (xy) and a field rotation (theta).

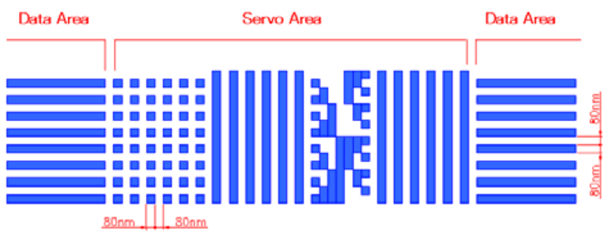


Fig.2 Discrete Track Media (DTM) Test Pattern

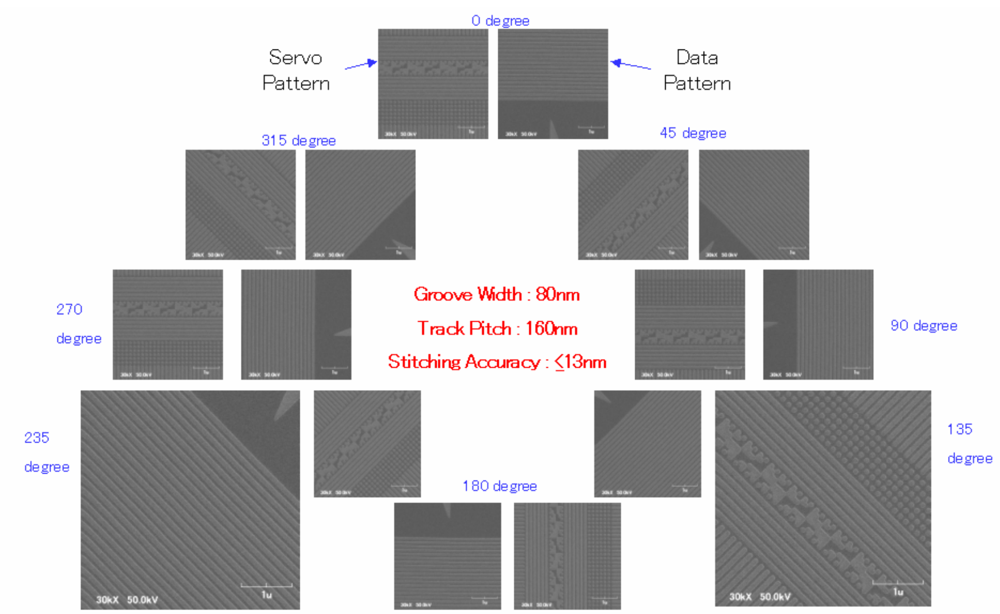
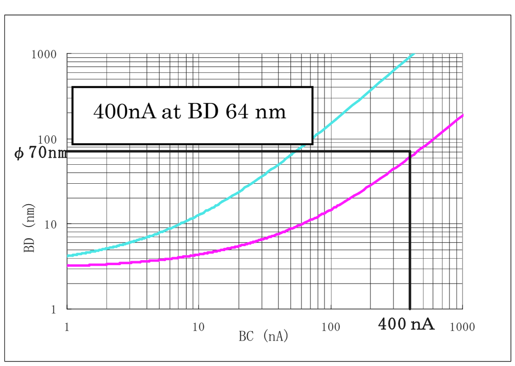


Fig.3
Write Results of DTM Test Patterns by CPWF



w/o Pre CL(Condenser Lens) w/ Pre-CL
Fig.4 BD (Beam Diameter) vs BC (Beam Current)

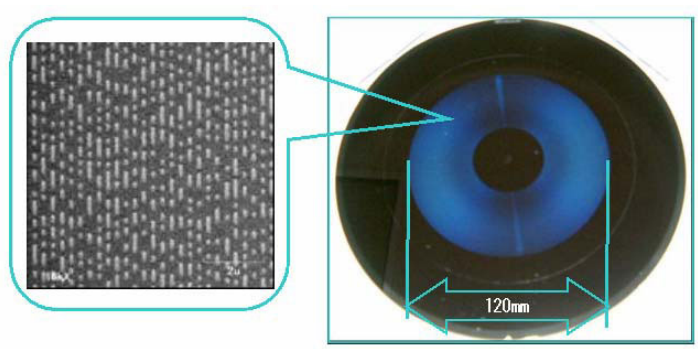


Fig.5 Random pit write by the EBR
TP (Track Pitch)=320nm, 2T=160nm (25GB)