

Resent Progress on the Research and Development for Practical Application of HDD-Type Ultra-High Density Ferroelectric Data Storage

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Abstract: We have proposed ferroelectric recording using scanning nonlinear dielectric constant microscopy (SNDM) as a next-generation ultra-high-density information recording method (SNDM probe memory) [1]. To date, we have confirmed extremely high recording densities and high-speed write characteristics using LiTaO₃ single-crystal media.

In this paper, we present the resent progress on the research and development for practical application of HDD-type SNDM probe memory.

Fist topic is “Non-Contact Heat Assisted Ferroelectric Reading (HAFer)”. Recently, we proposed a HAFer method as a technique to dramatically increase the read speed [2]. However, all these fundamental data were obtained with the SNDM probe tip in contact with the ferroelectric recording medium. Considering the practical implementation of HDD-type SNDM probe memory, it is self-evident that a non-contact method, similar to magnetic HDDs, is essential. Calculations using data from previously obtained temperature dependence of both linear and nonlinear dielectric constants suggest that even if a gap forms between the tip and sample, the SNDM signal is expected to increase proportionally to $(T_c - T)^{-1.5}$. Experimentally, the HAFer effect was confirmed for gap within the tip radius (approximately 30 nm). Since the gap length at the practical implementation stage of SNDM probe memory is expected to be 1 nm or less, it was found that the same HAFer effect as during contact can realistically be obtained.

Second topic is “Shingled Dielectric Recording”. Compared to magnetic recording, dielectric recording inherently allows for smaller bit formation, but in magnetic HDDs, where forming a single small polarization reversal dot is relatively difficult, the shingled recording technique is used to enhance recording density. We believe that applying this technique to dielectric recording could enable simpler and higher-density recording. Therefore, we have conducted a preliminary experimental study on shingled dielectric recording. Shingled recordings on a single track and triple track have been conducted. In particular, in the triple track case, extremely small dot formation was confirmed relative to the set pitch width, confirming that the shingled recording technique is an effective method for achieving high-density recording in dielectric recording as well.

Keywords: Scanning nonlinear dielectric microscopy, Ferroelectric data storage, SNDM probe memory

References

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