Ferroelectric data storage with 10Tbit/inch^2 class memory density and sub-nanosecond switching time

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With the advance of information processing technology, the importance of high-density data storage is increasing. Studies on thermal fluctuation predict that the magnetic storage, which plays a main role in this field, will reach a theoretical limit in the near future, and a novel high-density storage method is required.

Ferroelectrics can hold bit information in the form of a polarization direction. Moreover, the domain wall of typical ferroelectric material is as thin as the order of a few lattices. This feature is favorable for high-density data storage. Therefore, we have studied the ferroelectric high-density data storage based on scanning nonlinear dielectric microscopy (SNDM) [1] and had reported that nano-sized inverted domain dot arrays was successfully formed at a data density of 1.50 Tbit/inch^2 [2].

In this study, we have newly made great progress in the technology of ferroelectric data storage. At first, the memory density of 8.5 Tbits/inch^2 (almost 10Tbits/inch^2) and sub-nanosecond (500psec) domain switching speed have been successfully achieved using a $LiTaO_3$ thin plate. (Figs.1 and 2)

Next, conductive-diamond-coated cantilevers with the tip radius of 100 nm were used for the purpose of studying on the basic recording property, because this type of probe has excellent durability, and would be valid for practical use. Actual information data (data size: 128×128 bit) were recorded at the areal density of 260 Gbit/inch^2 with no bit errors in ten thousand data bits. (Fig.3) It means bit error rate was less than 1×10^{-4}.

Moreover, metal-coated cantilevers with sharp tip radius of 25 nm were also used as probe. This type of probe can write higher-density data bit patterns, because its tip radius is much less than that of diamond-coated cantilever. Real information data was recorded at the areal density of 982 Gbit/inch^2 with a few bit errors.

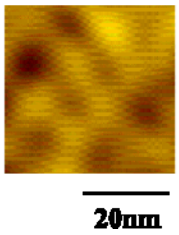

Fig.1 Artificial nano-domain dot array with the memory density of 8.5Tbit/inch^2 formed by the 9.5V pulse application in the $LiTaO_3$ thin plate with the thickness

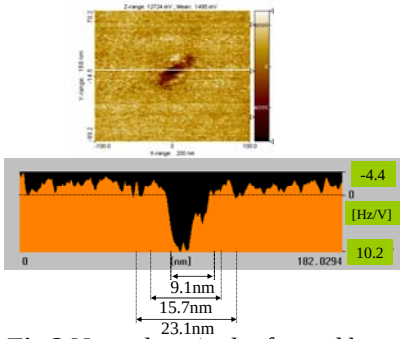

Fig.2 Nano-domain dot formed by the 10V, 500ps pulse in the $LiTaO_3$ Thin plate with the thickness of 17.6nm.

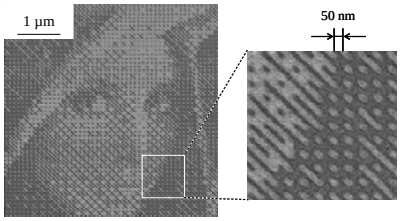

Fig. 3 Bit data written on a $LiTaO_3$ single crystal: The areal recording density was 260 Gbit/inch^2, and the bit error rate was less than 1×10^{-4}.

[1] Y. Cho, et al., Appl. Phys. Lett., **81**, 4401 (2002)
[2] Y. Cho, S. Kazuta, K. Matsuura, Appl. Phys. Lett, **72**, 2833 (1999)