Scanning Nonlinear Dielectric Microscopy-A High Resolution Tool for Observing Ferroelectric Domains and Nano-domain Engineering

Yasuo Cho
Research Institute of Electrical Communication, Tohoku University
2-1-1 Katahira, Aoba-ku, Sendai 980-8577, Japan

We have recently proposed and developed a new purely electrical method for imaging the state of the remanent polarization of ferroelectric materials, which involves the measurement of point-to-point variations of the nonlinear dielectric constant of a specimen, and is termed the "Scanning Nonlinear Dielectric Microscopy" (SNDM) Now, the stronger demands for the observation of very small domains with nanometer and sub-nanometer sizes has arisen amongst researchers of ferroelectric materials, for example, to investigate domain wall structures, to clarify the minimum domain sizes etc. Therefore, we developed a new SNDM with sub-nanometer resolution

At first, we report the results of the imaging of the ferroelectric domains in single crystals and in thin films using the SNDM Especially in the PZT thin film measurement, we succeeded to obtain a domain image with a sub-nanometer resolution We also show the result of the trial measurement with an atomic scale resolution.

Next, we describe about a new SNDM technique with a much higher resolution, which detects the higher order nonlinear dielectric constant The higher order nonlinear dielectric imaging has a higher resolution As expected, we experimentally confirmed that the higher order nonlinear dielectric imaging has higher lateral resolution than that of the conventional nonlinear dielectric imaging and also has sensitivity in much shallower region from the surface We also report a new type of the SNDM which can evaluate nonlinear dielectric constant ε_{311} for measuring the polarization direction parallel to the surface.

Finally, the formation of artificial small inverted domain is reported to demonstrate that SNDM system is very useful as a nano-domain engineering tool The nano-size domain dots were successfully formed in $LiTaO_3$ single crystal This means that we can obtain a very high density ferroelectric data storage with the density above T-bits/inch^2 in the future