ヘリウムイオン顕微鏡技術による $BaTiO_3$ 系誘電体の電位コントラスト評価

Voltage contrast of $BaTiO_3$ dielectric material by Helium Ion Microscopy

産総研[1]，（株）村田製作所[2]　○小川真一[1]，斎藤 彰[2]

AIST[1], Murata Manufacturing Co., Ltd.[2], ○Shinichi Ogawa[1], Akira Saito[2]

E-mail: ogawa.shinichi@aist.go.jp

Understanding degradation mechanism of $BaTiO_3$ dielectric under high electric field and temperature is required for highly reliable multi-layer ceramic capacitors products. It was shown that oxygen vacancies built up at a cathode side followed by electric field concentration with increased current to form Schottky barrier and depletion layer near cathode by a SEM voltage contrast method. (1)

In this work, $BaTiO_3$ dielectric layers of 7 um thick between Ni electrodes have been studied by voltage contrast method using helium ion microscopy (HIM) (2) comparing with the SEM method. Cross section HIM and SEM images at optimal conditions were shown in Fig. 1 with intensity of the voltage contrast at 0V, +7V, respectively. HIM and SEM showed images without any charge up at 0V, while under applied voltages HIM showed gradual slope in line profile closed to areas of Ni lines of lower voltages, on the other hand, constant slope in SEM case. At higher magnification measurements, both HIM and SEM showed gradual slope as shown in Fig. 2. It might probably be the reason that low energy (1-2 eV) secondary electron of shorter mean free path of 1-2 nm in HIM acted more surface sensitively than SEM of higher energy (a few eV) of -10 nm mean free path. Average signal from areas deeper from the measured surface might be evaluated in the SEM case, while the HIM showed the signals from only shallower surface areas.

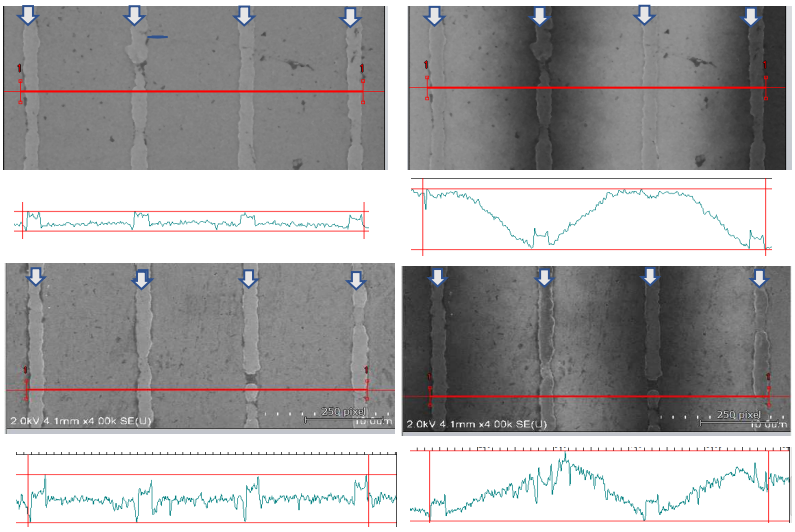

Fig. 1 Cross Section HIM (above) and SEM (below) with voltage contrast line profiles at 0V (Left) and +7V (Right). Arrows show Ni electrodes.

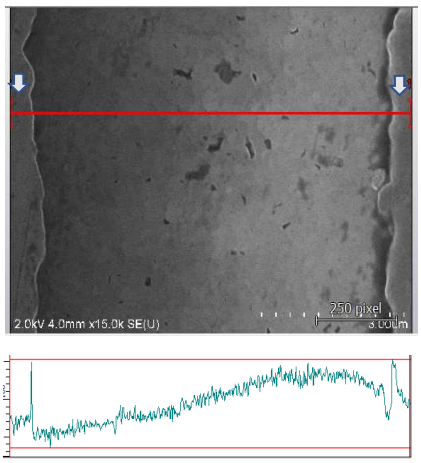

Fig.2 Cross section SEM and voltage contrast line profiles at +7V at higher magnification.

(1)A. Saito, ‘Analysis for Degraded Dielectric Material Using Voltage Contrast Methods in SEM’, NanoTS 2019-01 (2019), (2)S. Ogawa, et. al., ‘Characterization of VO_2 film domains by helium ion microscope (HIM) at controlled temperature and voltage’, The 77th JSAP Autumn Meeting 2016 13a-A31-3