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Magnetic properties of proton irradiated $BiFeO_3$

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The crystal structure and magnetic properties of $BiFeO_3$ samples, proton-irradiated with 0, 10, and 20 pC/μm^2, were investigated with x-ray diffraction (XRD), vibrating sample magnetometer, and Mössbauer spectroscopy measurements. From the Rietveld refinement analysis of the XRD patterns, the crystal structure of $BiFeO_3$ is determined to be rhombohedral with the space group of *R3c*. We have observed the decrease in the lattice constant and oxygen occupancy with proton irradiation. The magnetization hysteresis (M-H) curves show the appearance of the weak ferromagnetic behavior in the proton irradiated $BiFeO_3$ samples. The Mössbauer spectra of proton irradiated $BiFeO_3$ samples at 295 K were analyzed with two-sextets (B_1 and B_2) and doublet. From the isomer shift (δ) values, ionic states were determined to be Fe^{3+}. Compared to non-irradiated sample, having the antiferromagnetic area ratio (two-sextets) of 45.47, 54.53% the antiferromagnetic and paramagnetic area ratios (doublet) of 10 and 20 pC/μm^2 proton irradiated $BiFeO_3$ samples are 41.36, 51.26, and 7.38% and 41.03, 50.90, and 8.07%, respectively. Our experimental observation suggests that the increase in the paramagnetic area ratio is due to the disappearance of superexchange interaction, resulted from the removal of the oxygen with proton irradiation. Also, the appearance of the weak ferromagnetic behavior is caused by the breaking of the antiferromagnetic coupling. © *2013 American Institute of Physics.* [http://dx.doi.org/10.1063/1.4795616]