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The effect of proton irradiation on magnetic properties of NiCuZn ferrite

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Here, we report the experimental studies on the effect of 5.0 MeV proton irradiation on the magnetic properties of Ni$_{0.2}$Cu$_{0.6}$Zn$_{0.2}$Fe$_2$O$_4$ based on the x-ray diffraction, magnetization, and Mössbauer spectroscopy. Ni$_{0.2}$Cu$_{0.6}$Zn$_{0.2}$Fe$_2$O$_4$ powder was prepared by the solid-state reaction method and annealed at 900 °C. The prepared samples were proton-irradiated with 10, and 20 pC/µm$^2$. The crystal structure was found to be cubic spinel, and the lattice constant $a_0$ linearly increased from 8.3872 to 8.3904 Å with increasing proton irradiation. Also, with increasing proton irradiation, the magnetization ($M_s$) and coercivity ($H_c$) values decreased from 60.2 to 58.2 emu/g, and from 68 to 28 Oe, respectively. Based on the probability distribution of cations [1-3], we have analyzed the room-temperature Mössbauer spectra as 5 sets with six-lines. Hyperfine fields of $A$ and $B$ site were $H_{hf}(A) = 482$ kOe, $H_{hf}(B_0) = 504$ kOe, $H_{hf}(B_1) = 474$ kOe, $H_{hf}(B_2) = 463$ kOe, and $H_{hf}(B_3) = 434$ kOe in non-proton irradiated sample. However, hyperfine field of the $A$ site and the average value of hyperfine fields at the $B$ sites under 20 pC/µm$^2$ proton-irradiation were $H_{hf}(A) = 475$ kOe and $<H_{hf}(B)> = 462$ kOe. The proton-irradiated hyperfine field of $A$ site and $B$ site were smaller than the values of $H_{hf}(A) = 482$ kOe and $<H_{hf}(B)> = 468$ kOe of non-proton irradiated sample. The Fe valence states were determined to be ferric from the isomer shift values. These results suggest that the proton irradiation induces the oxygen vacancy defect, which in turn leads to the changes in magnetic properties.