Characterization of Neutron Irradiated Materials Using ESR Spectroscopic Method

Young Hwan Cho*
Korea Atomic Energy Research Institute, 111, Daedeok-daero 989beon-gil, Yuseong-gu, Daejeon, Republic of Korea
*yhcho@kaeri.re.kr

1. Introduction

Neutron irradiation produces a stable defect center to a lattice of various solid materials [1]. Electron Spin Resonance (ESR) spectroscopy is a convenient and powerful tool for quantifying this defect center rapidly and nondestructively. Silicon carbide, SiC, is a candidate semiconductor material to be used under intense irradiation environment such as nuclear reactor and space. Alanine is also a candidate radiation dosimeter material useful for multi-purpose dosimetry. Several metal oxide single crystals host defect centers by irradiation applicable for new optoelectronic materials development. Here, for these materials, the post neutron irradiation properties are studied using ESR spectroscopy

2. Experimental

2.1 Materials

Silicon carbide, SiC, alanine, and metal oxide materials are purchased having high purity, 99.99%. Neutron irradiation experiments are carried out at HANARO Research Reactor.

2.2 ESR Measurements

The ESR spectroscopy was used to measure the concentration of defect center of the neutron irradiated samples. All ESR measurements were made at X-band (9.6 GHz) and room temperature on a Bruker EMX spectrometer.

3. Results

Figure 1 shows the esr spectra of neutron irradiated SiC with varying neutron fluence. It shows the relative paramagnetic defect center concentration dependent on neutron irradiation.

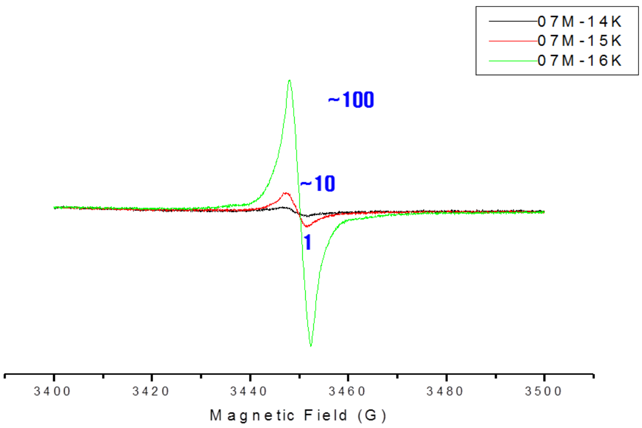

Fig. 1. ESR spectra of neutron irradiated SiC with varying neutron fluence 1:10:100 ratio.

Figure 2 shows the ESR spectra of neutron irradiated alanine. The concentration of the paramagnetic defect is also proportional to the neutron fluence. The irradiation effect on alanine molecules can be explained by following reaction.

$$CH_3(NH_2)CHCOOH \rightarrow {}^{\bullet}NH_2 + CH_3{}^{\bullet}CHOOH$$

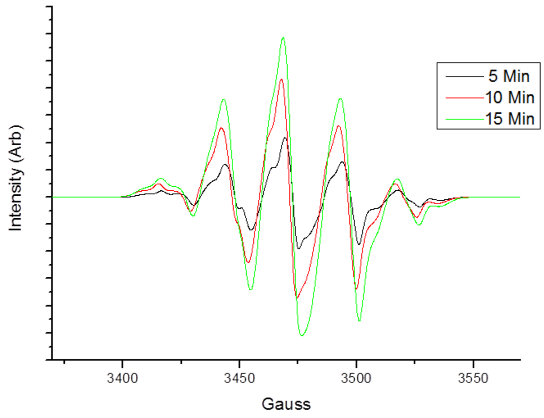

Fig. 2. ESR spectra of neutron irradiated alanine with varying neutron fluence.

4. Discussions

Neutron irradiation produces various types of stable defect center within solid lattice of a material of interest for nuclear applications. Electron Spin Resonance (ESR) spectroscopy is a convenient tool for quantifying this defect center rapidly and nondestructively. Alanine can be used for neutron dosimeter material that can be used for retrospective, emergency dosimeter method. Neutron irradiation can produce useful paramagnetic defect center that can alter the opto-electromagnetic properties of metal oxide materials. For this purpose, ESR can be used to quantify the concentration as well as investigating the structure of the defect center.

5. Conclusion

Neutron irradiation produces a stable defect center to certain materials useful for nuclear applications. Electron Spin Resonance (ESR) spectroscopy is a convenient tool for quantifying this defect center rapidly and nondestructively.

REFERENCES

[1] V. Bratus, et al. Semiconductor Physics, Quantum Electronics & Optoelectronics, 2015. V. 18, N 4.P. 403-409 (2015).