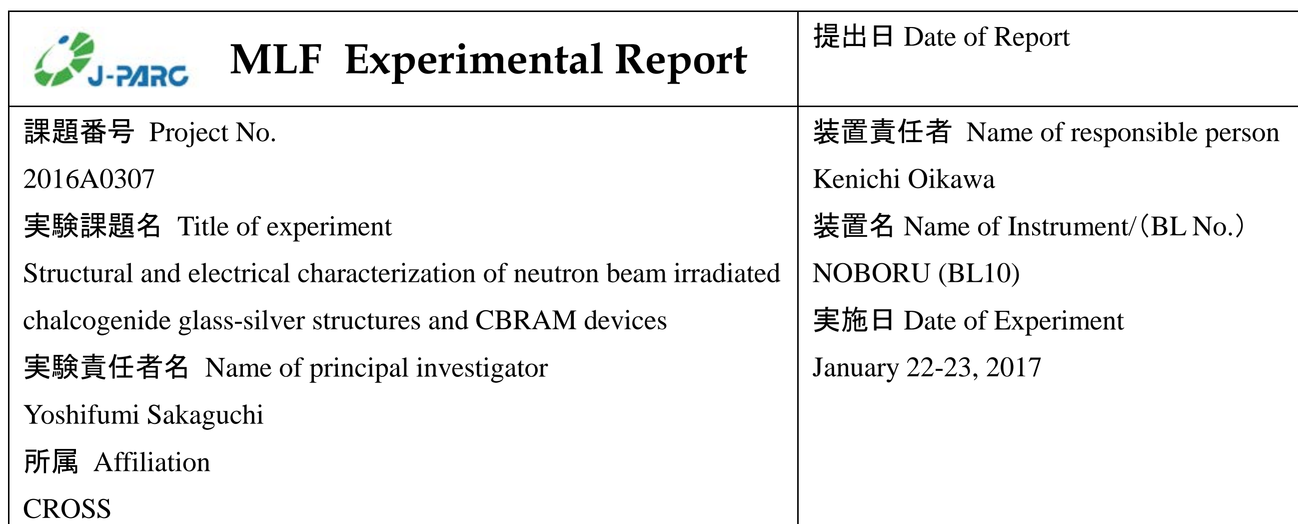

MLF Experimental Report

提出日 Date of Report	
課題番号 Project No. 2016A0307 実験課題名 Title of experiment Structural and electrical characterization of neutron beam irradiated chalcogenide glass-silver structures and CBRAM devices 実験責任者名 Name of principal investigator Yoshifumi Sakaguchi 所属 Affiliation CROSS	装置責任者 Name of responsible person Kenichi Oikawa 装置名 Name of Instrument/(BL No.) NOBORU (BL10) 実施日 Date of Experiment January 22-23, 2017

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。（適宜、図表添付のこと）
Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.

Ag/ $Ge_{20}S_{80}$/ W/ SiO_2/Si, Ag/ $Ge_{40}S_{60}$/ W/ SiO_2/ Si, Ag/ $Ge_{20}Se_{80}$ W/ SiO_2/Si, Ag/ $Ge_{40}Se_{60}$/ W/ SiO_2/Si
Memory device (Ag/ $Ge_{40}Se_{60}$/ SiO_2/ Si is inside)

2. 実験方法及び結果（実験がうまくいかなかった場合、その理由を記述してください。）

Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.

We prepared 6 sample packages (Fig.1(a)) which are made of aluminum coated polythene sheet (110mm x 110mm) and in which 4 different films (Fig.1(b)) and 1 memory device (Fig.1(c)) are contained. The exposure to light was avoided with the aluminum coated polythene sheet. The sample package was set on the neutron beam path in order that all of the films and the device in the package were exposed to the neutron beam with 100mm x 100mm beam size. The neutron beams were irradiated with 6 different time conditions (1 min, 5 min, 20 min, 90 min, 6 h, and 22 h) as summarized in Table 1. After cooling down of the radio-activation of the irradiated samples, the samples were shipped to Boise State University (U.S.A.) and the effect of the neutron irradiation was investigated by Raman spectrometer.

Fig.1 (a)

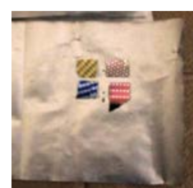

Fig.1(b)

Fig.1(c)

Fig. 2

2. 実験方法及び結果（つづき） Experimental method and results (continued)

After receiving the samples in Boise their structure was studied by Raman spectroscopy. The spectra were fitted and the area under the peaks calculated. In $Ge_{20}S_{80}$ and $Ge_{40}S_{60}$, the variation in the Dimerized S-S bonding with the radiation follow the same trends. The double layer structure remains constant with the radiation doses in the 40-60 composition. The results for this system are shown in Figures 3(a) and 3(b).

Irradiation time
1 min
5 min
20 min
90 min
6 h
22 h

Table 1

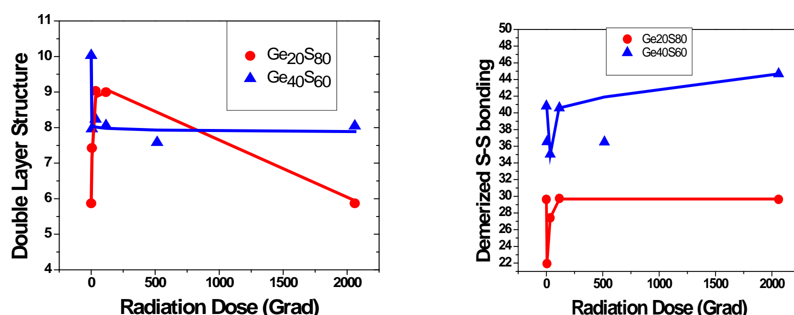

Figure 3: Raman relative structural unit analysis due to neutron irradiation for Ge_xS_{1-x} film.

By deconvoluting the curve, the area under different structural unit are separated. The figure 4(a), 4(b), 4(c) are demonstrating the structural unit changes with different radiation doses.

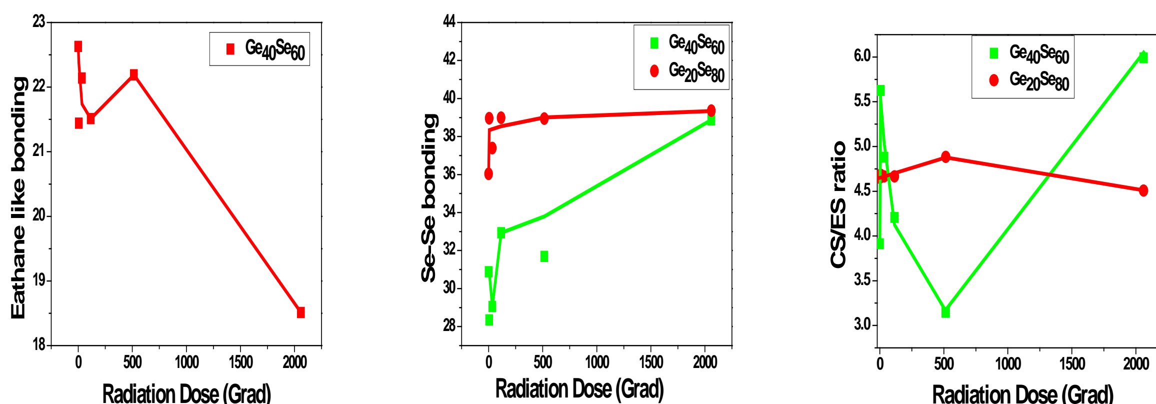

Figure 4: Raman relative structural unit analysis due to neutron irradiation for different composition of Ge_xSe_{1-x} film.

From the above study, it is obvious that structural composition changes as the doses change. More structural changes are observed in $Ge_{40}Se_{60}$ possibly because of the presence of weak ethane-like structural units in these films than $Ge_{20}Se_{80}$ films. Interestingly with increasing of the radiation dose the changes diminish, which we suggest is due to the formation of a very high number of defects which are in a close proximity. This causes their fast recombination and so the net effect is lack of structural change in the material. In case of silver diffusion it is much more expressed in the $Ge_{20}Se_{80}$ samples which could be related to the high affinity between the chalcogen elements and Ag on one hand and on the other hand to the formation of defects mainly related to the lone-pair electrons of the chalcogen elements which due to their negative charge attract the Ag ions.