実験報告書様式（一般利用課題・成果公開利用）

| # MLF Experimental Report | 提出日 Date of Report<br>**Oct.10, 2013** |
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| 課題番号 Project No.<br>**2012B0084**<br>実験課題名 Title of experiment<br>**Quantitative Evaluation to Martensite Elastoplastic Deformation of Multilayered Austenite-Martensite Steel Composites during Tensile Deformation**<br>実験責任者名 Name of principal investigator<br>**P.G. Xu**<br>所属 Affiliation<br>**Japan Atomic Energy Agency** | 装置責任者 Name of responsible person<br>**S. Harjo**<br>装置名 Name of Instrument/（BL No.）<br>**TAKUMI**<br>実施日 Date of Experiment<br>**Mar. 13-17, 2013.** |

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.

1. SUS316/0.13C/SUS316, austenite/martensite/austenite 3-layer steel sheet
2. SUS316/Ferrite/SUS316, austenite/ferrite/austenite 3-layer steel sheet
3. SUS316Mono, austenite monolithic steel
4. 0.13CMono, martensite monolithic steel
5. Ferrite monolithic steel

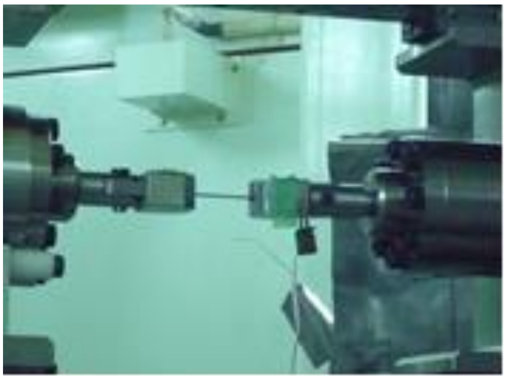

Fig.1 (right) View for *in situ* steel sheet tensile deformation to monitor the in-plane microstructure and principle orientation evolutions by horizontal sample setting.

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.

As-quenched martensite is of low ductility and generally not suitable for direct usage as an important sheet structural material. By using the sandwich-type structure alternatively with martensite steel layer and austenite steel layer, the multilayered steel composite after hot rolling, cold rolling and short-time solid solution treatment was reported to possess good strength-ductility balance. Though there were some EBSD observation about the martensite deformation behaviour, however, it is not clear about the elastoplastic deformation characteristics of martensite layer in bulk sheet, and why the martensite layer is not brittle like that in the martensite monolithic steel. The neutron diffraction techniques were here employed to investigate the evolution of the difference in elastoplastic deformation characteristics among martensite layers, martensite sheets

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

together with austenite layers and ferrite layers. Moreover, the bulk texture and the deformation induced martensite transformation after uniaxial tensile deformation of multilayered steel composite at different engineering strains. Fig.1(a) compares the macroscopic strain-stress curves of SUS316/0.13C/SUS316 austenite/martensite and SUS316/Ferrite/SUS316 austenite/ferrite multilayered steels, showing that 20% martensite containing multilayered steel possesses more than 40% uniform elongation, larger than the ferrite-austenite multilayered steel. Fig.1(a) also gives the nominal stresses when the loading was held during the elastic deformation and when the maximum stresses when the loading was stopped during the plastic deformation. Fig.1(b) shows that the heterogeneous deformation of austenite/martensite multilayered steel was composed of three stages: (a) the austenite and martensite layers both deform elastically up to 200MPa and the martensite layer undertakes more tensile strain along tensile direction and more compressive strain along compressive direction. (b) the yielding occurs in austenite layer while the martensite layer continues the elastic deformation and undertakes more partitioning stress. (c) the austenite work hardens without any deformation induced martensite transformation because of high stability, while the yielding occurs in martensite layer. It is interesting that the work hardening is not so evident in the martensite layer even up to 30% uniform tensile deformation. It is suspected that lots of movable dislocations in martensite annihilate with other dislocations with a reciprocal vector during the plastic deformation of martensite. After unloading during the uniform plastic deformation, the tensile residual strain occurs in the martensite along the tensile direction and along the transverse direction, while the compressive residual strain occurs in the austenite layers. It is similar to the residual strain partitioning characteristics of the meta-stable austenite/martensite multilayered steel we measured at RESA-2. Moreover, the inverse pole figures obtained from the Retvield analysis confirmed that the evident crystallographic rotation really takes place in martensite layer during tensile deformation, a little similar to that in ferrite layer, suggesting that under the interface constraint of austenite layer, the martensite layer may deform similar to the ferrite to certain extent though their microstructure morphology is quite different to the each other. The further crystallographic texture measurement will be carried out during the next neutron experiment to confirm the above deformation characteristics of martensite and ferrite in the multilayered steels.

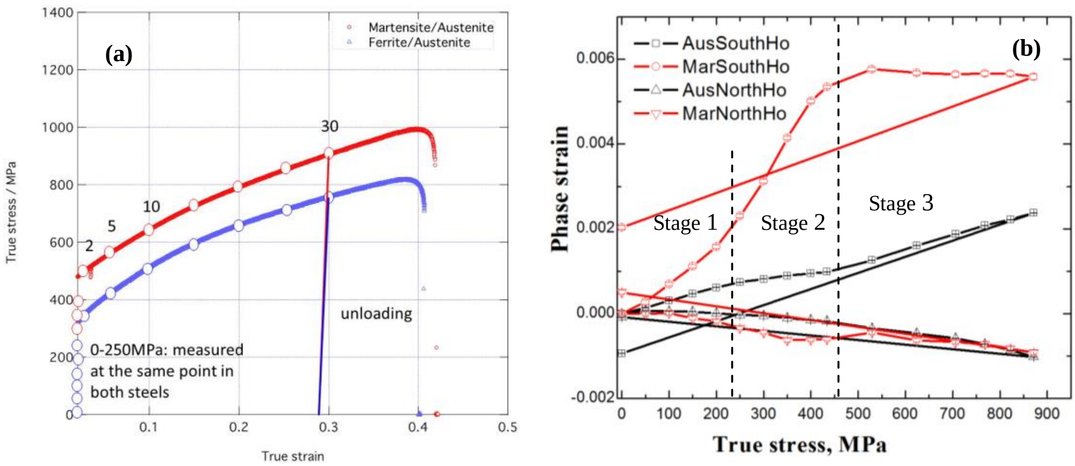


Fig.1 (a) Macroscopic strain-stress flows between SUS316/0.13C/SUS316 and SUS316/Ferrite/SUS316 multilayered steel; (b) (hkl) lattice deformation behaviors of martensite and austenite layers in SUS316/0.13C/SUS316 steel under the horizontal sample setting condition.