

課題番号 : F-13-NU-0009  
利用形態 : 機器利用  
利用課題名 (日本語) : 繰返し圧縮応力によるシリコン単結晶中の欠陥形成と残存引張強度に関する研究  
Program Title (English) : Damage Accumulation and Residual Tensile Strength in Silicon under Cyclic Compressive Stress  
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## 1. 概要 (Summary)

Internal defect accumulation process in single crystalline silicon induced by cyclic compressive stress was investigated by applying a electron beam induced current (EBIC). A specimen with an oval trench, which was made of a p-type wafer, was designed for compressive stress concentration over 2 GPa applicable without any possibility of fracture. Fatigue tests were performed at a frequency of 20 Hz ranging from  $1 \times 10^6$  to  $1 \times 10^7$  cycles. EBIC images were successfully obtained with a scanning electron microscope showing accumulation of recombination defects which reduces the current level generated by electron beam. After the compression fatigue test, static tensile test was carried to confirm fracture strength reduction due to the damage accumulation.

## 2. 実験 (Experimental)

A 0.3 mm thick (100) oriented single crystalline wafer with electrical resistivity of 10 to 20Ωcm was used to fabricate the specimens. Lithography (PEM-800, Union Optical Co. Ltd.) and DRIE process were carried out to make oval trenches for stress concentration. Then phosphorus ions (P<sup>+</sup>) and boron ions (B<sup>+</sup>) at 10keV and dosage of  $1.0 \times 10^{15}$  cm<sup>-2</sup> were implanted into the front and the back surface respectively, to compose a p-n junction on the front side and ohmic contacts on both sides. Afterwards, silicon wafer was cut into specimens with a rectangular form of  $6 \times 50$  mm<sup>2</sup> by dicing saw. Au was evaporated to deposit ohmic contact electrodes on the front and back surfaces for EBIC

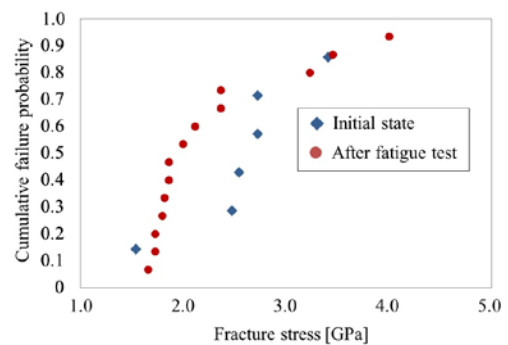


Fig.1 Fracture stress plotted by using mean rank method before and after fatigue test.

observation. Compressive fatigue test was performed under the conditions of controlled temperature 80°C and 80% RH in an environmental chamber to practically accelerate damage accumulation.

## 3. 結果と考察 (Results and Discussion)

Fig. 1 shows the results of static strength test performed before and after the fatigue test, where the cumulative failure probability evaluated by mean rank method is plotted along the ordinate and the tensile fracture stress evaluated at the trench tip along the abscissa. Average fracture stress after fatigue test is 16% lower than the average stress 2.57GPa at initial state from the graph.

## 4. その他・特記事項 (Others)

なし。

## 5. 論文・学会発表 (Publication/Presentation)

(1) S. Kamiya et al., Defect Accumulation and Strength Reduction in Single Crystalline Silicon Induced by Cyclic Ccompressive Stress, Sens. Actuator A, Vol. 208 (2014), pp. 30-36.

## 6. 関連特許 (Patent)

なし。