[Evaluation of trace of metal contamination in silicon dioxide film by Pulse Photoconductivity Method - Shotaro Kuzukawa]

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Abstract

We have proposed the evaluation of silicon dioxide film quality based on PPCM(***P***ulse ***P***hoto***c***onductivity ***M***ethod)[1] which is the photoconductivity measurement method by non-destructive and non-contact. In this Paper, we report the principle of silicon dioxide film evaluation, and the evaluation result of a trace of metal contamination in silicon dioxide film.

Introduction

At advanced semiconductor devices, a trace of metal contamination at the atomic level in wafers is known to adversely affect electrical characteristics. For example at image sensors, due to the influence of a ultra-trace of metal impurities in photodiodes, electrical signals is output in spite of non-light-receiving, which is recognized as white flaws. As a method of reducing the concentration of metal impurities in the device formed region, gettering by BMD(Bulk Micro Defect) which oxygen is precipitated in wafers is known. However, no method for sensitive analyzing of metal impurities in wafers surface which is the device formed region by non-destructive and non-contact is an issue. PPCM measures electrical conductivity of silicon dioxide film in the wafer surface, and we report the result of attempting evaluation of gettering ability by BMD in wafers applying this method.

Experimental method and results

We show the PPCM signal sequence diagram in FIG 1, the measurement concept diagram in FIG 2, the measured equivalent circuit diagram in FIG 3. PPCM is a method for calculating the conductivity from the time constant using the photoelectric effect and the polarization effect of the substance [1]. We bring the probe to the silicon dioxide film in non-contact(~1um), and when we irradiate Xe pulse light and apply the voltage from the probe, the carrier is excited. And the carrier is polarized by outside electric field. The time constant and the conductivity are calculated by measuring these transient voltage reactions. Electrical conductivity σ_{insul} is expressed in the next formula. Here, Δt is an elapsed time from light irradiation, and $\Delta V(t)$ is the reply voltage, and $\varepsilon_{\mathrm{insul}}$ is an oxidation film dielectric constant.

$$\sigma_{insul} = \varepsilon_{insul} \frac{\log_{10} \Delta V_{(t)}}{\Delta t} \log_e 10 \qquad (1)$$

The thermal process which simulates the device process is applied to silicon wafers, we evaluated electrical conductivity of oxidation film formed in that process by PPCM, and BMD density in the bulk by IR tomography (MO441 manufactured by Raytex Corp.).

We show the relationship between electrical conductivity σ of oxidation film measured by PPCM and BMD density in the bulk measured by IR tomography about two silicon wafers Wafer10 and Wafer11 in FIG 4. Correlation coefficients between electrical conductivity σ and BMD density in Wafer10 and Wafer11 are -0.662 and -0.634, respectively. Both result low negative correlations.

From the above results, it was confirmed that the higher BMD density, the lower electrical conductivity σ. Therefore, the difference in the wafer surface of metal contamination due to gettering ability by BMD is considered that it is possible to evaluate by measurement of electrical conductivity σ of oxidation film applying PPCM.

In addition, we will report on the day of the symposium the results of white flaws at the high sensitivity image sensor manufactured using a substrate under the same condition as these wafers.

Conclusion

Applying PPCM method, we proposed the evaluation of a trace of metal contamination in silicon dioxide film by non-destructive and non-contact. By indirectly estimating metal contamination in the silicon wafer surface from measurement of electrical conductivity σ of oxidation film, we consider evaluation of gettering ability by BMD is possible.

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References

[1] Y. Nishi, *et al.*, ***The International Symposium on Semiconductor Manufacturing***, PC-P-064, Tokyo, Japan, (2010)

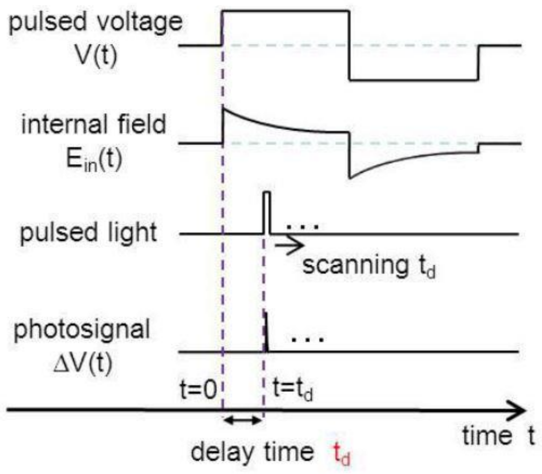

FIG 1. Signal sequence diagram

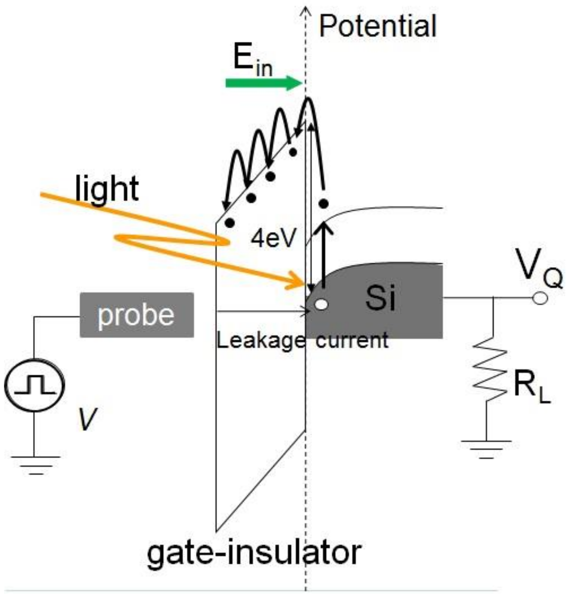

FIG 2. Measurement concept diagram

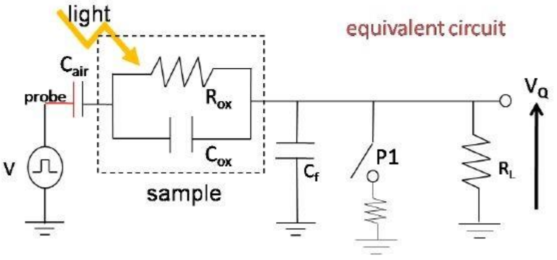

FIG 3. Measured equivalent circuit diagram

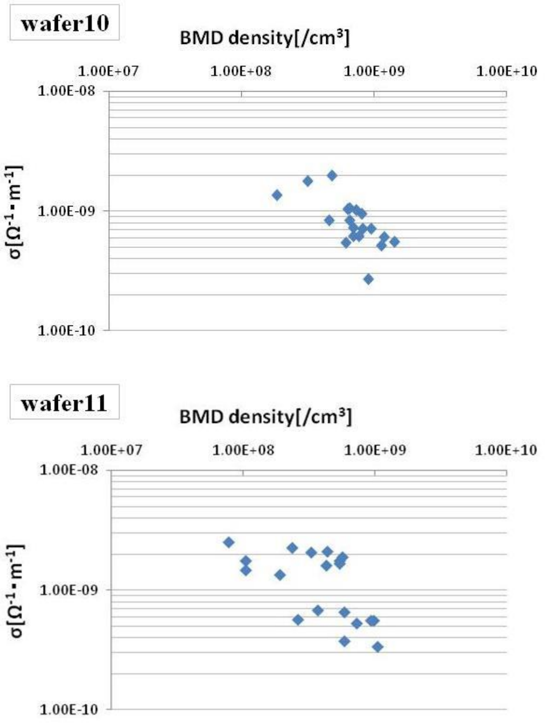

FIG 4. Relationship between BMD density and electrical conductivity