Introduction

Silicon complementary metal-oxide-semiconductor (CMOS) devices have been continuously scaled down to the 10 nm logic industry technology node defined by the international technology roadmap for semiconductors (ITRS). However, the industry is facing more technical challenges.

Application of Raman Spectroscopy for Local Stress Methodology and Characterization of Amorphous Carbon and SiGe Films in Semiconductor Process Development

Jae Hyun Kim1,2, Chang Hwan Lee2, Koon Ho Bae2, Seung Min Han1

1KAIST (Korea Advanced Institute of Science and Technology), Daejeon, Republic of Korea
2SK hynix, Ichon-si, Gyeonggi-do, Republic of Korea

Methodology of stress measurement around active silicon

The stress in the active area influences the structural shape made in the area and the performance of the device. And, as the pattern size in semiconductor devices reduces, the control of the stress applied to active area in “STI” structure is needed. Furthermore, accurately understanding the stress components that applies on the active area is becoming important in the device manufacturing process.

Manipulation of stress is essential in the device manufacturing process. The stress in the active area influences the structural shape made in the area and the performance of the device. And, as the pattern size in semiconductor devices reduces, the control of the stress applied to active area in “STI” structure is needed. Furthermore, accurately understanding the stress components that applies on the active area is becoming important in the device manufacturing process. The Raman can be effectively used to characterize the local mechanical stresses in the trench structures as a function of the processing parameters. Raman spectroscopy will be a measure of the out-of-plane stress, where a positive shift in frequency is translated into a tensile stress state. Specimens with the oxidation sample of side wall have out-of-plane compressive stress (negative shift) within the measured active silicon area. Deposted amorphous silicon sample of side wall showed tensile stress in the measured area, where as the volume of deposited amorphous silicon to active silicon almost increased twice as much.

Carbon materials in semiconductor processes are applied to the passivation layer. Gate etching processes rely on the formation of a thin diamond like carbon layer on the feature sidewalls to achieve profile control. The final gate profile results from competition between lateral etch rate and deposition rate and vertical etch rate. For carbon films, the Raman spectrum of G band usually occurs between 1480 and 1580 cm⁻¹, while the D band position appears between 1320 and 1440. Figure 3 shows that the G band position changes depending on the type of source and deposition temperature gas. In order to obtain DLC film, it requires a C₂H₆ gas and a deposition temperature of 300 degrees. It was possible to obtain the proper gate sidewall profile after etch process.

Raman frequency of amorphous carbon layer

Except for Si-Si band in SiGe (Band 1), all spectral parameters (Peak shift, Amplitude, Width) changed in each samples. Raman spectroscopy has a possibility to characterize the local mechanical stresses in the trench structures as a function of the processing parameters. Raman spectroscopy will be a measure of the out-of-plane stress, where a positive shift in frequency is translated into a tensile stress state. Specimens with the oxidation sample of side wall have out-of-plane compressive stress (negative shift) within the measured active silicon area. Deposted amorphous silicon sample of side wall showed tensile stress in the measured area, where as the volume of deposited amorphous silicon to active silicon almost increased twice as much.

Raman frequency of SiGe layer

The Raman can be effectively used to characterize the local mechanical stresses in the trench structures as a function of the processing parameters. Raman spectroscopy will be a measure of the out-of-plane stress, where a positive shift in frequency is translated into a tensile stress state. Specimens with the oxidation sample of side wall have out-of-plane compressive stress (negative shift) within the measured active silicon area. Deposted amorphous silicon sample of side wall showed tensile stress in the measured area, where as the volume of deposited amorphous silicon to active silicon almost increased twice as much.

Summary

Micro Raman spectroscopy can be effectively measured as the process control of semiconductor device materials. Due to small beam size, the light is penetrated into active silicon area on patterned wafer, and then scattered Raman signal gives a stress state information. Also, it has been effectively used for characterization of composition analysis on unknown thin film. In Raman spectroscopy, non-contact optical metrology offers a fast and cost saving monitoring of dielectrics in IC manufacturing process.

Contact information

email: jhkim76@kaist.ac.kr