Area 1: Crystalline and Thin Film Silicon PV

NON-CONTACT MEASUREMENT OF FIELD-EFFECT PASSIVATION USING COMBINATION OF A LASER TERAHERTZ EMISSION MICROSCOPE AND A CORONA DISCHARGE

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On the silicon solar cells, passivation layers of various materials including SiOx, SiNx, and AlOx are deposited. Good surface passivation characteristics are essential to achieve and maintain high efficiency, therefore their field-effect passivation characteristics are often evaluated by capacitance-voltage (C-V) measurement. Laser Terahertz Emission Microscope (LTEM) measures THz emission from semiconductor surfaces excited by femtosecond laser pulses[1]. We have applied the LTEM to evaluate silicon solar cells [2–4]. Previously we have shown that the laser THz emission of silicon is very closely related to the surface band bending and LTEM can be a non-contact, non-invasive tool to quantitatively measure and map the surface band bending[5]. In this work, we propose the use of LTEM in combination with a corona-gun to evaluate surface passivation characteristics by measuring THz emission from a SiO2/Si interface with various deposited charge density. We have compared the THz Amplitude with lifetime measured by a QSS-μPCD technique and examined the total dielectric charge density estimated by LTEM and voltage-charge method (PV-2000A, Semilab).

Figure 1 shows the structure of the measured sample and experiment. An evaluation of SiOx passivated surfaces with LTEM and a spot corona-gun is exhibited. The sample used is an n-doped Si wafer coated in a 46 nm wet oxidised layer with a doping density of 3.6 x 10¹⁵ cm⁻². The oxidation is done at 900 °C in nitrogen gas and water vapour. Negative or positive ions with various charge density are deposited on oxidised surface with a corona gun covering a 12 mm spot size. Laser pulses (width: 100 fs, center wavelength: 800 nm, repetition rate: 80 MHz) were focused onto the sample at the incident angle of 45 degrees with a diameter of 10 mm. Laser power was 100 mW. The THz emission is focused on the detector with the pair of off-axis paraboloidal mirrors.

Figure 2 shows charge density dependence of the THz peak amplitude and minority carrier lifetime measured with a QSS-μPCD technique. With increasing density of deposited negative charge, the THz waveform inverted, showing an inversion of surface band bending. The lifetime was minimum when the surface Fermi energy was near the midgap. The surface potential of Si was changed by deposited charge, therefore THz Amplitude was changed. The zero point of THz amplitude in the flatband condition is approximately at -2.3 x 10¹¹ cm⁻². Thus, we can evaluate the total dielectric charge density of 2.3 x 10¹¹ cm⁻², without any calculation. We confirmed that this total dielectric charge density was almost the same as that measured by voltage-charge method. Moreover, we are set to compare with C-V measurement. With a corona-gun, LTEM can evaluate field-effect passivation of Si easily without electrodes.

References: