Investigation of the Gate Oxide of Si MOS Devices Fabricated Using Minimal Fab Laser Annealing Tool

Mickael Lozac'h[1], Kazushige Sato[1,2], Sommawan Khumpuang[1,3], Shiro Hara[1,3,4]

[1] Minimal Fab Promoting Organization, [2] Sakaguchi E.H. VOC Corp., [3] AIST,

and [4] Hundred Semiconductors, Inc.

Email: mickael.lozach@minimalfab.com

Introduction: We investigate the quality of the gate oxide of silicon MOS devices fabricated using Minimal Fab laser annealing tool and compared it to a gate oxide fabricated by Minimal Fab furnace heating. To characterize the two types of heating processes, the lifetime of minority carriers measured by micro-photoconductance decay (μ-PCD) is performed to evaluate the passivation quality. A higher lifetime is related to a lower density of interface states (D_{it}) between the oxide gate and the silicon substrate. Besides, the optical properties are measured by spectroscopic ellipsometry (SE) and the Si-O binding is evaluated by Fourier Transform Infra-Red (FTIR). Minimal Fab is an advanced, cost-effective, semiconductor fab where the area that requires a clean environment is minimized to the surrounding of the silicon wafers (diameter of 12.5 mm), encapsulated in a shuttle (wafer vehicle) and cleaned process chambers during the full fabrication process, thus bypassing the space and budget required for a mega fab [1,2].

Experiment: Here, the front and the rear surfaces of silicon wafers have an identical oxidized structure (inset **Fig.1**). After a chemical cleaning RCA process, the gate oxide deposition is performed by laser annealing (850 °C for 1h) or by furnace heating (1150 °C for 2min 25). Both SiO_x films have a thickness of 20 ± 2 nm confirmed by SE. A hydrogenation step is then performed by H_2 annealing at 400 °C for 15 min to passivate the dangling bonds at the interface SiO_x/c-Si.

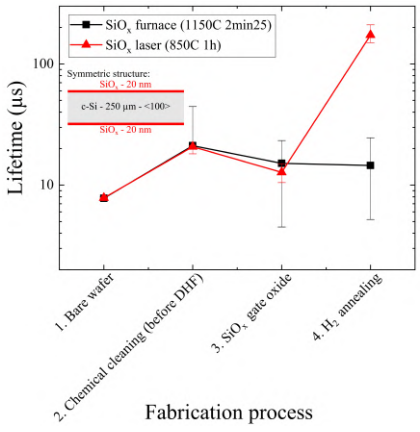

Figure 1: Lifetime evolution with the fabrication process for SiO_x realized by laser annealing (red) and by furnace (black). Inset: sample wafer structure.

In **Figure 1**, we present the evolution of the lifetime with the fabrication process for gate oxide realized by laser annealing (red) and by furnace heating (black). The μ-PCD mapping allows the estimation of the average lifetime on the entire silicon wafer surface, and the variation is indicated with error bars. Both processes are relatively similar after SiO_x gate deposition. However, the lifetime is clearly enhanced to up to 210 μs after the hydrogenation step only for the SiO_x film by laser process. A longer lifetime suggests a better material quality in terms of crystallinity and surface passivation. For the sample using furnace heating process, damages and/or deep level defects due the high temperature annealing (1150 °C) may be generated in the c-Si wafer. This observation is not related to the stoichiometry x of SiO_x determined over 1.9 for both films using the position of the in-phase Si-O stretching mode [3,4].

References: [1] S. Hara et al., *J. Jpn. Soc. Precis. Eng.* **77** (2011) 249-253. [2] S. Khumpuang et al., *IEEE Trans. Semic. Manuf.* **28** (2015) 393-398. [3] E. San Andrés et al., *J. Appl. Phys.* **87** (2000) 1187-1192. [4] M. Lozac'h et al., *Sol. Energy Mater. Sol. Cells* **185** (2018) 8-15.