Super Activation of Highly Surface Segregated Dopants in High Ge Content SiGe Obtained by Melt UV Laser Annealing

Toshiyuki Tabata
SCREEN-LASSE
Gennevilliers, France
toshiyuki.tabata@screen-lasse.com

Joris Aubin
SCREEN-LASSE
Gennevilliers, France
joris.aubin@screen-lasse.com

Karim Huet
SCREEN-LASSE
Gennevilliers, France
karim.huet@screen-lasse.com

Fulvio Mazzamuto
SCREEN-LASSE
Gennevilliers, France
fulvio.mazzamuto@screen-lasse.com

Yoshihiro Mori
SCREEN-LASSE
Gennevilliers, France
y.mori@screen.co.jp

Antonino La Magna
CNR IMM
Catania, Italy
Antonino.LaMagna@imm.cnr.it

Leonard M. Rubin
Axcelis Technologies, Inc.
Beverly, USA
Leonard.Rubin@axcelis.com

Petros Kopalidis
Axcelis Technologies, Inc.
Beverly, USA
Peter.Kopalidis@axcelis.com

Hao-Cheng Tsai
Axcelis Technologies, Inc.
Beverly, USA
Luke.Tsai@axcelis.com

Dwight Roh
Axcelis Technologies, Inc.
Beverly, USA
Dwight.Roh@axcelis.com

Ronald Reece
Axcelis Technologies, Inc.
Beverly, USA
Ron.Reece@axcelis.com

Abstract—Activation of surface segregated dopants above the solid solubility limit in a high Ge content SiGe substrate has been demonstrated by nanosecond melt UV laser anneal. This exceeds the activation possible with conventional solid-phase annealing technics. The segregation effects, strongly egcs.Beverly, USA

y [(w 0.0r5 -d35 -(at)-(c1(no)-138(r5 -1a T 0.n138(ali T 0.g,Tc 22 -1]TJnta)]t, o)-138(gr)-138(g1]TJ 2.5162(ne)-1, US)-a)]tiv38(a2.5162(ne)-1J

978-1-5386-6829-0/18/$31.00 ©2018 IEEE

tool. The deposited SiGe is partially relaxed and the macroscopic degree of relaxation is estimated to be 30-40% [12]. Gallium was then ion-implanted as a dopant (26 keV, at room temperature (RT)), to a nominal dose of ~1x10^{16} at/cm^2. The impurity projected range, R_p, was located at a depth close to 20 nm. 308 nm UV excimer laser annealing was applied with different laser energy densities (ED) on the samples at RT. The pulse duration was controlled to be 160 ns. The dopant profile before and after MLA was measured by SIMS. The dopant activation was studied by four-point probe and electrochemical capacitance-voltage profiling (ECVP) [13-14] techniques.

III. Results and Discussion

A. Process monitoring during LTA

When a SiGe is irradiated by a pulsed laser, the surface starts melting after a certain ED (J/cm^2) and the depth of the molten layer increases progressively with increasing ED. Figure 1 shows a set of TRR signals obtained during the MLA process on our SiGe samples with different EDs. While the sample surface is liquid, it shows a higher reflectivity than when it is solid. It is clearly seen that the melting time (the full width at half maximum of the TRR signal peak) becomes longer with increasing ED, meaning that the melting depth is increasing. From a plot of the melting time vs. ED, a threshold ED of melting can be determined by extrapolation. An approximate melt front velocity can be estimated by dividing the full distance of melt evolution and recrystallization (i.e. 120 nm for the 60 nm thick SiGe layer) by the melting time. In our case, it was less than 1 m/s, where Ga has a distribution coefficient of less than 0.1 [11]. The first abrupt peak shown at around 190 ns can be attributed to an explosive melting of the SiGe surface which has been amorphized during ion implantation [15]. The difference betw789 Tr0.133 12(Tra6(e)12(Tra6i14(y)6l2(T)-(e r2)6(ed la)-12bf8(i)-9.16714q2(t)5(hda(er,(les2(r

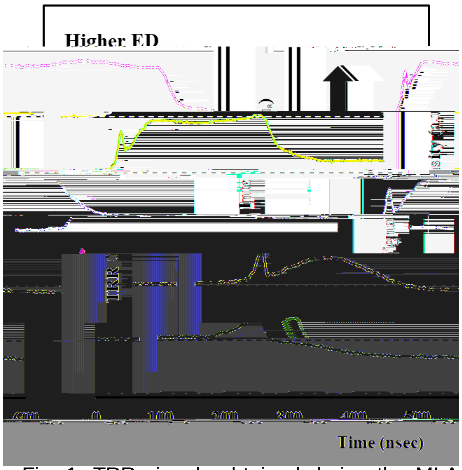

Fig. 1. TRR signals obtained during the MLA process of the Ga-doped SiGe layer.

Fig. 2. [69]Ga SIMS profiles of the non-annealed and annealed samples, where the melting depth (MD) was determined by the pile-up of the O profile (not shown).

Fig. 3. Ge SIMS profiles of non-annealed and annealed samples, where the melting depth (MD) was determined by the pile-up of the O profile. The Ge concentration is converted to at. % in $Si_{1-x}Ge_x$.