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6. AUTHOR(S)
S. D. Russell, B. W. Offord, and K. H. Weiner

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Ocean Systems Center
San Diego, CA 92152-5000

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Nanosecond thermal processing (NTP) using an XeCl excimer laser was employed in the fabrication of npn bipolar transistors in SOS. Functional devices, with current gain (β) approaching 100, were obtained. The deleterious effects of diffusion pipes in SOS material were minimized using rapid laser activation of ion implanted dopant.

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BIPOLAR TRANSISTORS IN SILICON-ON-SAPPHIRE (SOS): EFFECTS OF [illegible]OSECOND THERMAL PROCESSING

S. D. Russell and B. W. Offord
Naval Ocean Systems Center, Solid State Electronics Division,
Code 553, San Diego, CA 92152-5000

Kurt H. Weiner
Lawrence Livermore National Laboratory,
Livermore, CA 94550

Nanosecond thermal processing (NTP) using a XeCl excimer laser was employed in the fabrication of npn bipolar transistors in SOS. Functional devices, with current gain (β) approaching 100, were obtained. The deleterious effects of diffusion pipes in SOS material were minimized using rapid laser activation of ion implanted dopant.

Previous attempts at fabricating bipolar transistors in SOS have exhibited behavior attributed to diffusion pipes. SEM cross-sections of defect decorated SOS show crystallographic defects which extend from the surface to the first epitaxial (0.3 μm thick DSPE-improved) layer. Conventional furnace anneals of the emitter implant have resulted in shorted and/or high leakage emitter-collector characteristics in these materials. Diffusion of dopant atoms along dislocations during typical anneals of 950°C for 30 minutes are hypothesized to contribute to this dominant failure mechanism. NTP has been examined as a means to minimize the effects of these materials problems.

Devices were fabricated using n-type epitaxially deposited silicon on double-solid-phase-epitaxy (DSPE) improved SOS obtained from SRI. The total thickness of the first and second silicon epi-layers was nominally 2.0 μm, with UVR readings below 15 (at 280 nm). Conventional furnace anneals of ion implanted dopants were replaced with excimer laser NTP. The LLNL laser system operated at 308 nm using a XeCl gain medium, with in-situ process controls which have been described in detail elsewhere.[1] Masked wafers were illuminated with a homogenized intensity profile of varying fluences which melted the silicon and uniformly redistributed the dopant. Figure 1 shows a spreading resistance profile of the emitter implant following laser activation at 83 ns. The flat profile, showing uniformly distributed dopant is typical of the emitter and base junctions fabricated in these devices.

Devices were fabricated using three different laser fluences for the emitter anneal. This corresponds to a variation in melt duration and corresponding metallurgical junction depth. Qualitative measurement of the degree of diffusion along crystallographic defects is provided by measuring the collector current (I_C) versus the forward voltage (V_{BE}). Figure 2 shows this data for an npn transistor with a 1 x 8 μm emitter geometry for various melt durations. Devices with melt durations of 83 ns exhibit significant leakage, with collector current ideality factors exceeding ~1.2. Decreasing the melt duration to 68 ns, by decreasing the laser fluence, results in an improvement in ideality as shown. Melt durations of 57 ns exhibited the most ideal I-V characteristics, with ideality factors ~1.05.

These results suggest unwanted diffusion of dopant in SOS material with crystallographic defects can be inhibited by NTP. Due to the direct relationship between melt duration and junction depth, a corresponding decrease in base junction depth must be employed for short duration emitter activations to maintain desirable base widths. This is consistent with the strengths of NTP for fabricating ultra-shallow, high concentration dopant layers suitable for VLSI and ULSI technology as previously demonstrated in bulk silicon.[2]

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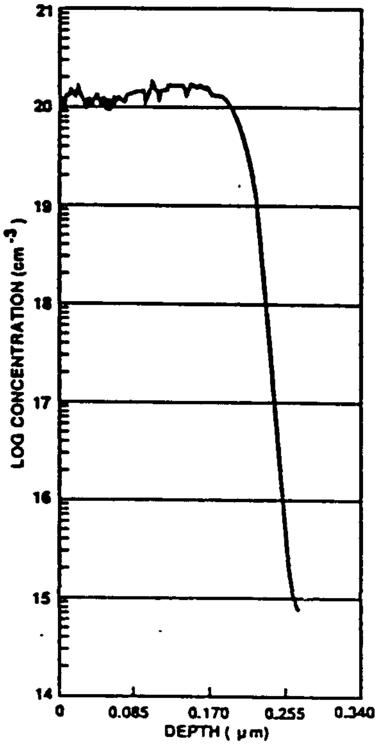

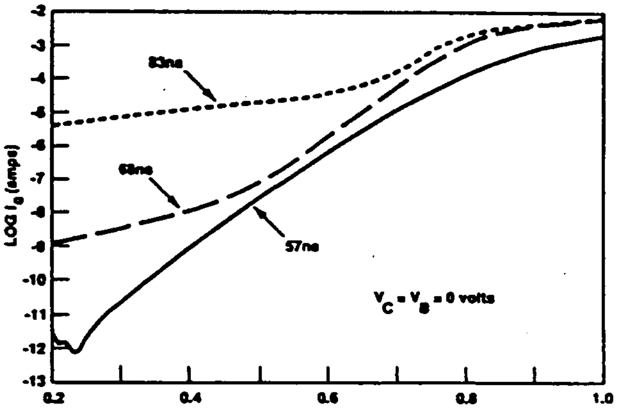

Figure 1. Laser-Activated Profile

Figure 2. I_C versus V_{BE}

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