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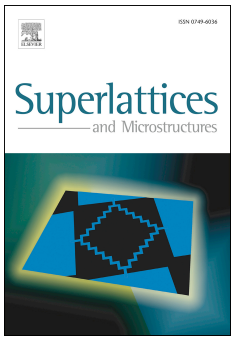

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Fast Recovery SOI PiN Diode With Multiple Trenches

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Abstract

In this paper, a 500V SOI PiN lateral diode is proposed and investigated by simulations and experiments. The proposed structure features multiple deep-oxide trenches (MDOT) arranged in the silicon region. Two DOTs (T1 and T2) locating in the i-layer help to block the cathode-anode voltage (V_{CA}), allowing the diode to shorten its i-layer length. With a similar breakdown voltage (BV) of 560V, the i-layer length is shortened from 47μm for the conventional diode to 21.9μm for the proposed MDOT diode. The shortened i-layer leads to a reduced number of stored carriers in the i-layer. Another DOT (T3) is inserted at the anode region of proposed MDOT diode and shorted with P^+ anode. T3 acts as a vertical field plate, reshaping the electric potential distribution at the anode region and accelerating the depletion during the reverse recovery process. Thanks to the decreased number of the stored carriers and the accelerated depletion, the reverse recovery time (t_{rr}) of the proposed MDOT diode (211ns) can be decreased by 56.7% compared with the conventional diode (487ns) at the forward current density of 400A/cm^2 at T = 300K. The proposed MDOT diode exhibits a better trade-off between forward voltage drop (V_F) and reverse recovery time (t_{rr}) than the conventional and other reported diodes.

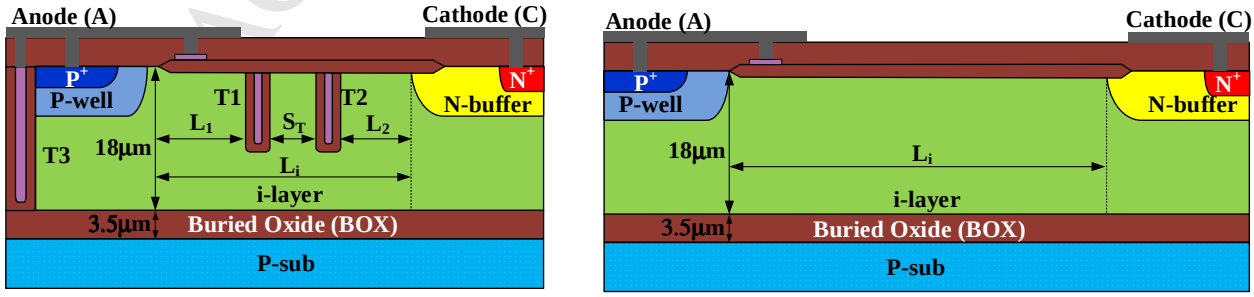
Key words: PiN diode, SOI, deep-oxide trench, reverse recovery

1. Introduction

Silicon-on-Insulator (SOI) lateral diodes are widely used as freewheeling diode for three-phase single chip inverter ICs [1-2]. In the three-phase single chip inverter ICs, the SOI diode is anti-paralleled with the high-side and low-side SOI-LIGBTs. During the inductive switching operation, the SOI diode delivers the load current when the SOI-LIGBT turns off. The SOI diode experiences a reverse recovery process when the SOI-LIGBT turns on again. For high-frequency and low power consumption of the three-phase single chip inverter ICs, SOI diodes with low reverse recovery time (t_{rr}) are attractive. For a 500V SOI diode, an i-layer of about 50μm is needed to block the cathode-anode voltage (V_{CA}) [3-4]. The long i-layer leads to a large number of stored carriers which need to be removed during the reverse recovery process, resulting in high t_{rr}. Hence, reducing the length of i-layer is beneficial to lower t_{rr}.

In this paper, a novel 500V SOI PiN diode with multiple deep-oxide trenches (MDOT) is proposed. By employing the MDOT, t_{rr} of the device is improved significantly. The proposed MDOT diode exhibits a superior trade-off between forward voltage drop (V_F) and t_{rr} as compared with the conventional diode. In Section II, the TCAD simulations are performed to reveal the structure mechanism. In Section III, the fabrication process flow and reverse recovery performance of the proposed diode are discussed.

II. Structure and Mechanism



(a) (b)

Fig. 1 Schematic cross-section view of (a) the proposed MDOT diode and (b) the conventional diode.