Advanced Magnetic Sensors Dedicated to Galvanic Current Monitoring of Power Devices in PV Inverters

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Purpose of Work

A short circuit protection scheme is necessary to prevent the power switch from exceeding its maximum current ratings. Monitoring the current of power devices with galvanic isolation is advantageous since it offers the increased efficiency and reduced circuit cost.

Approach

The widely used magnetic sensors based on IC compatible sensing devices, such as the one based on CMOS [1, 2] and bipolar [3, 4] technologies have modest sensitivity in the range of few mT [1] comparing with the non-IC compatible magnetic sensors such as giant magnetoresistors and/or superconducting quantum interference device (SQUID) having a sensitivity bellow nT [5]. Consequently, the increase of sensitivity of IC compatible magnetic sensors is always highly desirable for various applications, such as one mentioned above. In this work we presented recently developed magnetic sensing devices having at least order of magnitude increased sensitivity comparing to existing technologies; they are also fully compatible with modern bulk Si and SOI power IC technologies [6] employed for PV inverter design.

Results and Significance

LD MagFET for MS Power IC Bulk Si Technology – Recently we described the design and operation of lateral double-diffused magnetic sensitive MOSFET with integrated Hall plate (referred to as LD MagFET). Manufactured LD MagFET has vertical structure very similar to conventional LDMOSFET but with particular differences in their layout and geometry: (1) the channel length and the deep N-well drain extension are substantially elongated in LD MagFET design, the later one to allow for the Hall plate integration into the LDMOSFET; (2) unlike LDMOSFET with single drain contact, the LD MagFET has two drain contacts D1 and D2 placed at the end of N- drain region with maximal mutual separation. The sensor transfer function has been measured and investigated. Its current-related relative magnetic sensitivity is estimated as $30\%T^{-1}$.This sensitivity is order of magnitude higher than the one for the conventional split-drain silicon MagFETs reported so far to be in the range of 1.5-3.5 $\%T^{-1}$ [7, 8, 9].

Magnetic FinFET for MS Power IC SOI Technology - The innovative structure of new Magnetic FinFET designed has been proposed in SOI technology. Externally, it functions as the single gate split-drain split-source n-channel MagFET. Internally, it consists of the two lateral MOSFETs with the gates G1,G2 that share the same low doped (intrinsic) bulk area. The internal electron current density distribution of Magnetic FinFET in the on-state has been investigated using SILVACO TCAD industrial standard software. The results show that the transversal current flowing between the source and the drain contacts S1, S2 and D1, D2 respectively, is concentrated in the narrow region of bulk volume forming the so-called "current filament" with high electron density (electron plasma). An extremely high magnetic sensitivity around 100 $\%T^{-1}$ of new Magnetic FinFET is predicted, which is almost the two orders of magnitude larger than the one found in conventional MagFETs. It can be attributed to much higher mobility of bulk electrons in the current filament in comparisons with the mobility of surface channel carriers of conventional MagFETs.

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