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**Baliga**

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[54] **SEMICONDUCTOR SWITCHING DEVICES HAVING BURIED GATE ELECTRODES AND METHODS OF FORMING SAME**

[57] **ABSTRACT**

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Semiconductor switching devices having buried gate electrodes include a substrate, a drift region of first conductivity type (e.g., N-) extending to a face of the substrate and a first insulated gate electrode buried in the drift region. The first insulated gate electrode extends laterally in the substrate in spaced relation to the face. A second gate electrode is also provided on the face at a location extending opposite the first insulated gate electrode. A base region of second conductivity type (e.g., P) is also provided in the substrate, between the second gate electrode and an upper surface of the first insulated gate electrode. Similarly, an emitter region of first conductivity type (e.g., N+) is provided between the first face and the upper surface of the first insulated gate electrode. The base region is defined so that respective P-N junctions are formed with the emitter and drift regions. These P-N junctions preferably extend between the upper surface of the first insulated gate electrode and the first face. First and second electrodes are also electrically coupled to the emitter and the drift regions, respectively. In the event the semiconductor switching device comprises an insulated gate bipolar transistor (IGBT), the first electrode is preferably coupled to the emitter region at the first face and the second electrode is preferably disposed on a second face of the substrate and is indirectly coupled through a collector region of second conductivity type (e.g., P+) and a buffer region of first conductivity type (e.g., N+) to the drift region.

[73] Assignee: **North Carolina State University**, Raleigh, N.C.

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[51] **Int. Cl.<sup>6</sup>** ..... **H01L 29/78**

[52] **U.S. Cl.** ..... **257/366; 257/139; 257/378**

[58] **Field of Search** ..... **257/139, 141, 257/365, 366, 378**

[56] **References Cited**

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