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**Baliga**

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(54) **METHODS OF FORMING POWER SEMICONDUCTOR DEVICES HAVING T-SHAPED GATE ELECTRODES**

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(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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**ABSTRACT**

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Power semiconductor devices having recessed gate electrodes are formed by methods which include the steps of forming a semiconductor substrate having a drift region of first conductivity type therein extending to a face thereof and forming a trench in the substrate so that the trench has a bottom which extends opposite the drift region and a sidewall which extends from the drift region to the face. The sidewall may extend orthogonal to the face or at an angle greater than 90°. A preferred insulated gate electrode is formed by lining the face and trench with a gate electrode insulating layer and then forming a conductive layer on the gate electrode insulating layer. The conductive layer is preferably formed to extend opposite a portion of the face adjacent to the trench and into the trench. A step is then performed to pattern the conductive layer to define a T-shaped or Y-shaped gate electrode which fills the trench and also extends opposite the face at a location adjacent the trench. This step is preferably performed without planarizing the conductive layer using techniques such as chemical mechanical polishing (CMP). Emitter/source and base regions of first and second conductivity type, respectively, are then formed in the drift region. Preferably, the emitter/source regions are formed in a self-aligned manner to an edge of the patterned gate electrode. In particular, the emitter/source region and base region may be formed by implanting emitter/source and base region dopants into the drift region, using the gate electrode as an implant mask, and then diffusing the implanted dopants to define an emitter/source region within a base region well.

**Related U.S. Application Data**

- (62) Division of application No. 09/088,276, filed on Jun. 1, 1998.
- (51) **Int. Cl.<sup>7</sup>** ..... **H01L 21/332**
- (52) **U.S. Cl.** ..... **438/138; 438/135; 438/137; 438/542; 438/546; 438/547; 438/556**
- (58) **Field of Search** ..... 438/133, 135, 438/138, 136, 137, 542, 546, 547, 556

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**12 Claims, 5 Drawing Sheets**

