

ENGINEERING PRACTICES STUDY 1164

TITLE: STUDY TO REVIEW STEP COVERAGE REQUIREMENTS
FOR ALTERNATE CHANNEL METALLIZATION DESIGNS.

Project number: 5961-2018-052

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STUDY PROJECT

FINAL REPORT

Study Conducted by DLA LAND AND MARITIME

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I. **OBJECTIVES:** DLA Land and Maritime-VAC conducted an EP study on the step coverage requirements of MIL-PRF-19500 semiconductor die constructed using HEXFET, stripe, or other designs using large sheets of repeating metallization patterns (all three constructions hereafter will be referred to as 'repeating grid design'). The purpose of this EP study was to obtain input from the military services, manufacturers, and user communities concerning verification of step coverage in MIL-PRF-19500.

II. **BACKGROUND:** The scanning electron microscope (SEM) inspection of power MOSFET devices currently requires a minimum of 20 percent of the metallization thickness be present over the step coverage and in addition, the maximum calculated current density shall not exceed the current density that corresponds to the applicable conductor material in accordance with MIL-PRF-19500 paragraph H.3.6.

Die using a repeating grid design increase the width of the channel surface area and optimize current density. This distribution of the step width over multiple repeating locations across the die in a grid or a striped pattern allows for a decrease in the current density that is not accounted for in the cross section review currently required in test method 2077 of MIL-STD-750. The repeating grid design functions similar to separate devices connected in parallel able to uniformly distribute the load over the most of the structure with a load balancing effect. Test method 2077 only focuses on one cross section of one area and does not account for additional current paths, associated with this type of repeating grid design, around an area that may have thin metallization. Multiple current paths also reduce the potential for a failure due to electro migration that is more prevalent in designs using a single current path and larger current densities.

Designs using this repeating grid design could fail the minimum 20 percent metallization thickness requirement but pass the current density safety margin by large percentages when taking into account the entire step metallization area.

Proposals:

To account for the step coverage area across the entire die instead of the limited cross section area for this repeating grid design, the oxide step coverage acceptance criteria provided in MIL-STD-750, TM2077 paragraph 3.7.1.2 shall not apply, instead the minimum active metal thickness (cross section) shall provide for the maximum electro migration current specified. The source metallization shall be verified for overall thickness specification. The calculated current density shall not exceed the value, which corresponds to the applicable conductor material in accordance with MIL-PRF-19500 paragraph H.3.6.

The following SEM exception paragraph is based off the original proposal modified based on the comments discussed during this coordination.

* 4.5.X **SEM exception.** For devices with die using a repeating grid design, the oxide step coverage acceptance criteria provided in MIL-STD-750, Test Method 2077, paragraph 3.7.1.2 shall not apply. Instead, the minimum active metal thickness (cross section) shall provide for the maximum allowable current density of 5×10^5 amps/cm² in accordance with MIL-PRF-19500 paragraph H.3.6. The source metallization thickness at the oxide step shall be verified for the overall thickness, which corresponds to the applicable device channel width at the maximum rated continuous current (IDMAX). The maximum allowable current density may be found using the following equation; $\text{Current Density (A/cm}^2\text{)} = \text{ID current max} / \text{Step metal thickness (cm)} * \text{Channel width (cm)}$.

III. **RESULTS:** The comments submitted to DLA Land and Maritime have been reviewed and indicate that a modified version of the proposed paragraph should be used as the basis for evaluating repeating grid designs.

IV. **CONCLUSIONS:** Based on the comments received we will propose adding this alternate method to evaluate repeating grid designs into the applicable specification sheets at this time.

V. **RECOMMENDATIONS:** DLA Land and Maritime proposes that all the MOSFET specification sheets be evaluated to determine if this alternate method needs added. In addition, it is recommended that a new section be added to the SEM inspection test method 2077 of MIL-STD-750 to provide this additional option for repeating grid designs.