功率元器件

使用热电偶测量封装背面温度时的注意点

本应用手册记载了为了计算半导体芯片在实际动作时的结温，使用热电偶测量封装背面温度时的注意点。

测量仪器的额定范围

当使用热电偶测量封装背面的温度时，为了实现高精度的测量，需要把热电偶紧贴到封装上。图 1 是 SiC MOSFET 所使用的 TO-247 封装。在封装背面露出有用于散热的金属（Thermal Pad），该 Thermal Pad 在封装结构上和 Drain 连接在一起。当按照如图 2 所示的电路一边进行实际动作一边测量温度时，Drain 上会被施加高压，这样在 Thermal Pad 上也会产生相同的电压。因此，当把热电偶紧贴到 Thermal Pad 上并连接到数据记录仪上时，测量仪器上也会被施加高压。因此，如果测量仪器的额定范围低于所施加的电压，将无法进行测量。

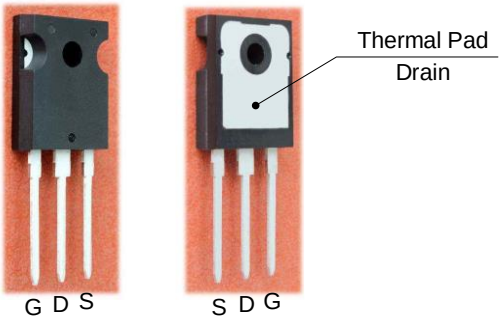

图 1. TO-247 封装
背面露出有 Thermal Pad

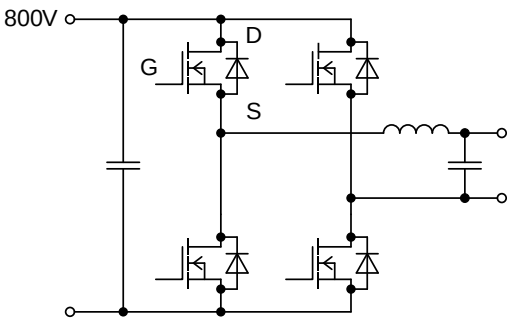

图 2. 逆变电路

噪声的影响

当被测器件所在的电路正在进行开关动作时，由于开关噪声的影响，可能无法正确地进行温度测量。为了减轻噪声的影响，有时会在 Thermal Pad 和热电偶之间加入聚酯薄膜等绝缘片，但是在绝缘片上会产生温度差，或者导致紧密性恶化。这样，所测量的温度会变低，导致估算有误，需要加以注意。

热阻的恶化

如图 3 所示，通过在封装背面和散热器之间插入热电偶来进行温度测量时，因为热电偶存在一定的厚度，TIM 会发生漂浮而产生空气层，这样会导致热阻恶化。在有的事例里，有无热电偶会导致 8°C/W 以上的热阻差产生。热阻差的产生程度和模组的结构、热电偶以及 TIM 的种类有关。

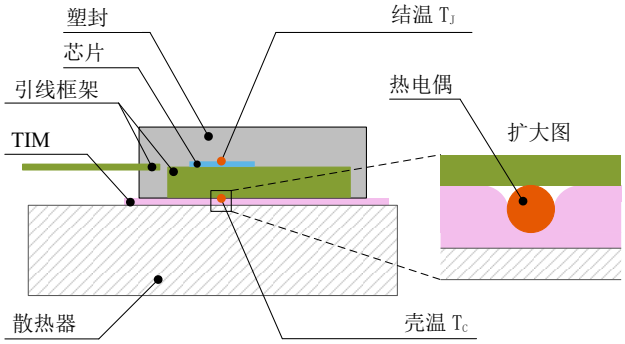

图 3. 当在封装背面插入热电偶时，
TIM 会漂浮导致热阻恶化

热电偶的嵌入方法

为了解决 TIM 漂浮的问题，有一个方法是在 Thermal Pad 上开槽，并将热电偶嵌入到槽中。图 4 是将热电偶放入槽中，为了实现和散热器之间的良好接触，使用焊锡进行嵌入之后的状态。在该例中，焊锡使得热电偶发生了短路。因为热电偶测到的温度是正极和负极这两个电极最开始接触位置的温度，所以此时所测到的是封装边缘的温度，和原本所希望的测量位置（芯片的正下方）的温度相差很大。这样，所测量的温度会变低，导致估算有误，需要加以注意。

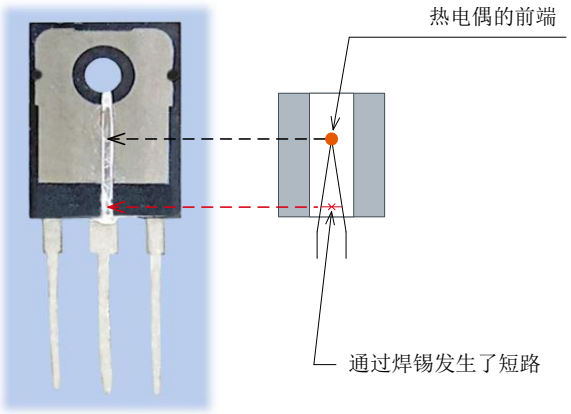

图 4. 将热电偶放入槽中，使用焊锡填充的状态
热电偶发生了短路，测到的是封装边缘的温度

图 5 是将热电偶放入槽中，使其前端与芯片正下方的封装接触并使用粘合剂进行固定，再使用导热硅脂对槽进行填充的方法。除了前端，热电偶的其他部位都通过绝缘层实现了电气绝缘，因此不会出现上例所示的测到封装边缘温度的情况。但是，先在 Thermal Pad 上开槽，再使用热导率较低的导线绝缘层、粘合剂、导热硅脂对槽进行填充时，会对封装的散热性能产生影响。并且，该测量结果与热电偶和导热硅脂的种类、槽的深度相关。

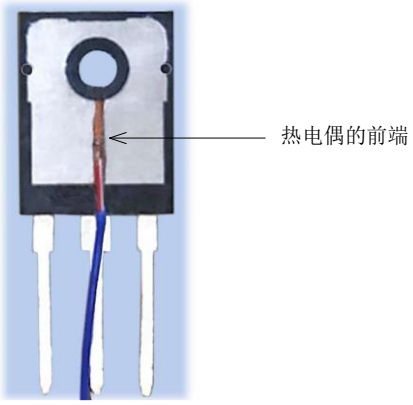

图 5. 将热电偶放入槽中，使其前端和芯片的正下方接触
并使用粘合剂进行固定，再使用导热硅脂对槽进行填充的方法

RthJC 值的区别

使用热电偶测量封装背面温度所算出的从 PN 结到外壳的热阻（RthJC）的值，和数据手册所记载的 RthJC 的值，两者的计算方法不一样，请不要混为一谈。数据手册的值是基于 JESD51-14 TDI 法的数值，测量时不使用热电偶（参考应用手册：《热阻 RthJC 的测量方法和使用方法》）。因此，当使用热电偶测量封装背面温度，并使用数据手册的 RthJC 来估算结温（T_J）时，估算值会比实际值偏低，需要加以注意。当使用热电偶测量封装背面的温度、通过该值估算 T_J 时，一定要在最终产品的状态下，求出热特性参数（表示 T_J 和封装背面之间温度的参数），并使用该热特性参数进行估算。另外，为了保证测量质量，需要将热电偶的测量位置和种类、导热硅脂的种类等测量条件详细地进行书面化。

参考资料

[1] JESD51-14:2010, *Transient Dual Interface Test Method for the Measurement of the Thermal Resistance Junction to Case of Semiconductor Devices with Heat Flow Through a Single Path*

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