热设计

关于绝缘垫片的热阻的注意点

对于 TO (Transistor Outlines)封装等，在背面有用于散热的裸漏金属焊盘（散热焊盘）的封装形式，当将这种非绝缘型的封装安装在散热片上时，会经由封装的金属焊盘对散热片施加高压，因此需要使用绝缘垫片进行隔离。在进行热估算时，如果绝缘垫片的热阻取值不恰当，会无法得到正确的热估算结果，因此本应用手册记载了关于绝缘垫片的热阻的注意点。

图 1 是 TO 封装之一的 TO-247 封装的外观图。在背面有用于散热的裸漏金属焊盘，如果是 MOSFET 产品，该焊盘和封装内部的芯片（半导体芯片）的漏极存在电气连接，因此在电路应用中会存在高压。 当将此封装安装在散热片上时，如图 2 所示，需要在封装和散热片之间插入绝缘型的散热垫片。

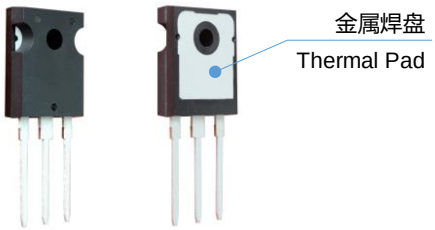


图 1. TO-247 封装的外观图

在散热片和 TO 封装之间，通常会使用螺丝或者夹片等固定件进行加压使两者牢固接触。加压时的压力会造成绝缘垫片产生压缩并使其热阻发生变化。热阻发生变化的原因，包括压力所导致的接触热阻变化等。

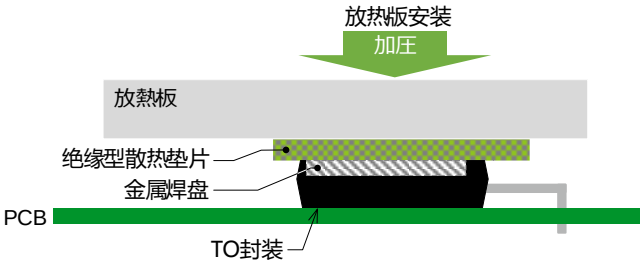


图 2. TO 封装的金属焊盘和散热片之间的绝缘

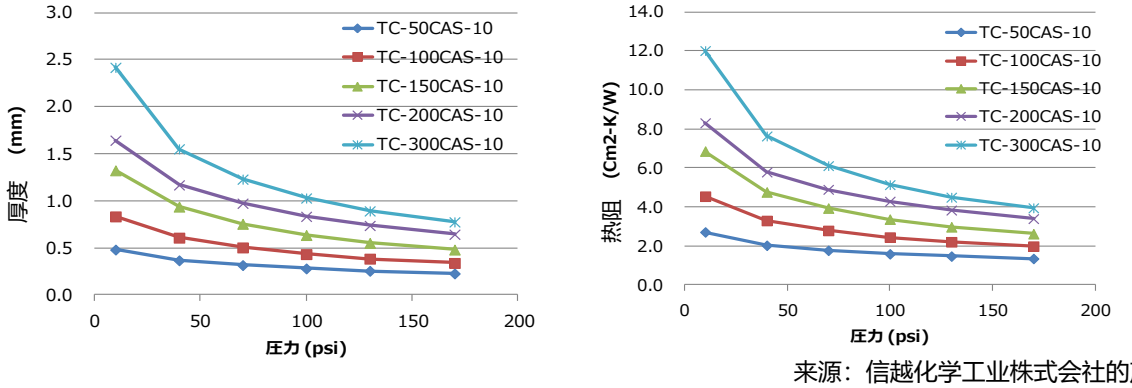
获取绝缘垫片的热阻

在查看绝缘垫片的产品目录和官网的公开规格时，会发现不同厂家的描述不一样，有的厂家的产品规格里包含了接触热阻、有的没有包含接触热阻，也有的将压力作为参数进行了记载等。即便是对于包含了接触热阻的规格值，也需要考虑接触热阻随垫片两端的接触材质和表面粗糙度所产生的变化。

有的产品在规格里只记载了导热系数。导热系数是物质固有的参数，用来表示物质内部发生热转移的难易程度，与产品的厚度无关，同时因为无法判断接触热阻，有可能造成热估算偏小。

因此，需要从垫片厂商获取与实际使用的压力值所匹配的热阻数据来进行热估算。图 3 是低硬度的绝缘垫片、图 4 是高硬度的绝缘垫片的示例。低硬度的绝缘垫片会在施加压力时变薄，因此垫片自身的热阻会变低。高硬度的绝缘垫片在施加压力时厚度几乎不变，但是热阻也会变低，这是因为当施加压力时，接触热阻会变低。对于高硬度的绝缘垫片，接触热阻会在垫片两端的接触材质和表面粗糙度变化时可能变大，因此更容易受到压力的影响。

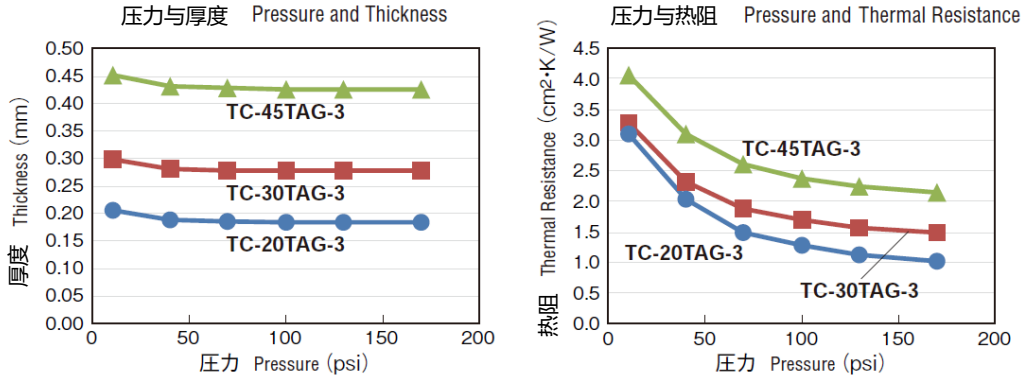
低硬度的散热硅胶垫片 TC-CAS-10 系列



来源：信越化学工业株式会社的产品目录

图 3. 低硬度垫片在压力变化时的热阻特性

高硬度的散热绝缘硅胶加工品 TC-TAG-3 系列



来源：信越化学工业株式会社的产品目录

图 4. 高硬度垫片在压力变化时的热阻特性

接下来讨论一下当考虑接触热阻和不考虑接触热阻时，结温估算的差别。此处给出的是按照图 2 模型进行仿真的结果。仿真条件为器件功耗 P_C=30W，环境温度 T_A=65℃。

当不考虑接触热阻时的热估算：

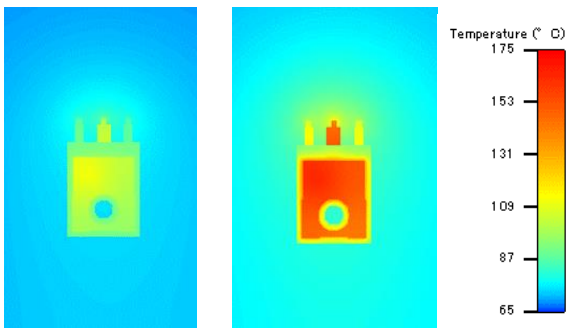
- θ_{JA} 按照 1.5°C/W 计算。
- $T_J = \theta_{JA} \times P_C + T_A$
  $= 1.5°C/W \times 30W + 65°C = 110°C$

当考虑接触热阻时的热估算：

- 加上接触热阻后，θ_{JA} 按照 3°C/W 计算。
- $T_J = \theta_{JA} \times P_C + T_A$
  $= 3°C/W \times 30W + 65°C = 155°C$

从本例可以看出，当不考虑接触热阻时，热估算结果是芯片结在规格范围以内没有使用问题，但是当实际加上接触热阻后，热估算结果是芯片结温会超过最大额定值。

综上所述，对于功耗较大的应用，如果不考虑接触热阻会得到错误的热估算结果，需要加以注意。



无接触热阻　　有接触热阻

图 5. 是否考虑接触热阻的温度差别

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