

V·I晶片母线转换模块(BCM)之热处理

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引言

此应用笔记探讨在不同室温、风速及散热片条件时, BCM之功率输出能力。

并叙述如何测度BCM之封装温度以描绘其热阻抗曲线。此等曲线连同效率参数将用作计算BCM于指定室温及气流条件下之最高功耗(及最高可用的输出功率)。

效率及功耗

在工作时, BCM之内部元件如半导体、控制电路、变压器及印刷电路板之上铜线均会发热。发热量跟BCM之效率有直接关系。如以下方程式所示, BCM之典型效率值为95%, 相当于每100W负载功率时消耗5W。

$$P_{DIS} = P_{OUT} \cdot \left(\frac{1}{\eta} - 1 \right)$$

方程式 1:

P_{DIS} 为BCM之功耗

P_{OUT} 为负载功率

η 为BCM之效率

散热途径

BCM之热量会传到晶片之外壳及印刷线路板(经过J-型接脚), 其等效热阻抗分别为 $R_{\Phi JC}$ 及 $R_{\Phi JB}$ 。此等热量最后会经外壳至环境阻抗 $R_{\Phi CA}$ 或经线路板至环境阻抗($R_{\Phi BA}$)等散发至四周环境, 如图1所示。

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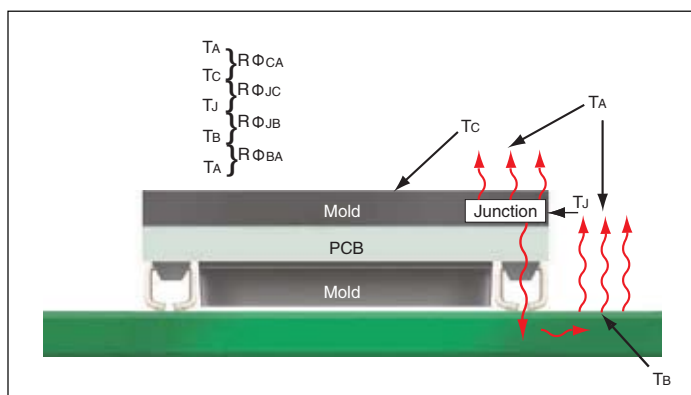


图1
透过外壳及印刷线路板散热

在大部分应用中, 以印刷线路板散热将取决于围绕BCM之铜量, 气流流经铜面的风量及周围元件所发热而耦合到板上的情况。此笔记假设BCM不以印刷线路板散热 (因为 $R_{\Phi BA}$ 非常大), 而只以外壳散热(因此 $R_{\Phi CA}$ 需保持越少越好)。

在大部分应用中，印刷电路板仍能提供少许散热，这样可略增加BCM可用功率之余量。BCM之外壳对环境之热阻抗($R_{\Phi_{CA}}$)取决于外壳之表面面积(基本上固定)及经过之空气流量(视乎应用及风扇能力)。

散热片选择

其中一个减低 $R_{\Phi_{CA}}$ 之方法就是增加BCM外壳之等效表面面积。如图2所示，外加散热片即能达至这目的。然后之热阻抗模型即如图3所示。如前述，这里仍假设印刷电路板不能提供散热。

图2
安装散热片能有效地增加BCM
之表面面积，从而降低 $R_{\Phi_{CA}}$

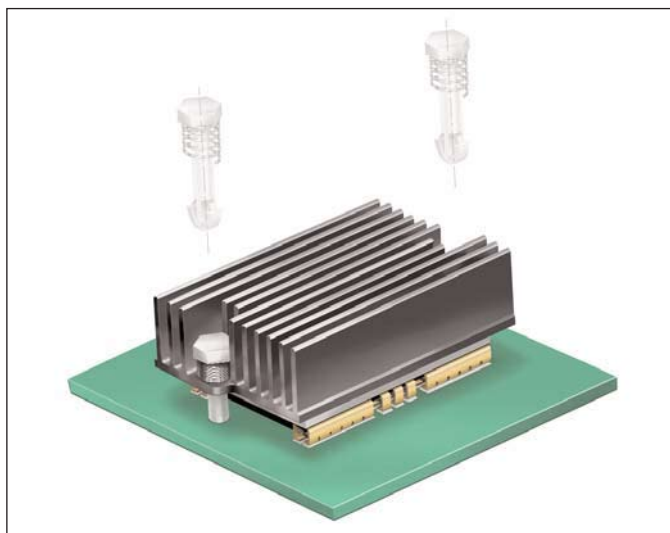
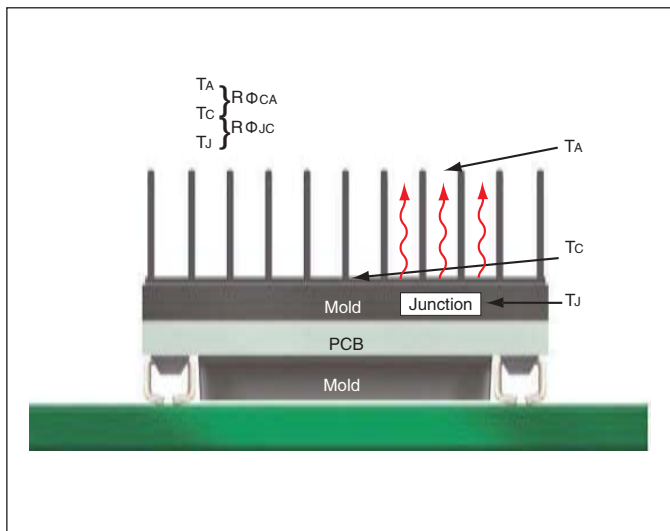


图3
带散热片后之热流模型 (忽略
 $R_{\Phi_{JB}}$)



散热片有两种高度; 6.3mm(图4)及11mm(图5)及两种方向; 横向(图6)及纵向(图7), 此等散热片已附带传热介面物料, 能提供晶片与散热片之优良传导。

采用两枚弹簧推针, 可紧固散热片并产生5lb/psi之压力。推针有四种不同长度以配合从0.055" 至0.172" 不同厚度的线路板。若需更多资料, 包括印刷线路板之钻孔形状及位置, 可浏览以下网址: http://www.vicor-china.com/pro_main.php?url=1,33,510&lang_code=gb

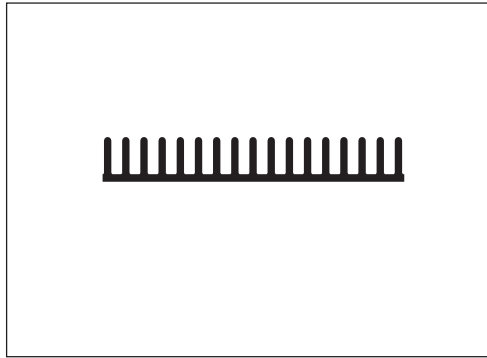


图4: 6mm散热片

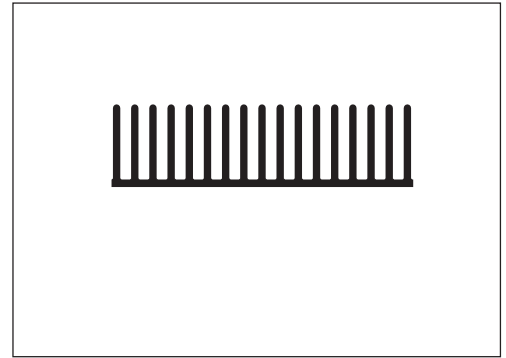


图5: 11mm散热片

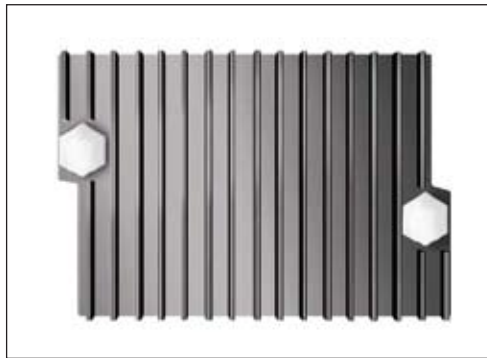


图6: 横向叶片

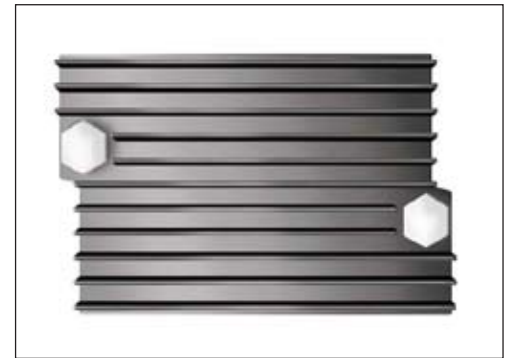


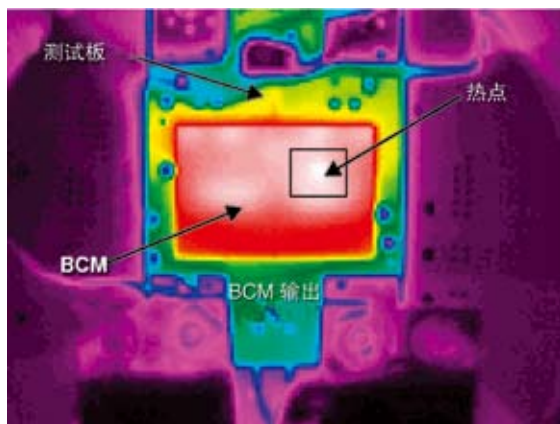
图7: 纵向叶片

量度技术

为了找出BCM未带散热片时之 $R_{\theta CA}$ 值, 量度外壳温度将会在风洞内进行, 并采用红外线感应摄像头于不同风速下测度。测试时, BCM被安置于6层印刷线路评估板, 其内层为3oz铜铂而外层为2oz。环境温度则采用热电耦置于箱内量度。

图8是其中一些测试结果，此图为BCM未带散热片之红外影象。附加散热片可把热量更均匀地分布于外壳，从而减少过分热力集中点。在测试前，BCM之表面会涂上带特定发射性之黑墨。参考点则为外壳最热的地方，而这点是不同于不同型号的。当采用热电耦去量度外壳温度时，可用红外线影象去决定应放在那一位置。以下会有更多红外线影象例子。

图8
不带散热片之红外线发热影象



热降额曲线

热降额曲线让用户知道在某一工作环境时，元件可安全地输出之功率。为防止压模里的零件不会超过125°C之结温度，模块之外壳应限制于100°C以下。

我们会以0°及90°风向，分别以不带散热片，带6.3mm散热片及带11mm散热片去量度外壳至环境之热阻抗($R_{\theta CA}$)与气流速度之关系。于0°方向时，风由前向后流经一纵向散热片(图9)。相反地，于90°方向时，风由右至左流经一横向散热片(图10)。

图9
带纵向叶片及0°风向

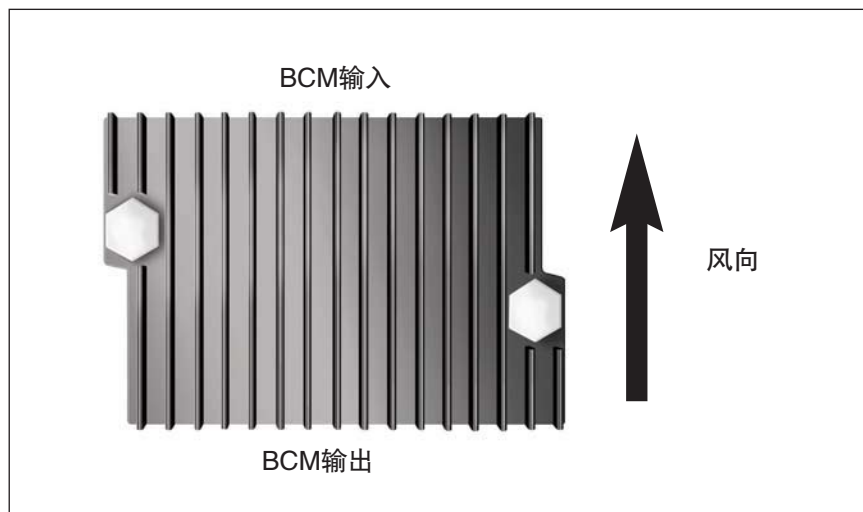
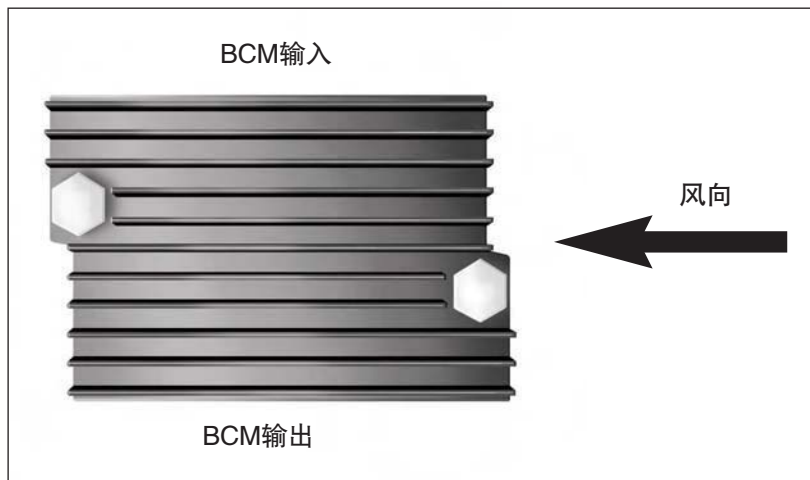


图10
带横向叶片及90° 风向



量度出之热阻抗结果于图11至12显示。个别型号之热阻抗曲线，可参考有关之章节。从这些热阻抗曲线，于特定之环境温度及风速时，便可用以下之方程式去决定最高容许之功耗：

$$P_{DIS(max)} = \frac{(T_{CASE(max)} - T_A)}{R\Phi_{CA}}$$

方程式2:

$P_{DIS(max)}$ 为BCM最高容许之功耗

$T_{CASE(max)}$ 为BCM之最高容许外壳温度(100°C)

T_A 为环境温度

$R\Phi_{CA}$ 为特定散热片及风速条件下之外壳至环境热阻抗参数

对每一BCM型号来说，其最高功耗是对应其输出功率及效率。以48V输入BCM系列而言，此等水平是取决于不同负载时之最差效率值，及不同环境温度及风速时之关系。其结果于后页显示。应留意最差值与数据表上之典型值会不同。基于不同之环境，测试设定等，用户应尽量保证最终系统内模块之外壳温度不超过100°C。

图11
典型外壳至环境热阻抗($R_{\theta CA}$)与
风速之关系。48V输入之BCM,
0° 风向

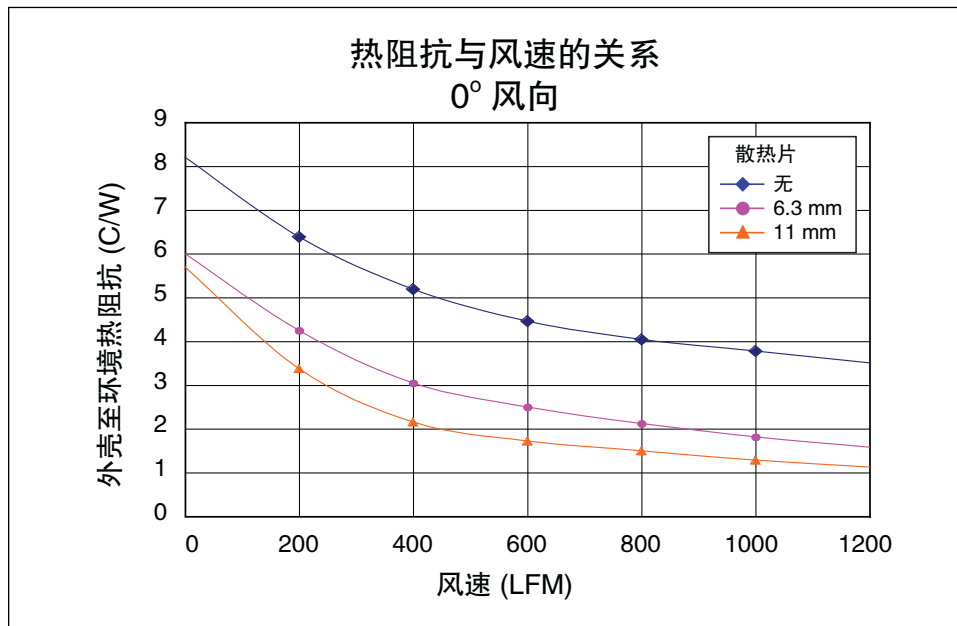
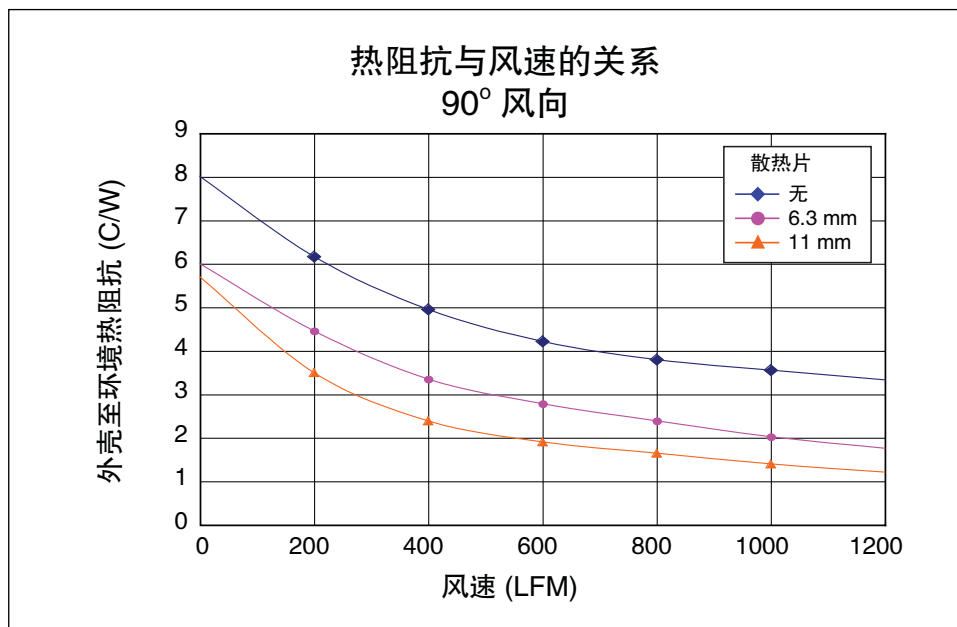


图12
典型外壳至环境热阻抗($R_{\theta CA}$)与
风速之关系。48V输入之BCM,
90° 风向



如何选用散热片(如有需要)

以下之步骤说明于某输出功率，而最高环境温度及气流速度已知的条件下，需采用怎样的散热片。

- 1) 确定最高之环境温度， $^{\circ}\text{C}$ ($T_{A(\text{max})}$)
- 2) 确定最高之风速，以LFM为单位($A_{F(\text{max})}$)及风向
- 3) 确定所需之最高输出功率($P_{\text{out}(\text{max})}$)
- 4) 找出有关之特定风向之BCM降额曲线
- 5) 开始时尝试用“不带散热片”之曲线图并找出对应于 $T_{A(\text{max})}$ 及 $A_{F(\text{max})}$ 之一点
 - a) 如此点之输出功率是高于 $P_{\text{out}(\text{max})}$ ，便无需采用散热片。否则，继续下一步
- 6) 用“带6.3mm散热片”之曲线图并找出对应于 $T_{A(\text{max})}$ 及 $A_{F(\text{max})}$ 之一点
 - a) 如此点之输出功率是高于 $P_{\text{out}(\text{max})}$ ，便需采用6.3mm散热片。否则，继续下一步
- 7) 用带11mm散热片之曲线图并找出对应于 $T_{A(\text{max})}$ 及 $A_{F(\text{max})}$ 之一点
 - a) 如此点之输出功率是高于 $P_{\text{out}(\text{max})}$ ，便需采用11mm散热片。否则，便需要更大之风速才可提升可应用之输出功率 $P_{\text{out}(\text{max})}$

热分析例子

应用一枚48V转12V之BCM(B048F120T30)并用于 50°C 环境及400LFM 0° 方向吹风下要求输出250W。

开始时采用“不带散热片”及 0° 方向吹风之降额曲线(图13)。然后找出对应于 50°C 及400LFM时最高可输出功率为175W。由于这是低于要求之250W，故此便需附加散热片。

现在采用“带6.3mm散热片”之降额曲线(图14)。找出对应于 50°C 及400LFM时最高可输出功率为290W。由于这是高于要求之250W，故此采用6.3mm散热片于400LFM风速为合适应用条件。

有些情况是不允许采用散热片的。通常，用户都要权衡功率、风速及体积之轻重而作取舍。这些降额图表正好给予用户合适之参考资料以作出最有利之决定。

图13
不带散热片之12V BCM
降额例子

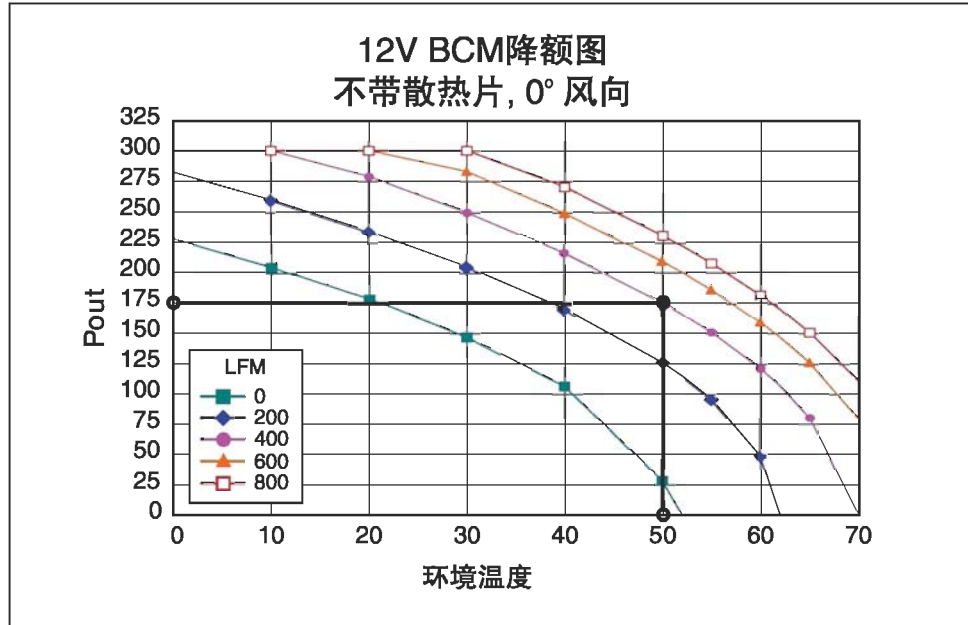
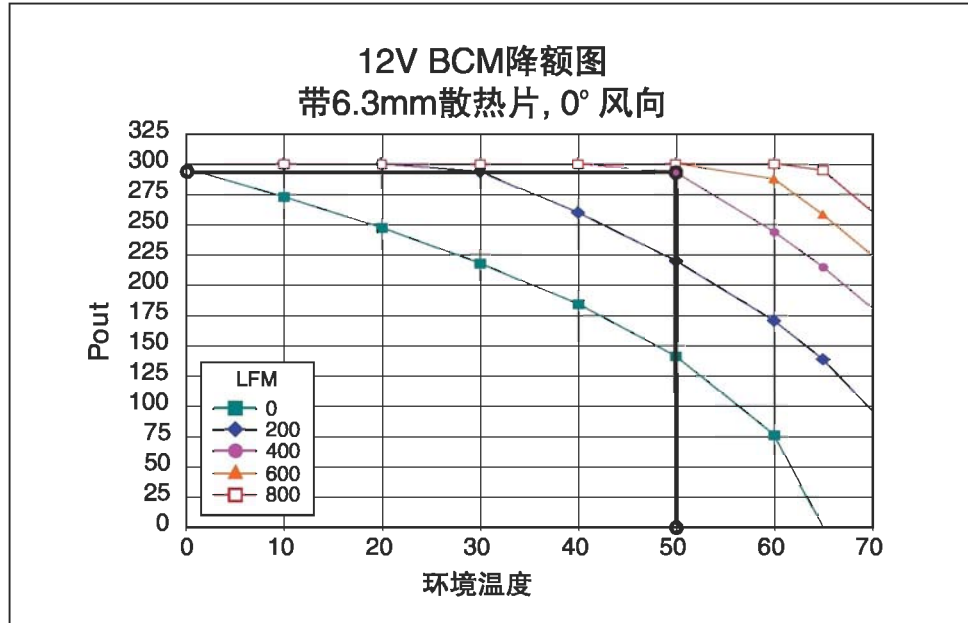


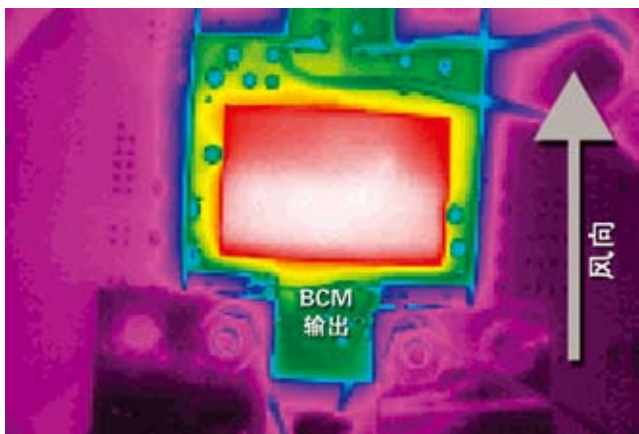
图14
带6.3mm散热片之12V BCM
降额例子



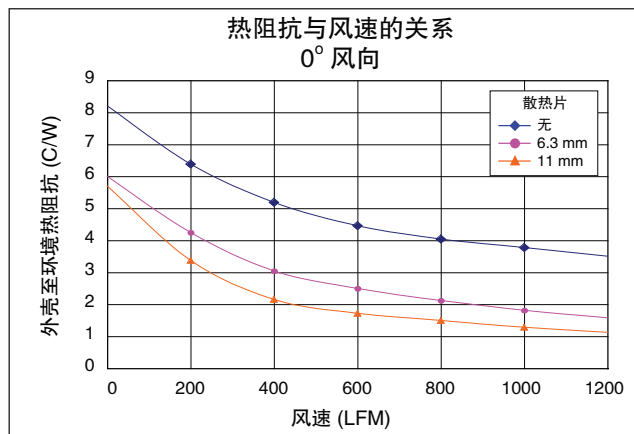
曲线图目录

| | |
|--------------------|-------|
| <i>B048F030T21</i> | 10-11 |
| <i>B048F040T20</i> | 12-13 |
| <i>B048F060T24</i> | 14-15 |
| <i>B048F096T24</i> | 16-17 |
| <i>B048F120T30</i> | 18-19 |
| <i>B048F160T24</i> | 20-21 |
| <i>B048F240T30</i> | 22-23 |
| <i>B048F320T30</i> | 24-25 |
| <i>B048F480T30</i> | 26-27 |

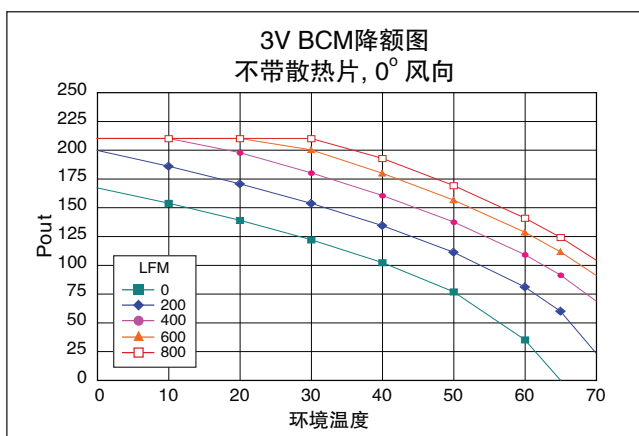
B048F030T21 0° 风向



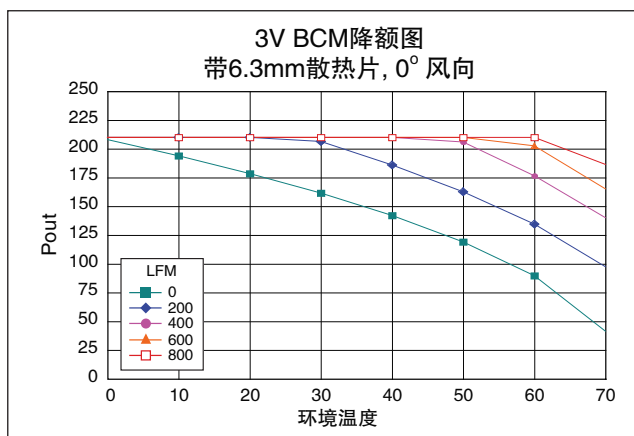
红外影象, 0° 风向; 满载, 200LFM, 不带散热片



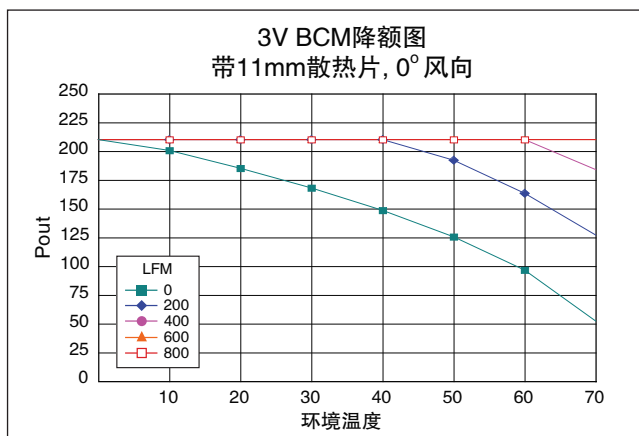
热阻抗与风速之关系, 0° 风向



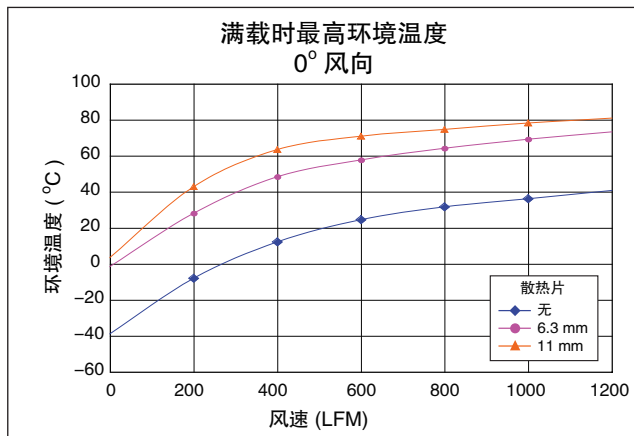
不带散热片之降额线, 0° 风向



带6.3mm散热片之降额线, 0° 风向

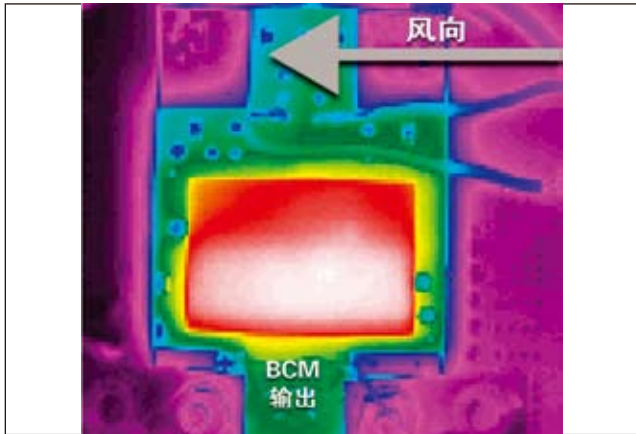


带11mm散热片之降额线, 0° 风向

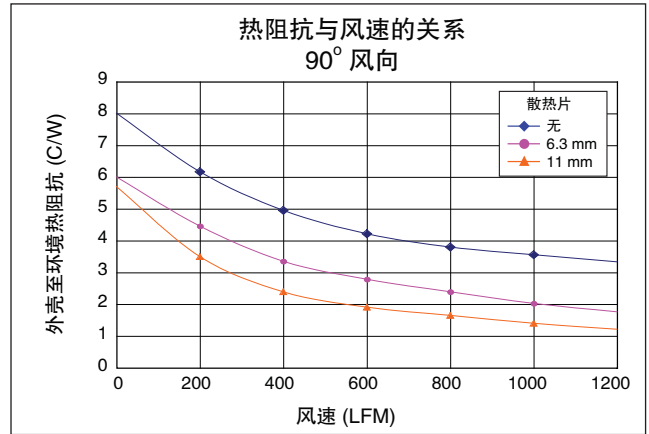


满载时, 晶片之最高工作温度

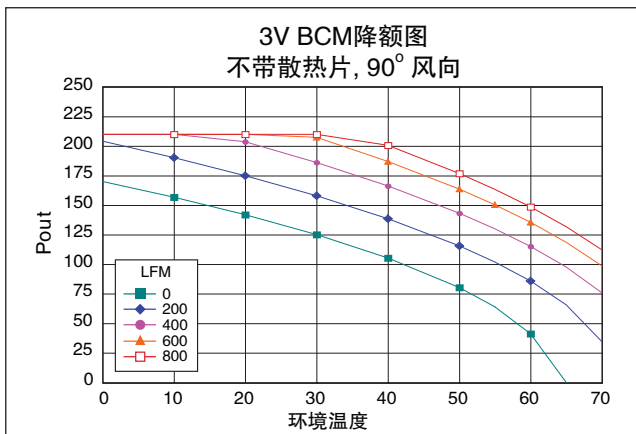
B048F030T21 90° 风向



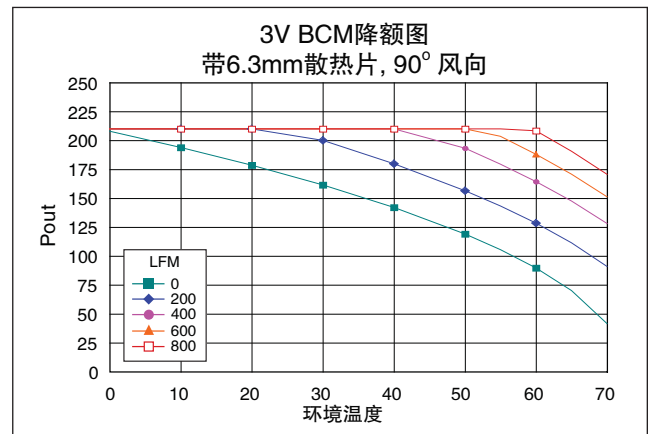
红外影象, 90° 风向; 满载, 200LFM, 不带散热片



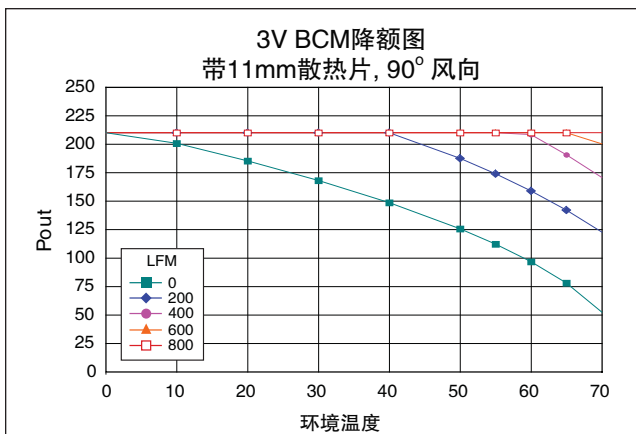
热阻抗与风速之关系, 90° 风向



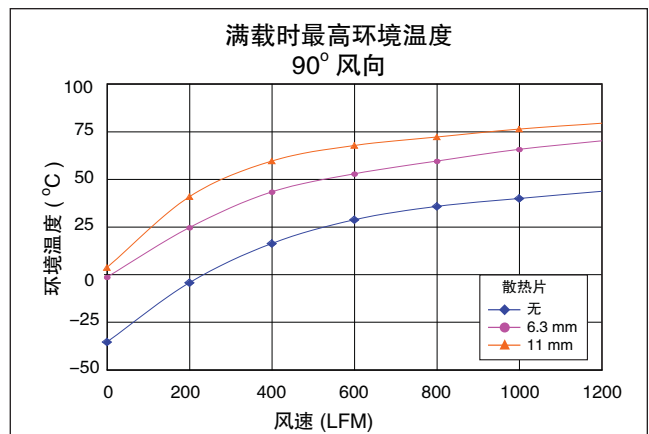
不带散热片之降额线, 90° 风向



带6.3mm散热片之降额线, 90° 风向

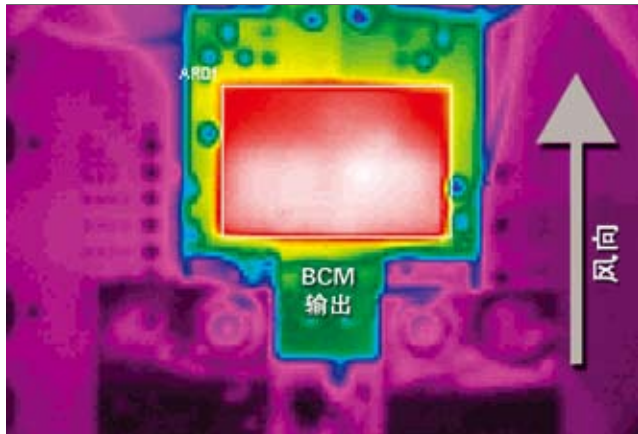


带11mm散热片之降额线, 90° 风向

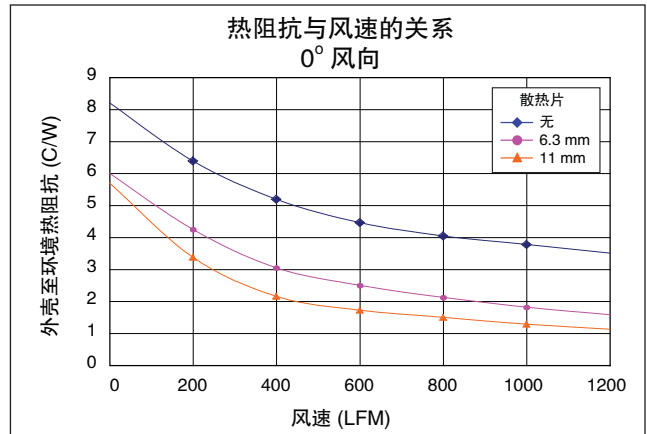


满载时, 晶片之最高工作温度

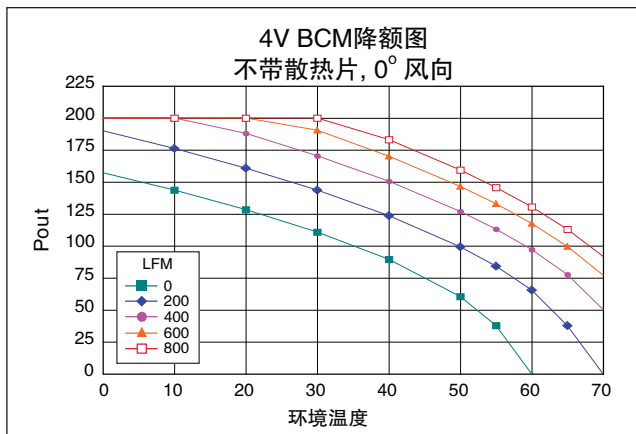
B048F040T20 0° 风向



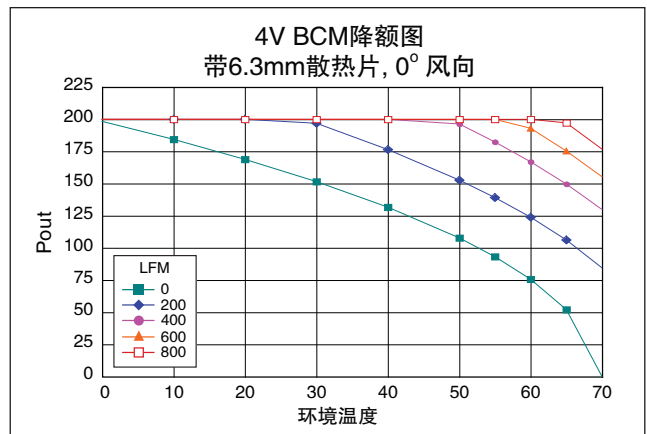
红外影像, 0° 风向; 满载, 200LFM, 不带散热



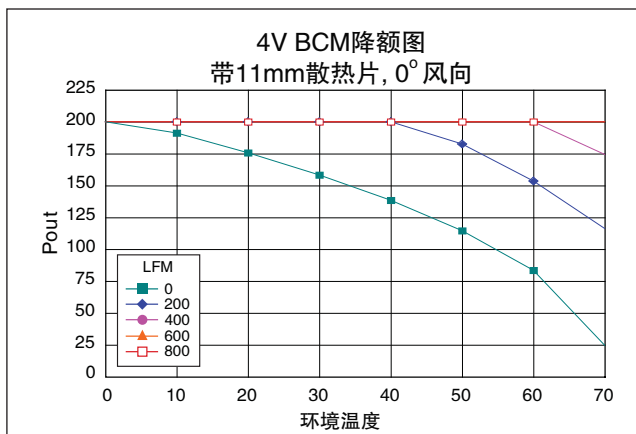
热阻抗与风速之关系, 0° 风向



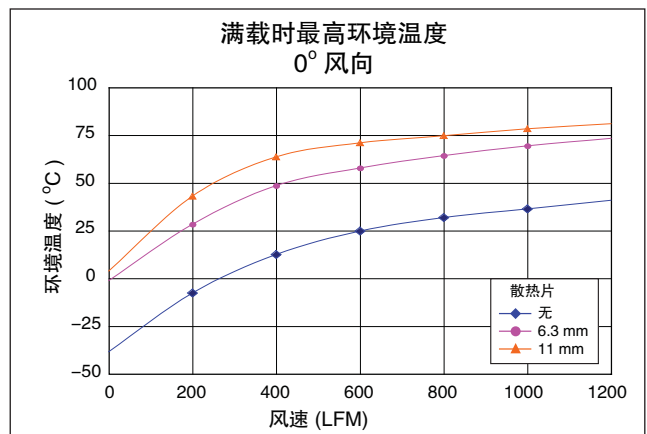
不带散热片之降额线, 0° 风向



带6.3mm散热片之降额线, 0° 风向

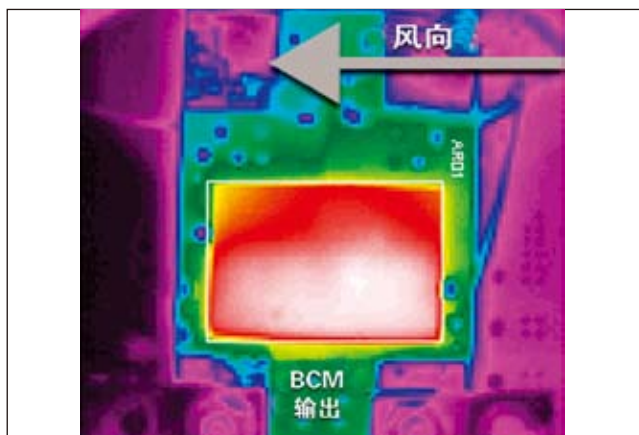


带11mm散热片之降额线, 0° 风向

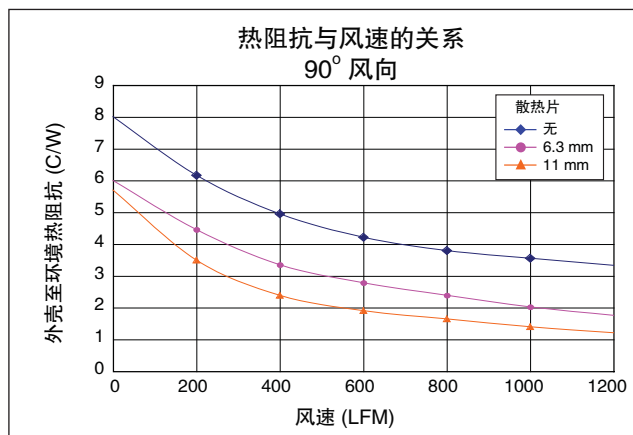


满载时, 晶片之最高工作温度

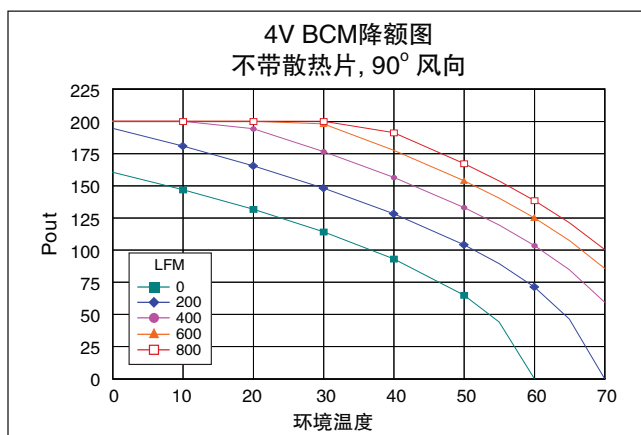
B048F040T20 90° 风向



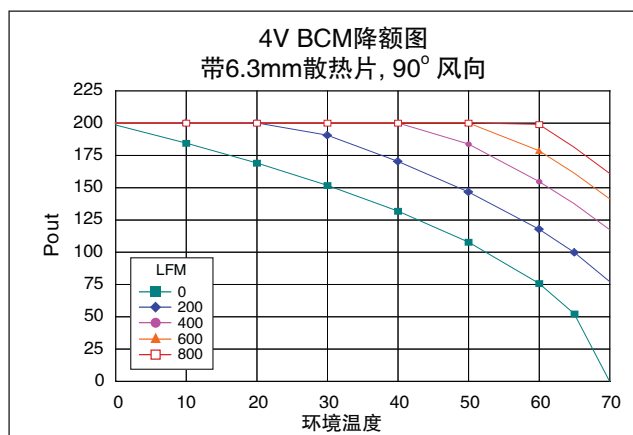
红外影象, 90° 风向; 满载, 200LFM, 不带散热片



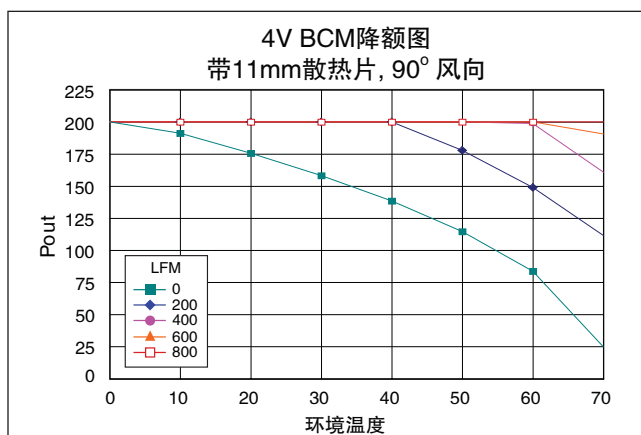
热阻抗与风速之关系, 90° 风向



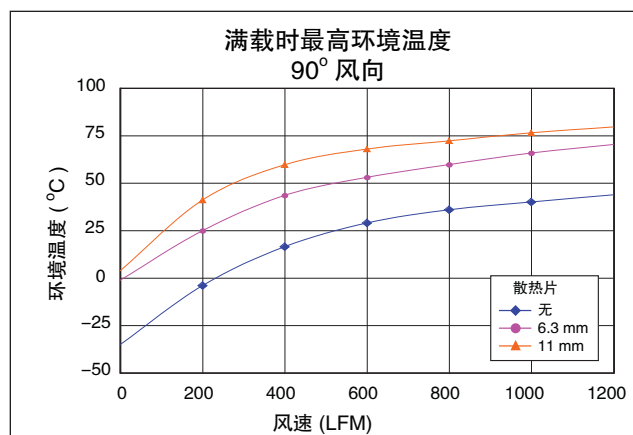
不带散热片之降额线, 90° 风向



带6.3mm散热片之降额线, 90° 风向

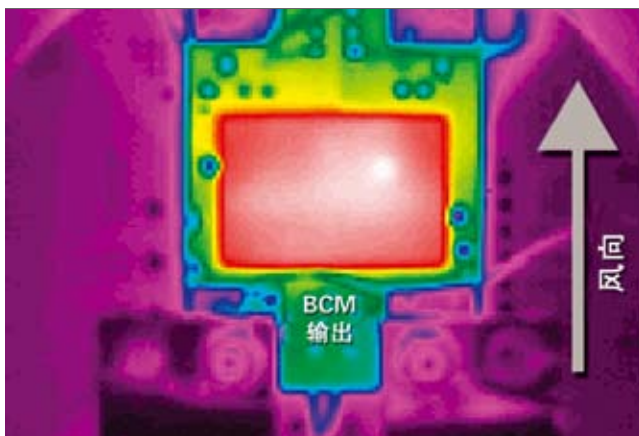


带11mm散热片之降额线, 90° 风向

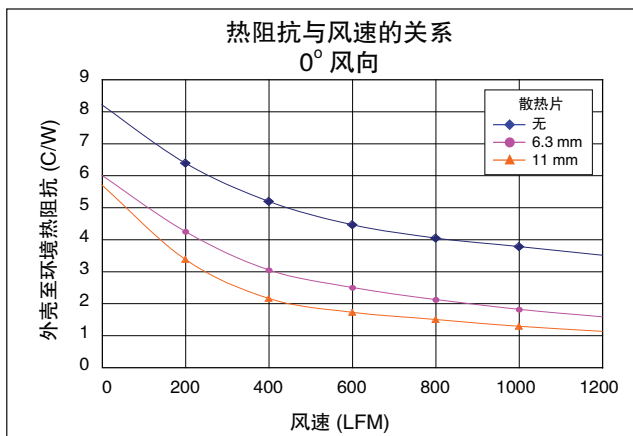


满载时, 晶片之最高工作温度

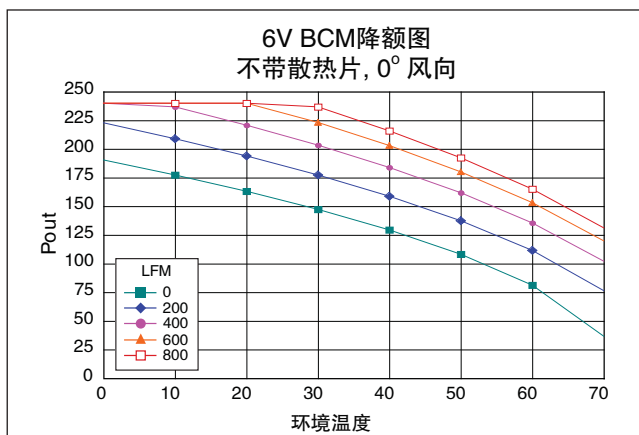
B048F060T24 0° 风向



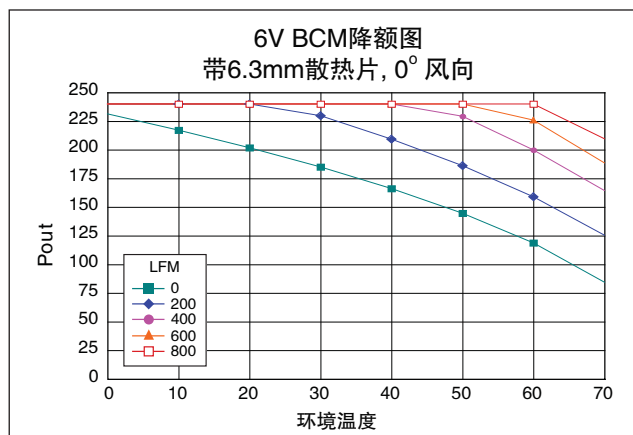
红外影象, 0° 风向; 满载, 200LFM, 不带散热片



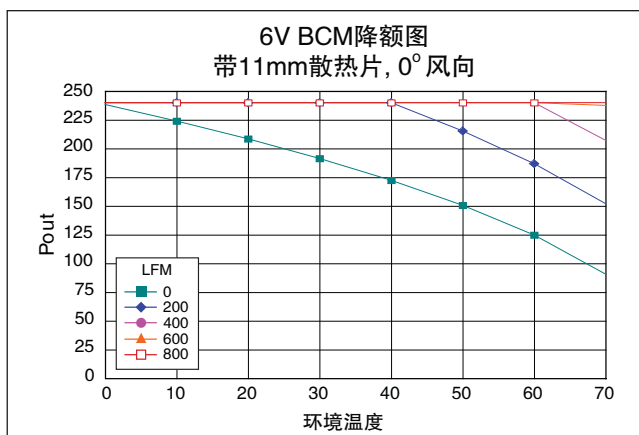
热阻抗与风速之关系, 0° 风向



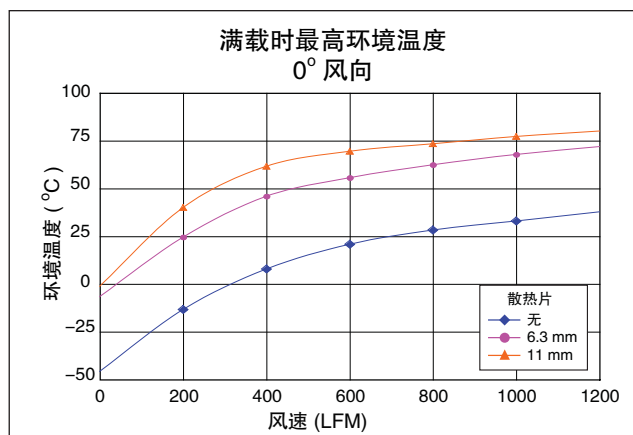
不带散热片之降额线, 0° 风向



带6.3mm散热片之降额线, 0° 风向

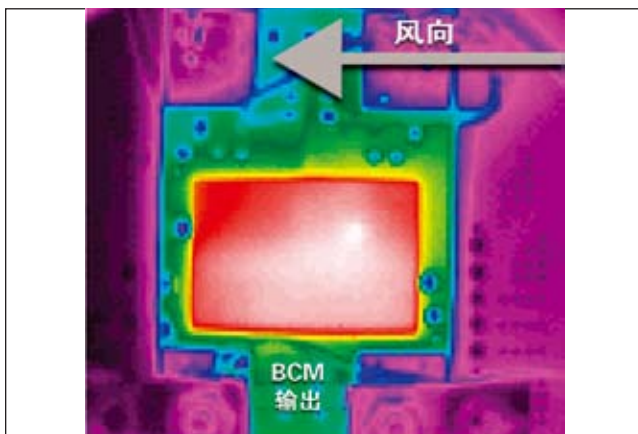


带11mm散热片之降额线, 0° 风向

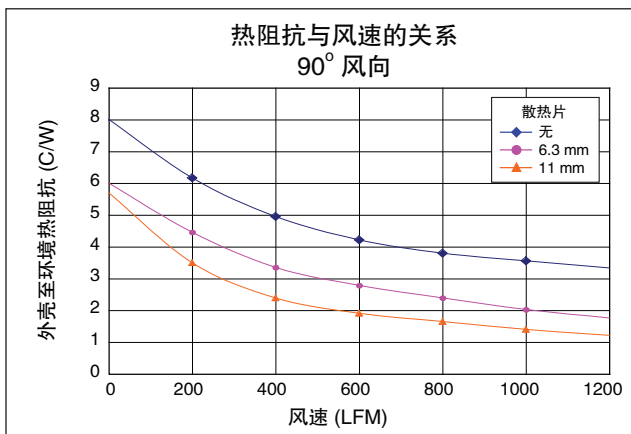


满载时, 晶片之最高工作温度

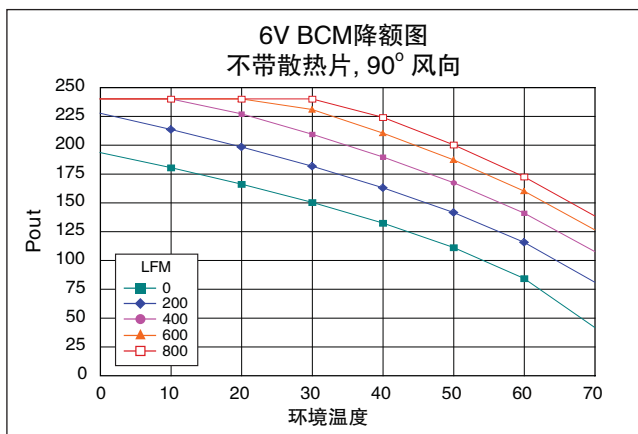
B048F060T24 90° 风向



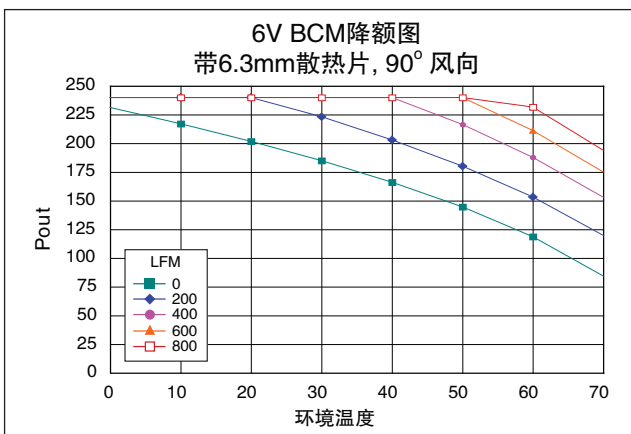
红外影象, 90° 风向; 满载, 200LFM, 不带散热片



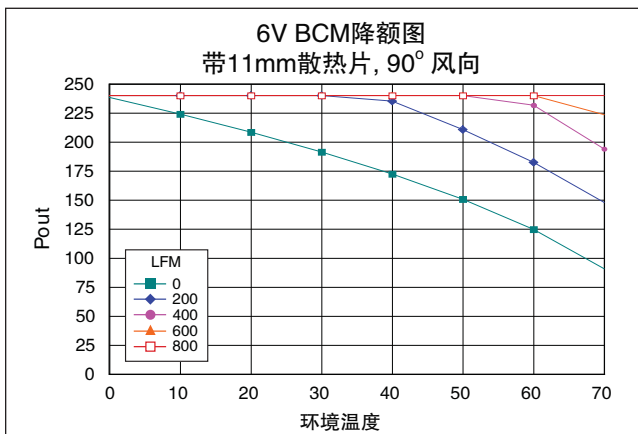
热阻抗与风速之关系, 90° 风向



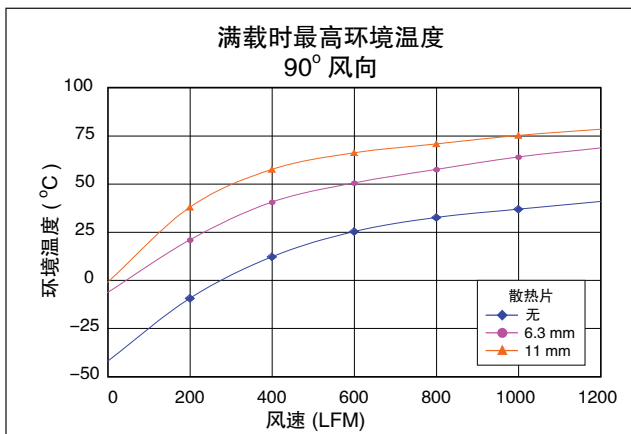
不带散热片之降额线, 90° 风向



带6.3mm散热片之降额线, 90° 风向

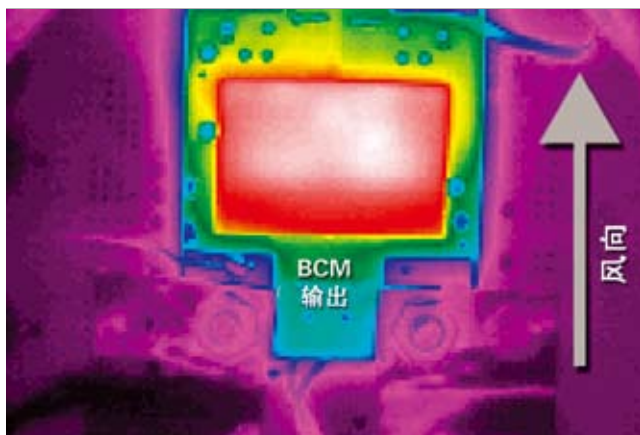


带11mm散热片之降额线, 90° 风向

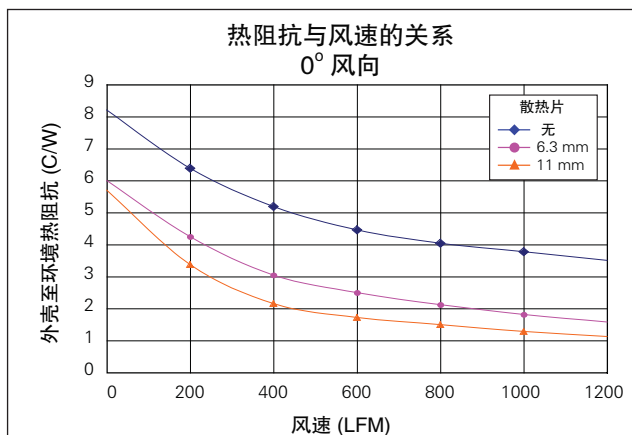


满载时, 晶片之最高工作温度

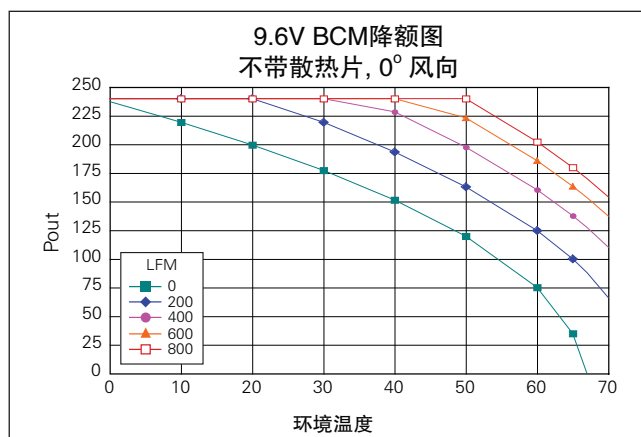
B048F096T24 0° 风向



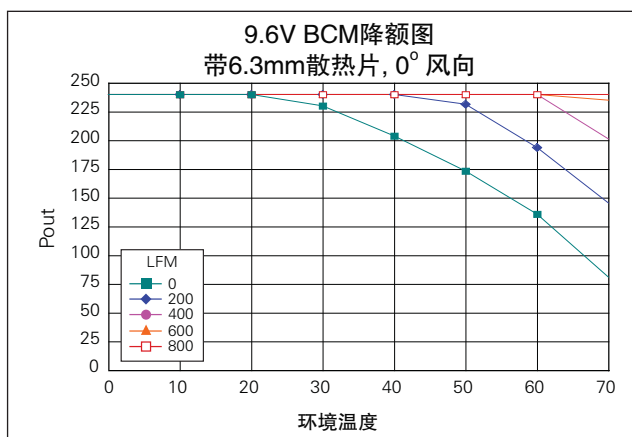
红外影象, 0° 风向; 满载, 200LFM, 不带散热片



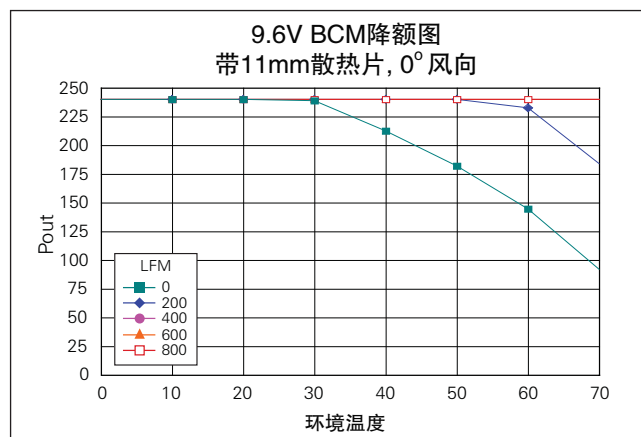
热阻抗与风速之关系, 0° 风向



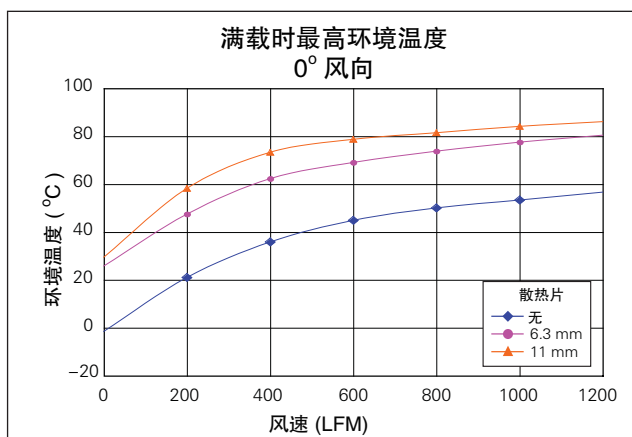
不带散热片之降额线, 0° 风向



带6.3mm散热片之降额线, 0° 风向

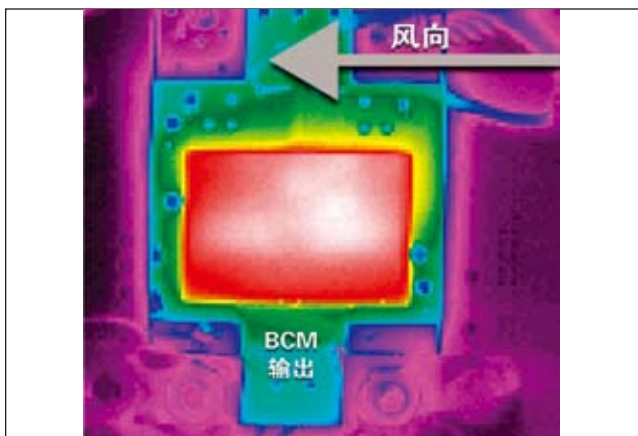


带11mm散热片之降额线, 0° 风向

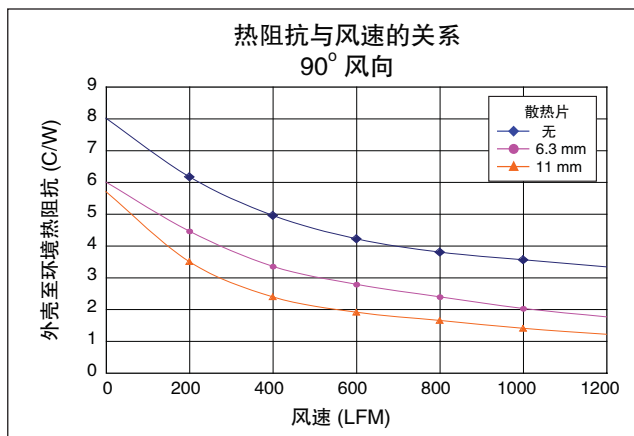


满载时, 晶片之最高工作温度

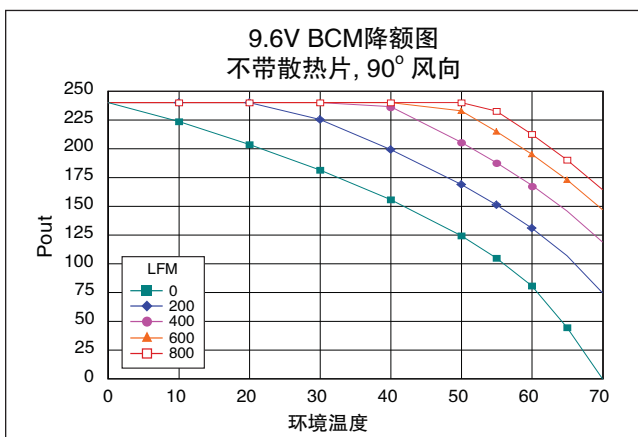
B048F096T24 90° 风向



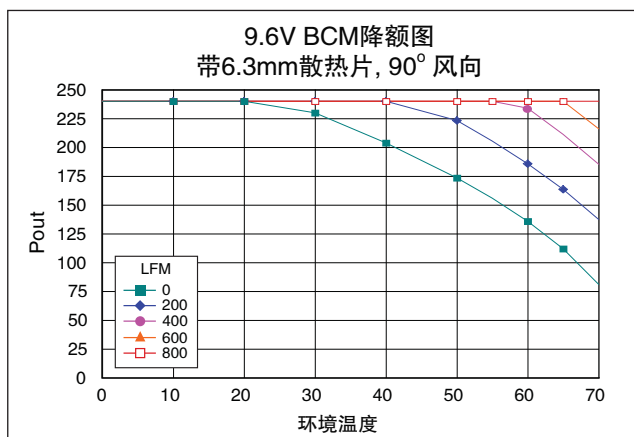
红外影象, 90° 风向; 满载, 200LFM, 不带散热片



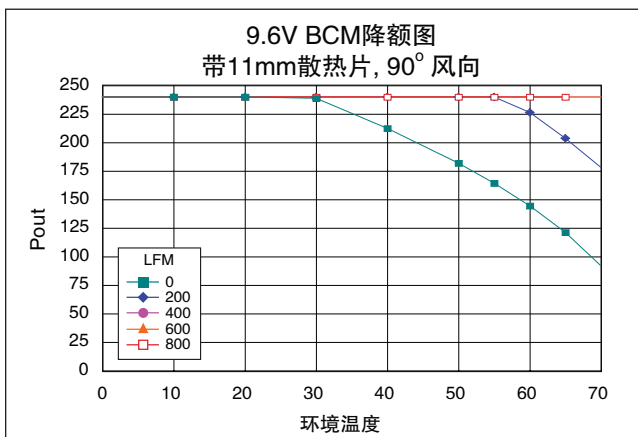
热阻抗与风速之关系, 90° 风向



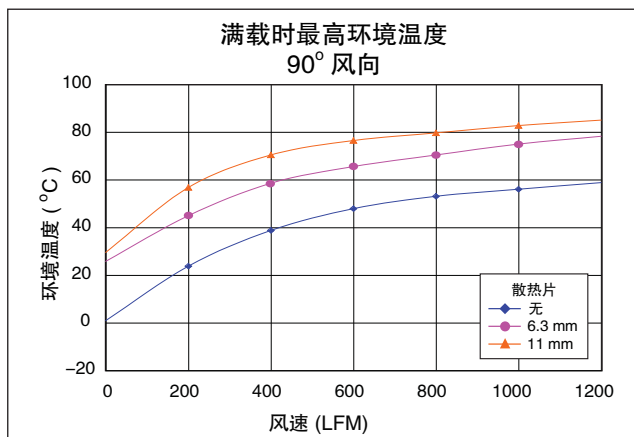
不带散热片之降额线, 90° 风向



带6.3mm散热片之降额线, 90° 风向

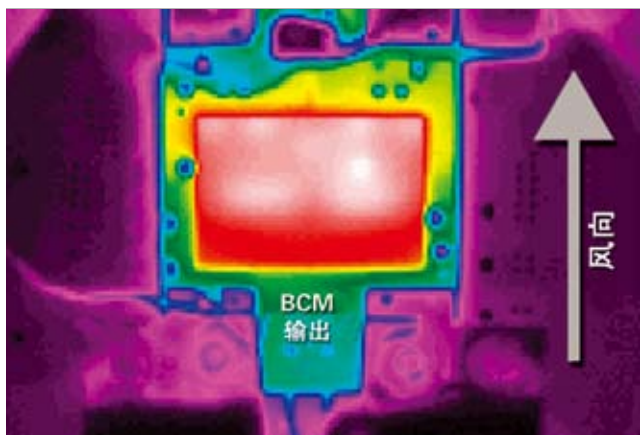


带11mm散热片之降额线, 90° 风向

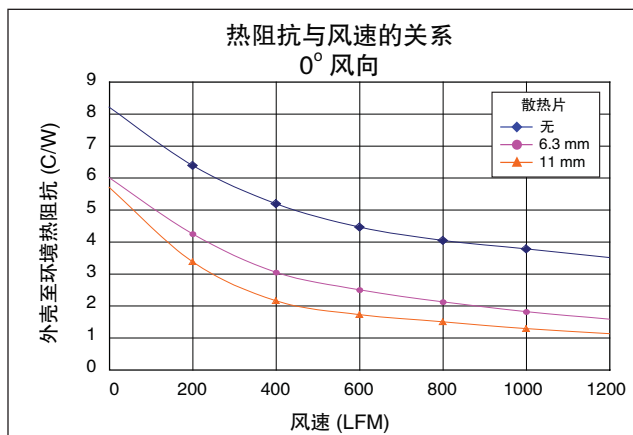


满载时, 晶片之最高工作温度

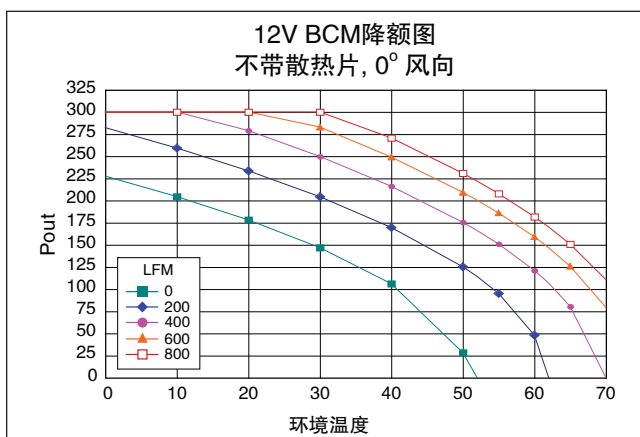
B048F120T30 0° 风向



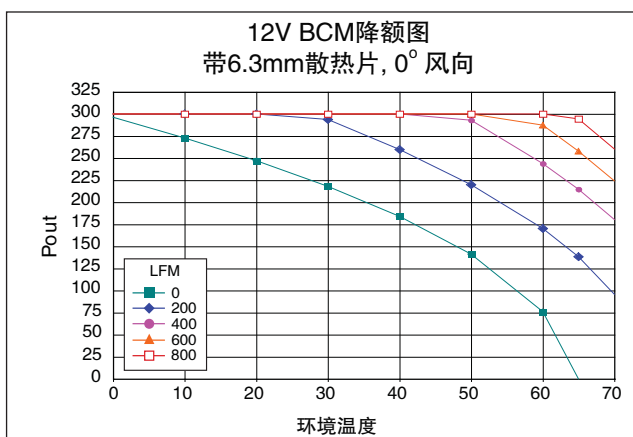
红外影象, 0° 风向; 满载, 200LFM, 不带散热片



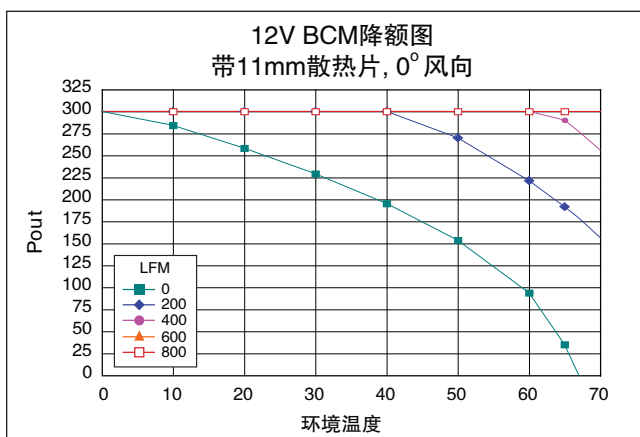
热阻抗与风速之关系, 0° 风向



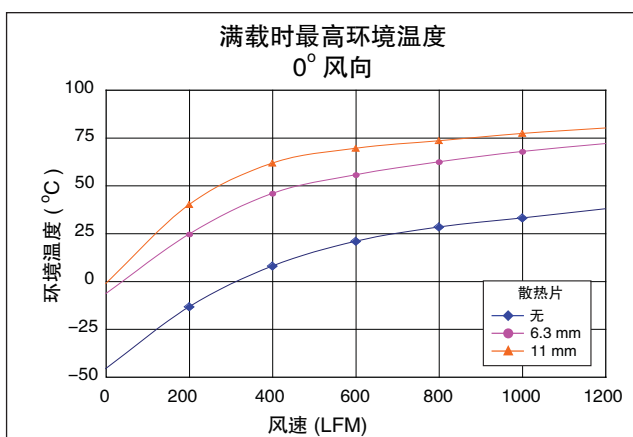
不带散热片之降额线, 0° 风向



带6.3mm散热片之降额线, 0° 风向

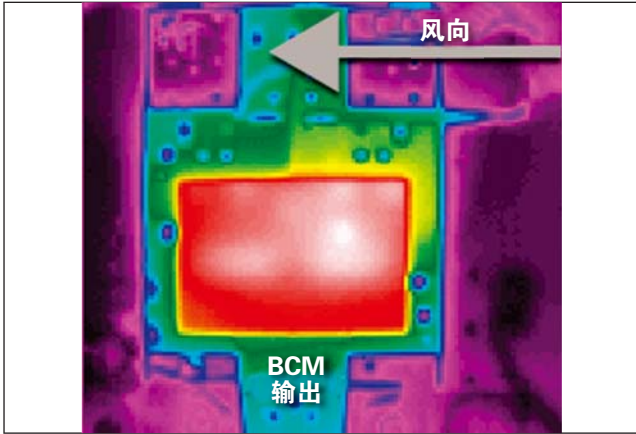


带11mm散热片之降额线, 0° 风向

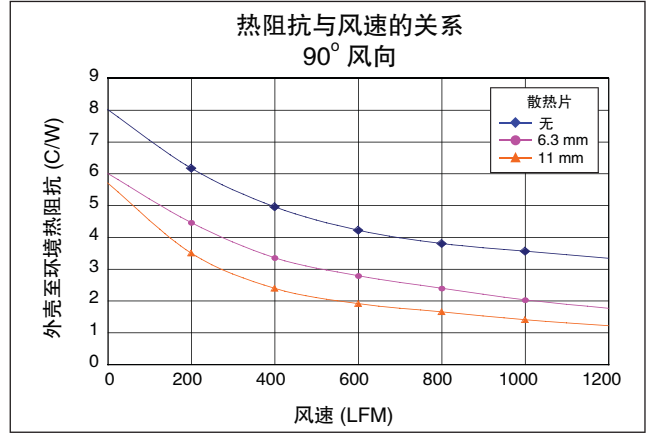


满载时, 晶片之最高工作温度

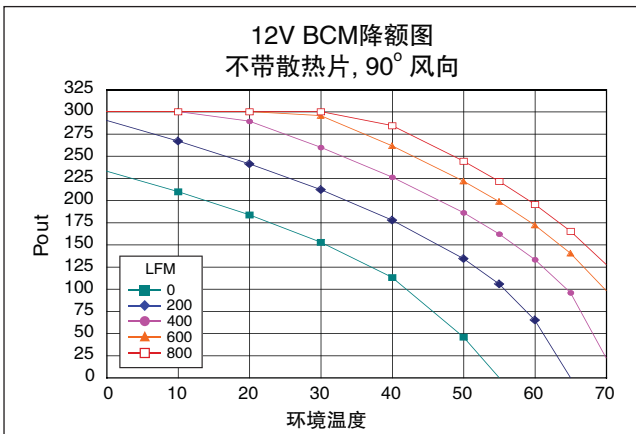
B048F120T30 90° 风向



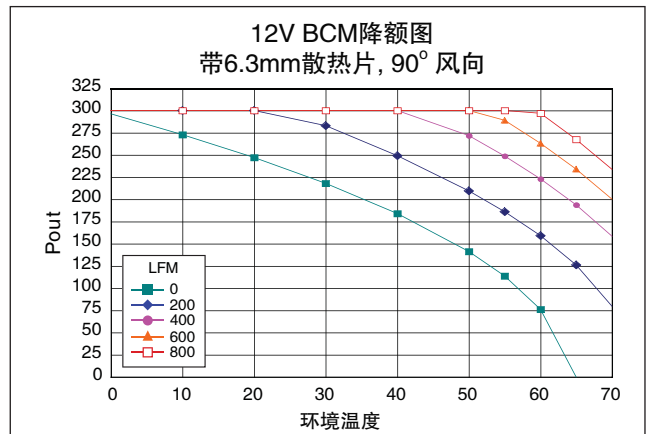
红外影象, 90° 风向; 满载, 200LFM, 不带散热片



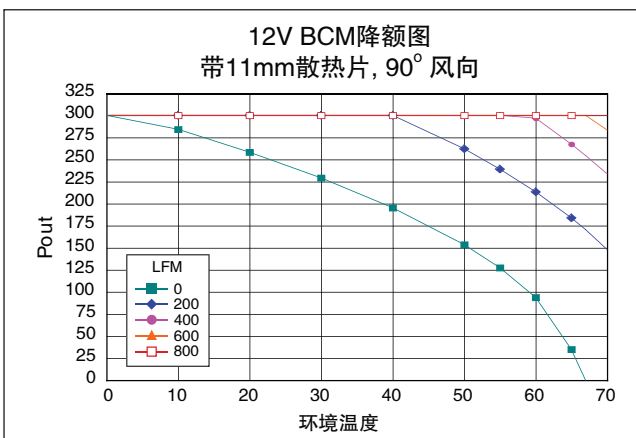
热阻抗与风速之关系, 90° 风向



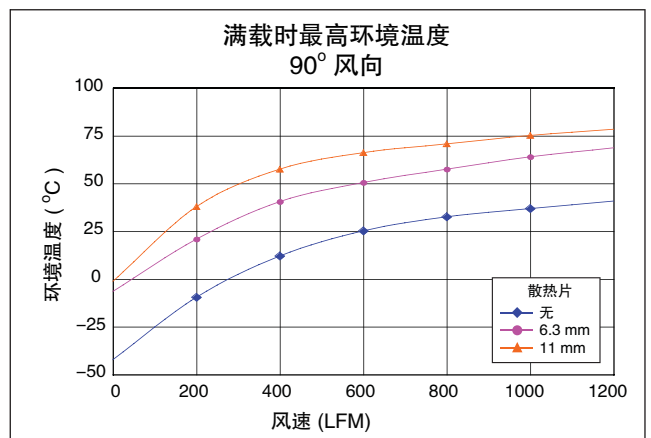
不带散热片之降额线, 90° 风向



带6.3mm散热片之降额线, 90° 风向

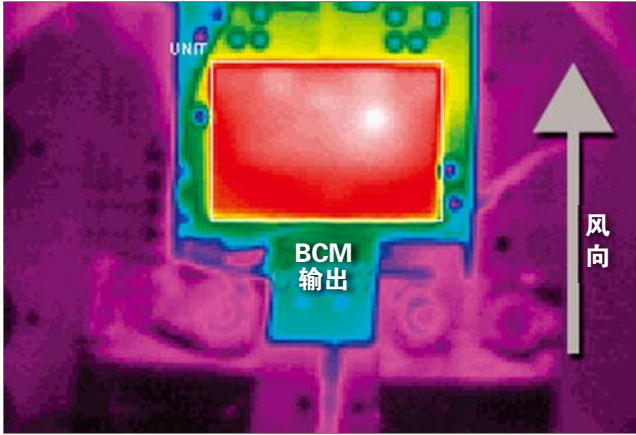


带11mm散热片之降额线, 90° 风向

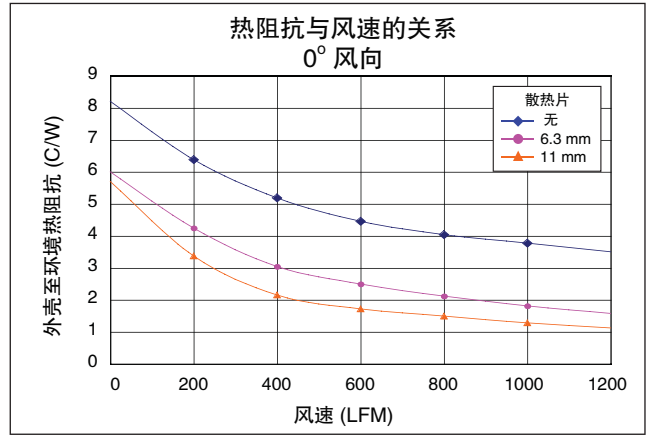


满载时, 晶片之最高工作温度

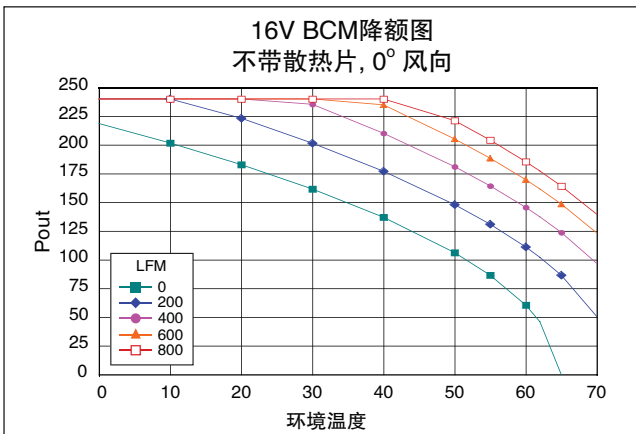
B048F160T24 0° 风向



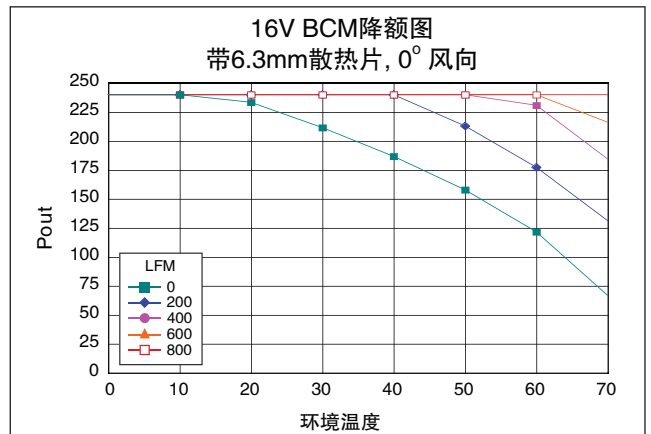
红外影象, 0° 风向; 满载, 200LFM, 不带散热片



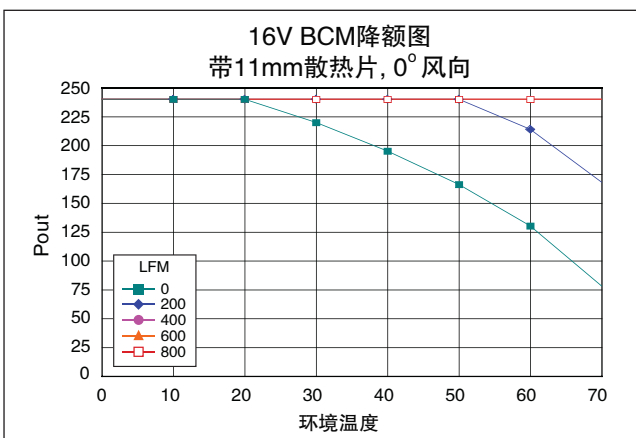
热阻抗与风速之关系, 0° 风向



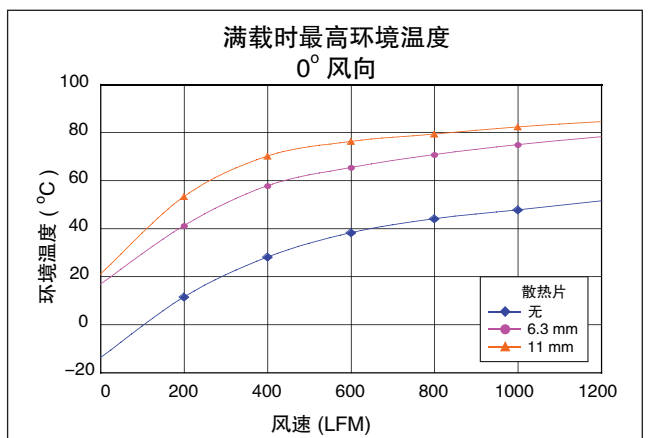
不带散热片之降额线, 0° 风向



带6.3mm散热片之降额线, 0° 风向

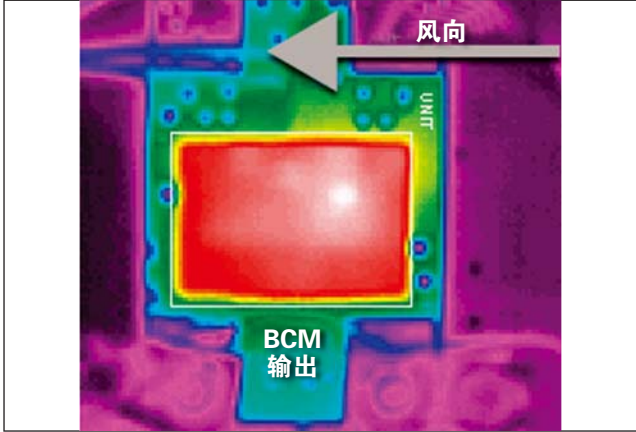


带11mm散热片之降额线, 0° 风向

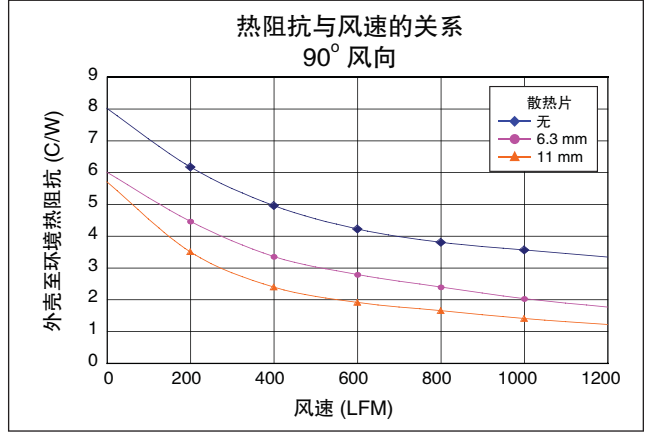


满载时, 晶片之最高工作温度

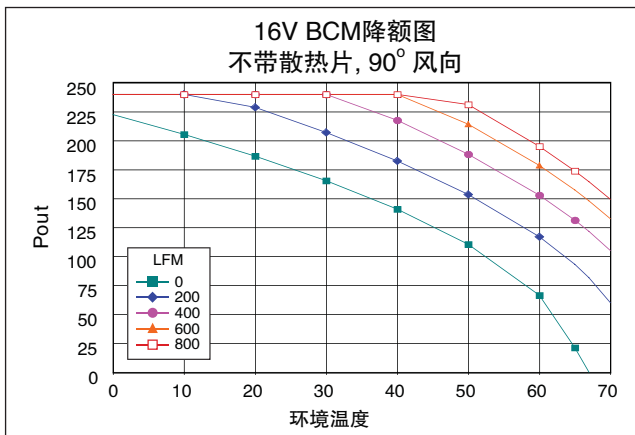
B048F160T24 90° 风向



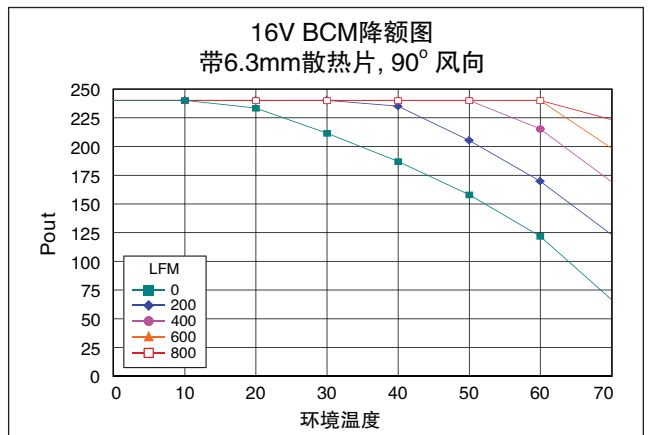
红外影象, 90° 风向; 满载, 200LFM, 不带散热片



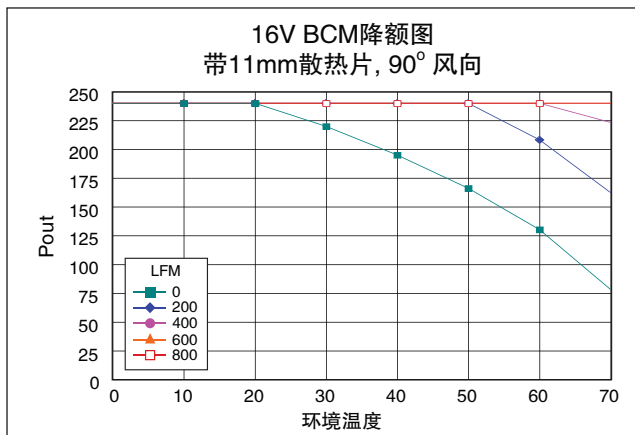
热阻抗与风速之关系, 90° 风向



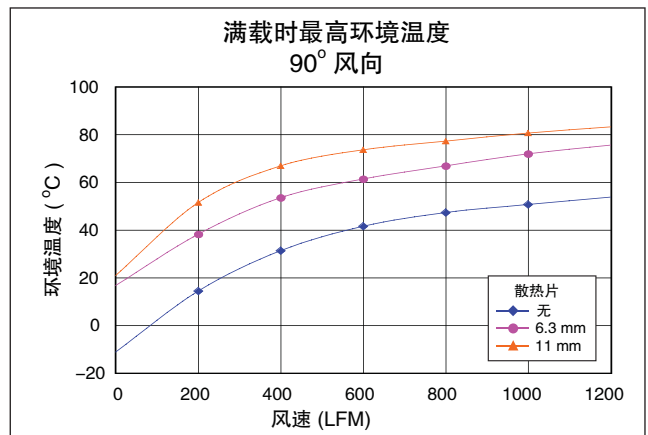
不带散热片之降额线, 90° 风向



带6.3mm散热片之降额线, 90° 风向

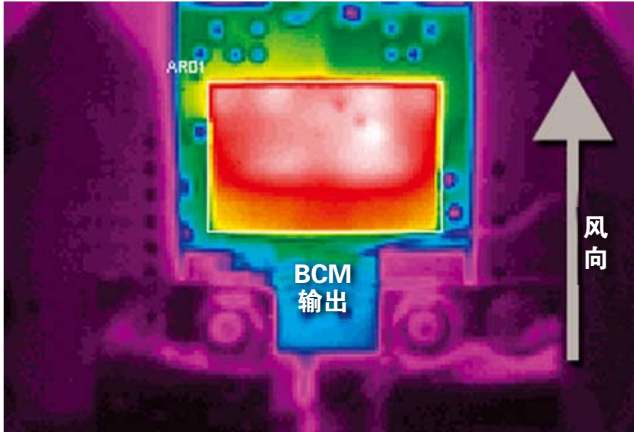


带11mm散热片之降额线, 90° 风向

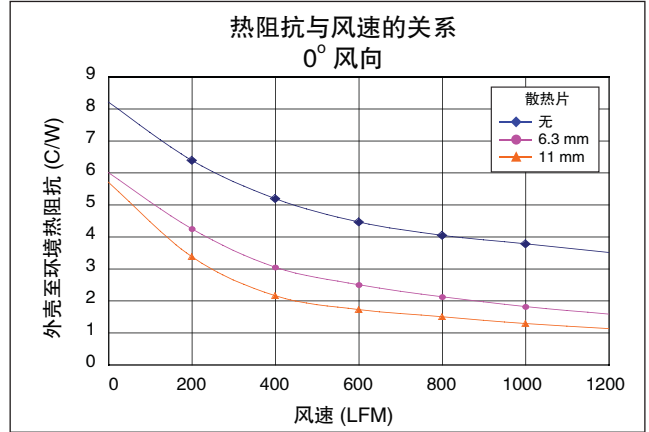


满载时, 晶片之最高工作温度

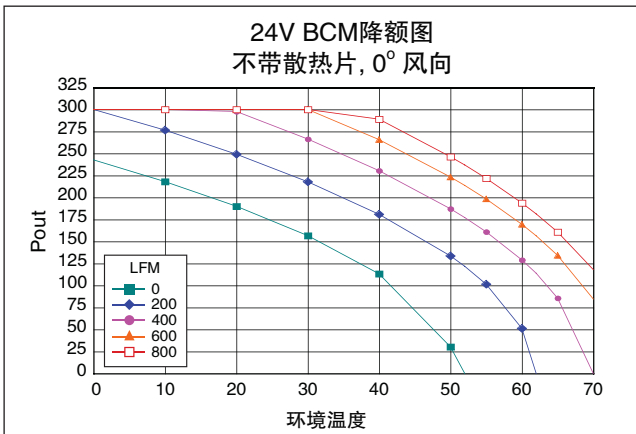
B048F240T30 0° 风向



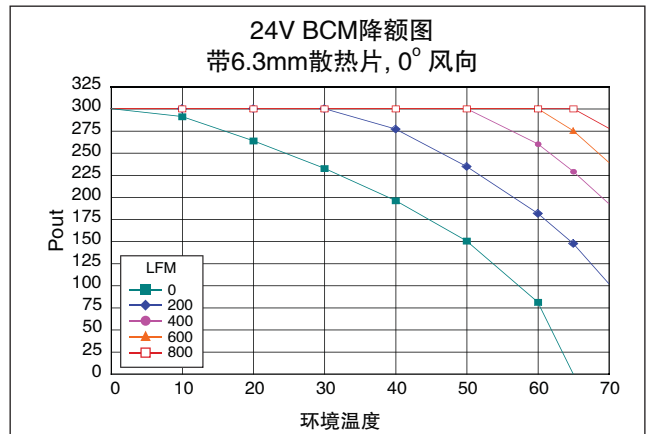
红外影像, 0° 风向; 满载, 400LFM, 不带散热片



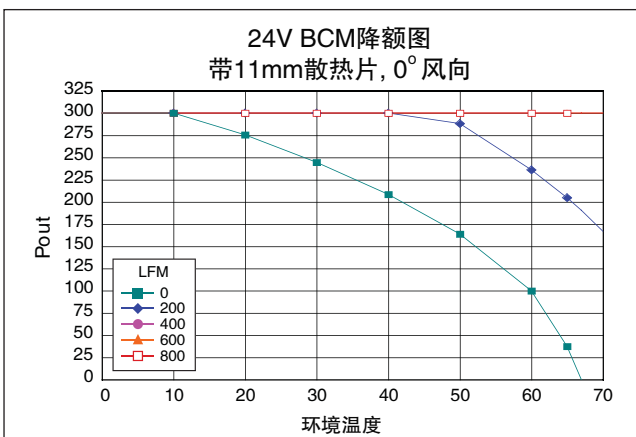
热阻抗与风速之关系, 0° 风向



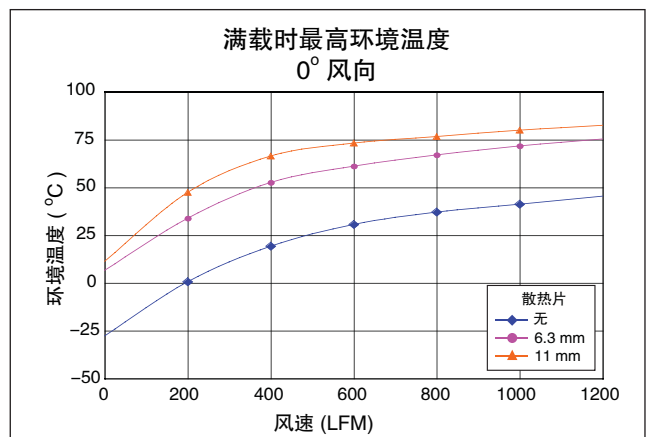
不带散热片之降额线, 0° 风向



带6.3mm散热片之降额线, 0° 风向

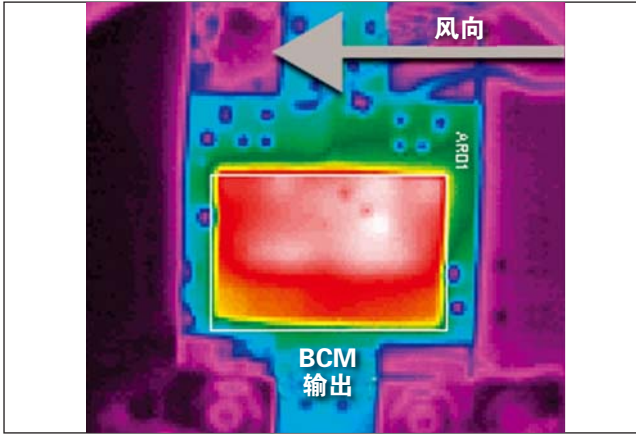


带11mm散热片之降额线, 0° 风向

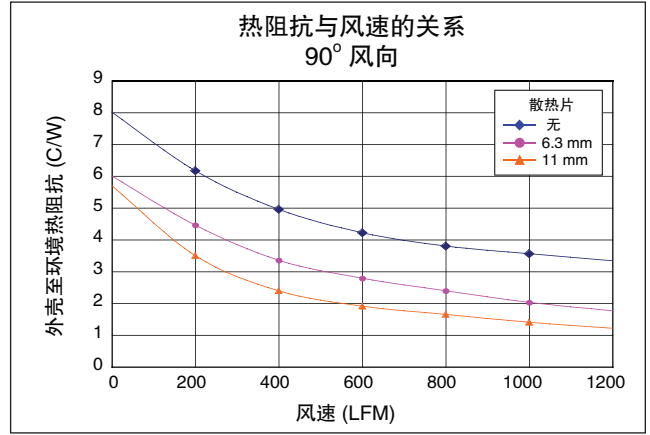


满载时, 晶片之最高工作温度

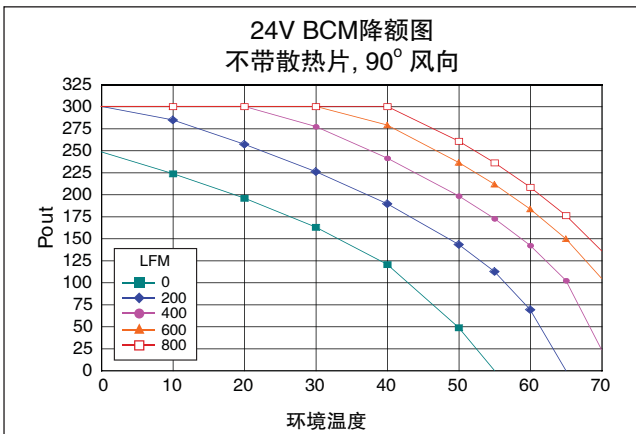
B048F240T30 90° 风向



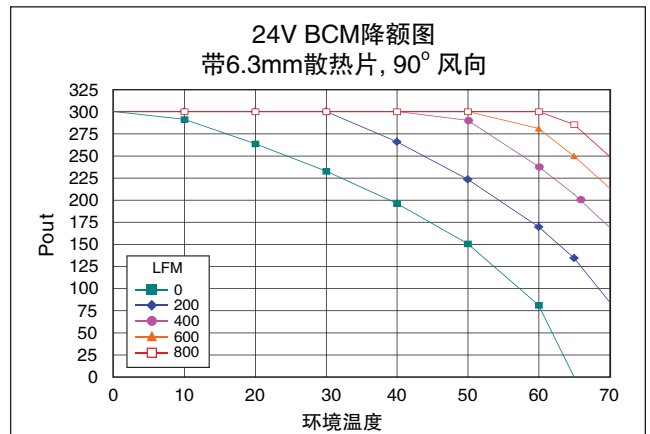
红外影像, 90° 风向; 满载, 400LFM, 不带散热片



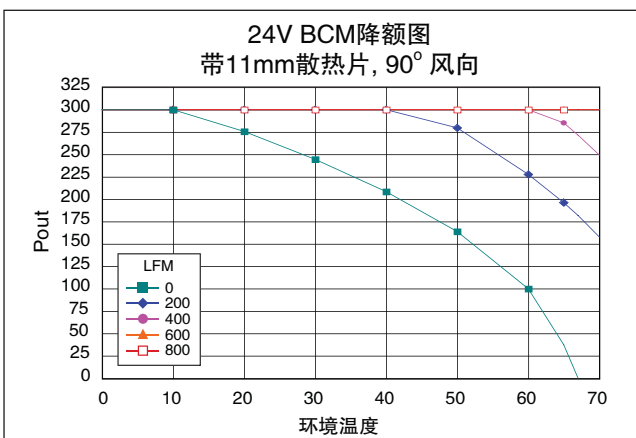
热阻抗与风速之关系, 90° 风向



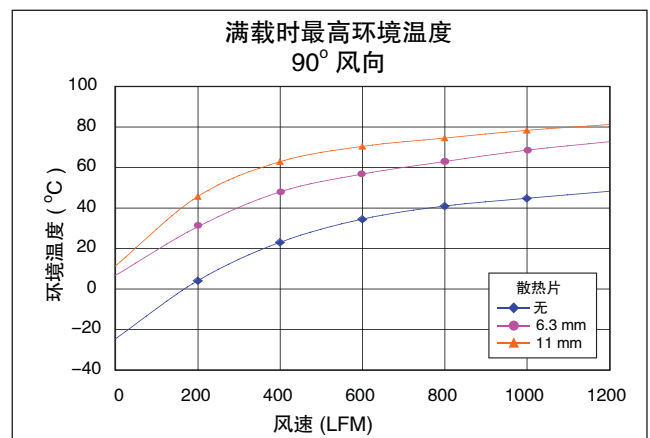
不带散热片之降额线, 90° 风向



带6.3mm散热片之降额线, 90° 风向

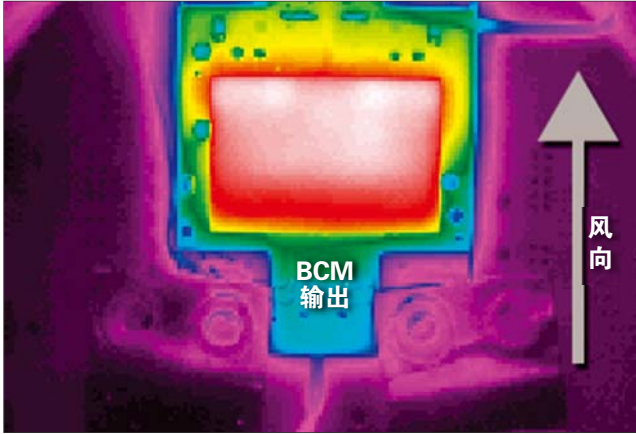


带11mm散热片之降额线, 90° 风向

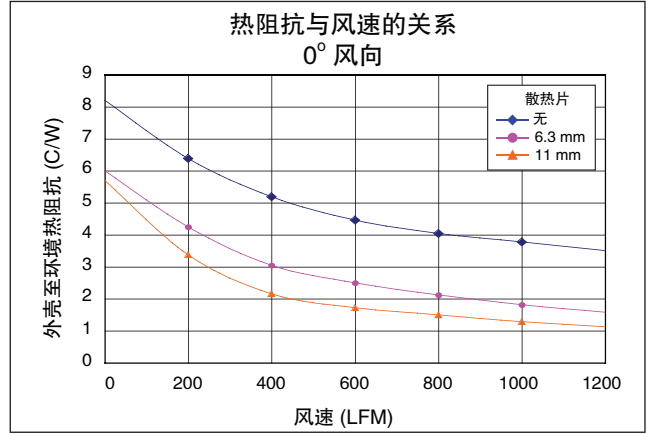


满载时, 晶片之最高工作温度

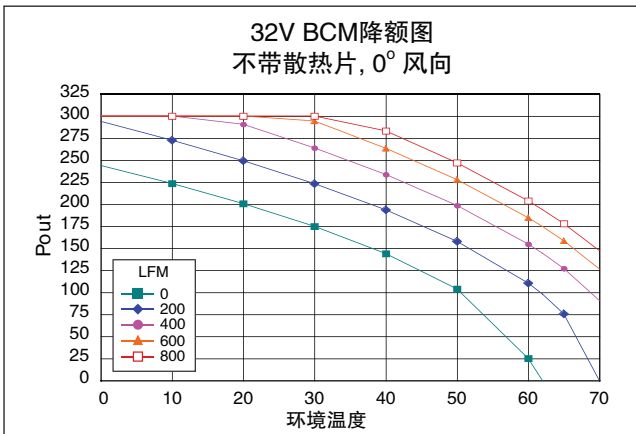
B048F320T30 0° 风向



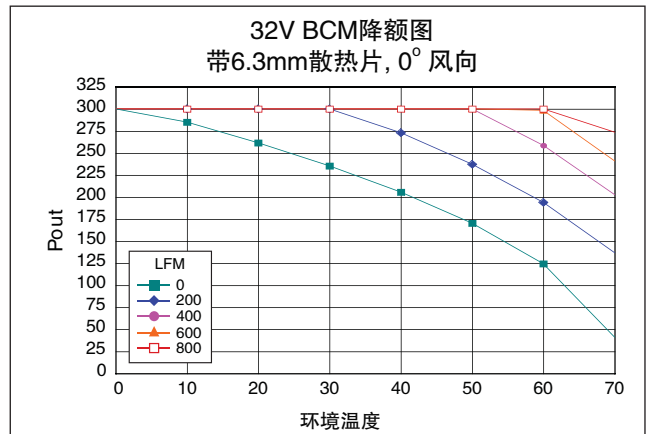
红外影像, 0° 风向; 满载, 200LFM, 不带散热片



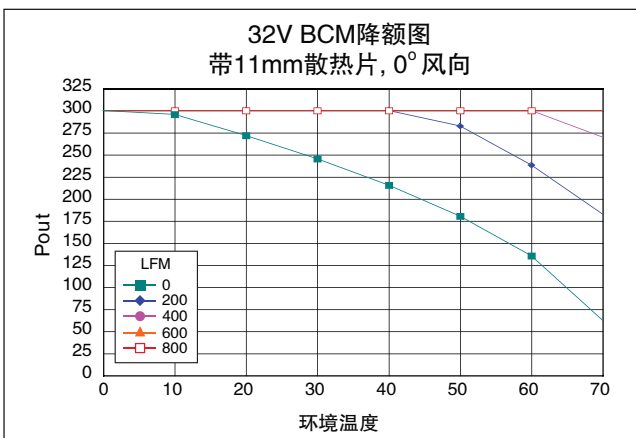
热阻抗与风速之关系, 0° 风向



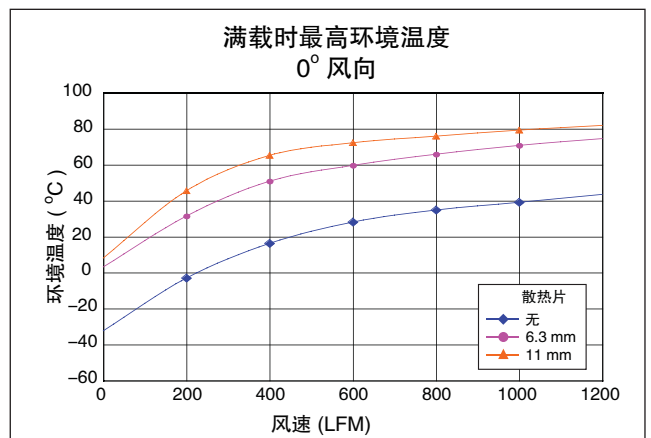
不带散热片之降额线, 0° 风向



带6.3mm散热片之降额线, 0° 风向

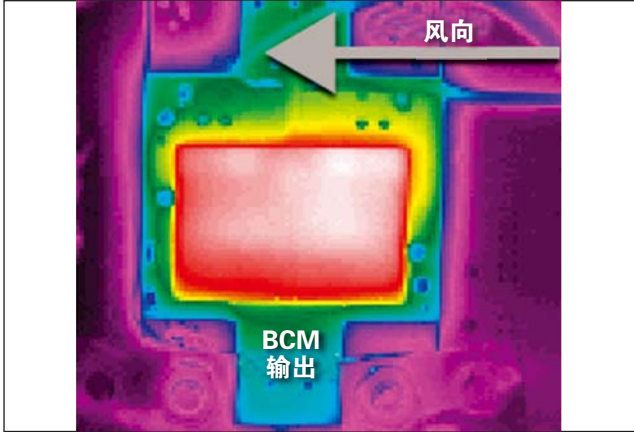


带11mm散热片之降额线, 0° 风向

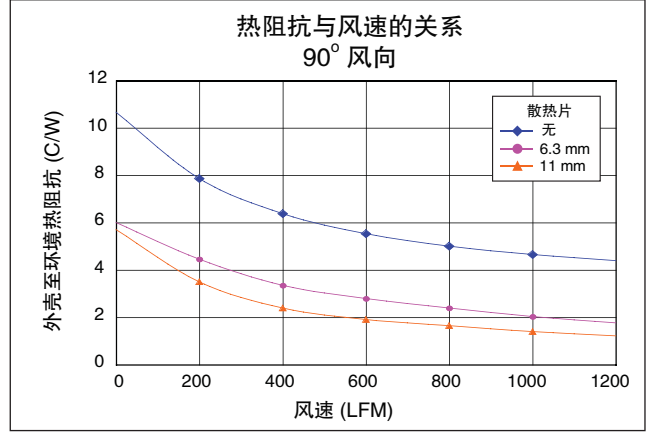


满载时, 晶片之最高工作温度

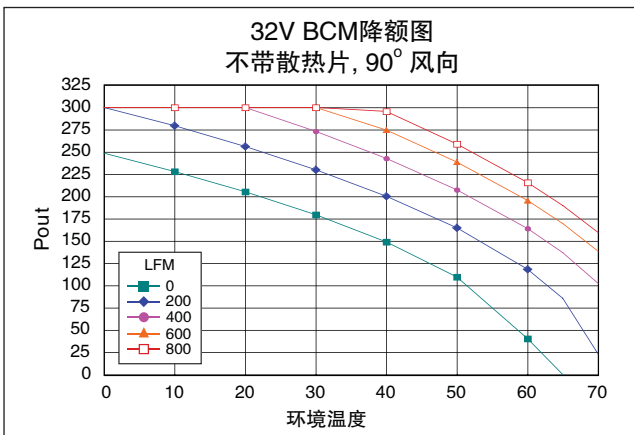
B048F320T30 90° 风向



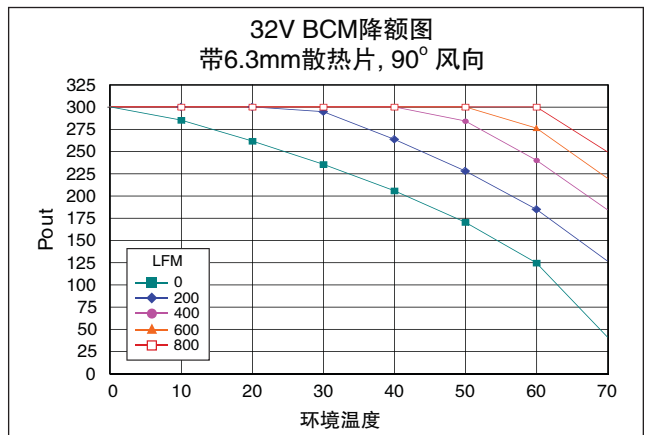
红外影象, 90° 风向; 满载, 200LFM, 不带散热片



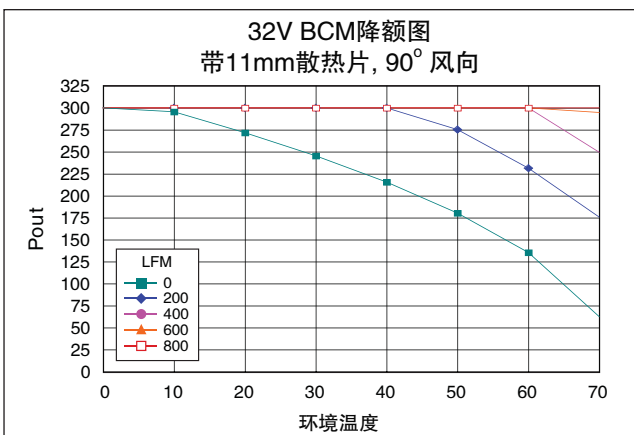
热阻抗与风速之关系, 90° 风向



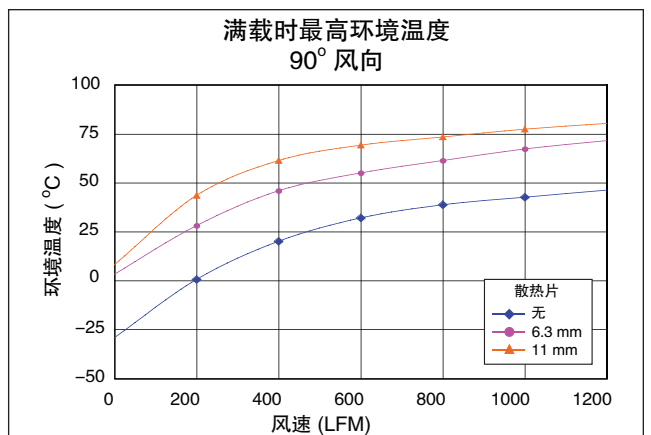
不带散热片之降额线, 90° 风向



带6.3mm散热片之降额线, 90° 风向

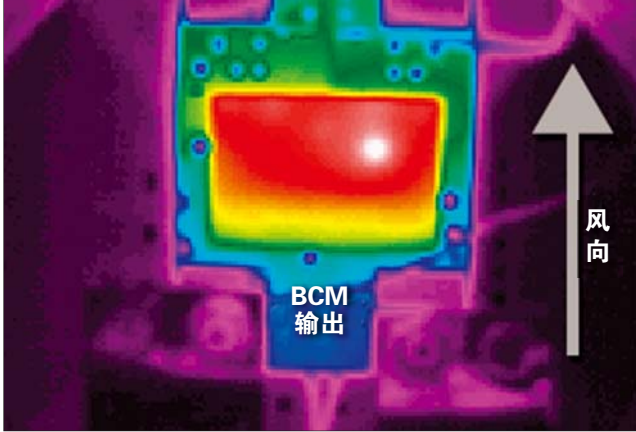


带11mm散热片之降额线, 90° 风向

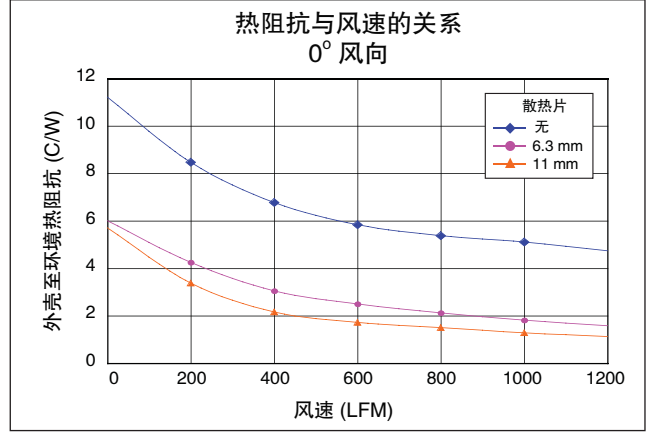


满载时, 晶片之最高工作温度

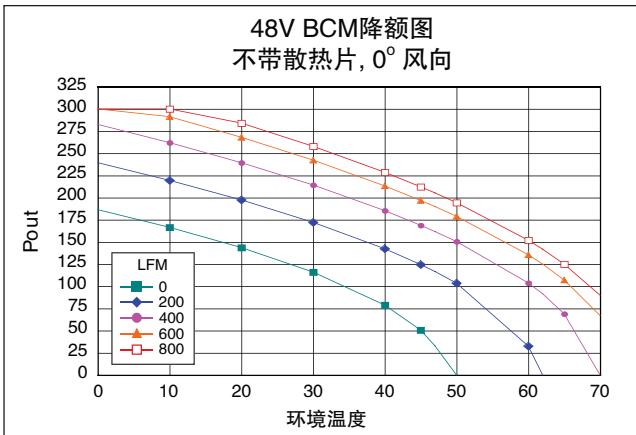
B048F480T30 0° 风向



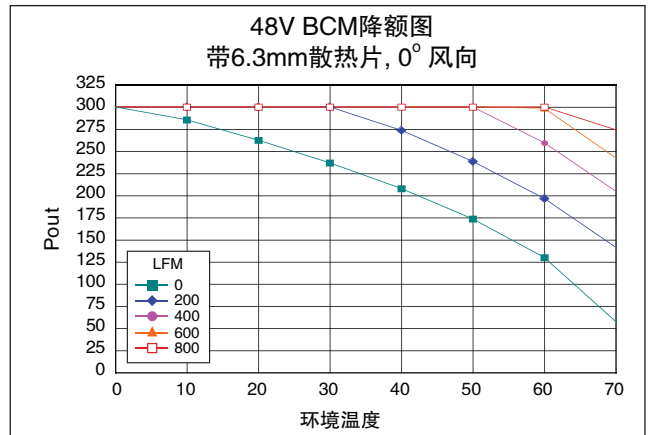
红外影像, 0° 风向; 满载, 200LFM, 不带散热片



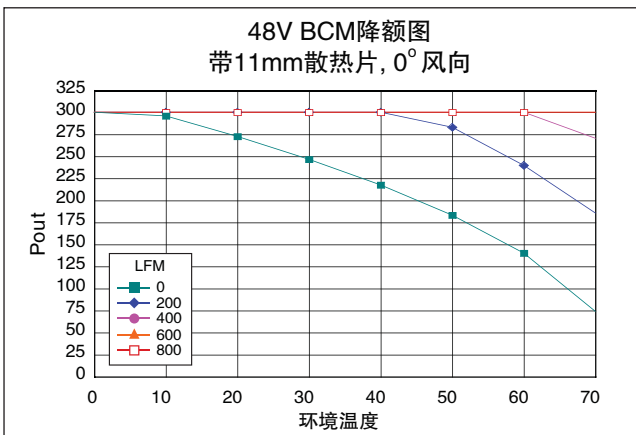
热阻抗与风速之关系, 0° 风向



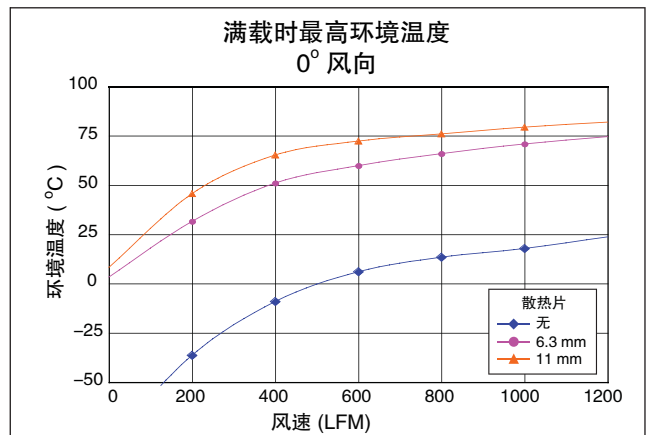
不带散热片之降额线, 0° 风向



带6.3mm散热片之降额线, 0° 风向

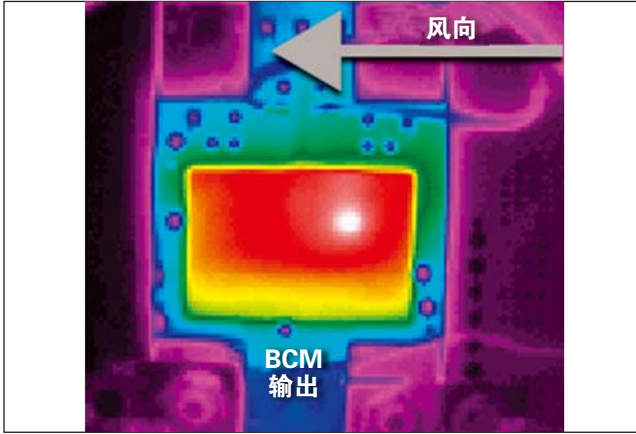


带11mm散热片之降额线, 0° 风向

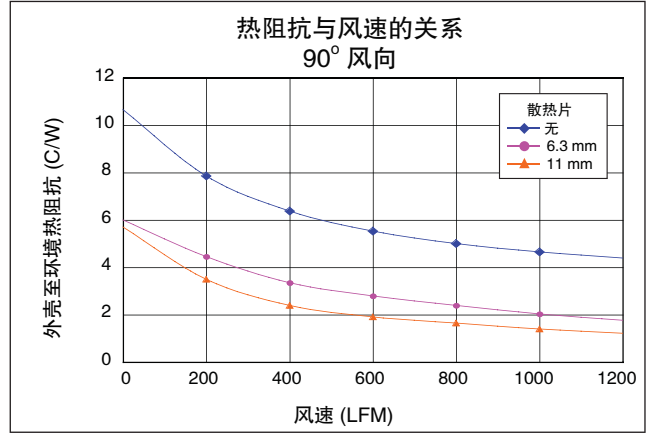


满载时, 晶片之最高工作温度

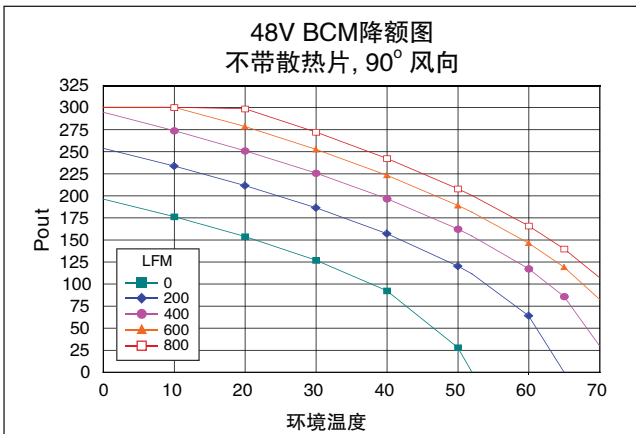
B048F480T30 90° 风向



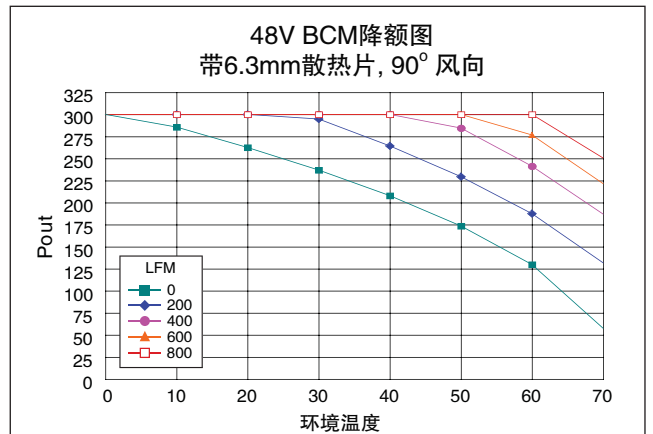
红外影像, 90° 风向; 满载, 400LFM, 不带散热片



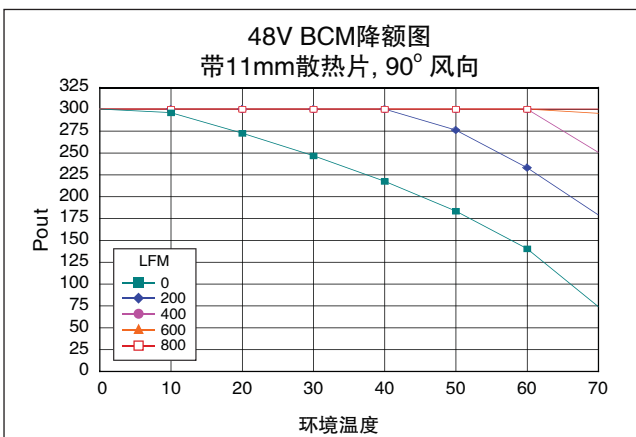
热阻抗与风速之关系, 90° 风向



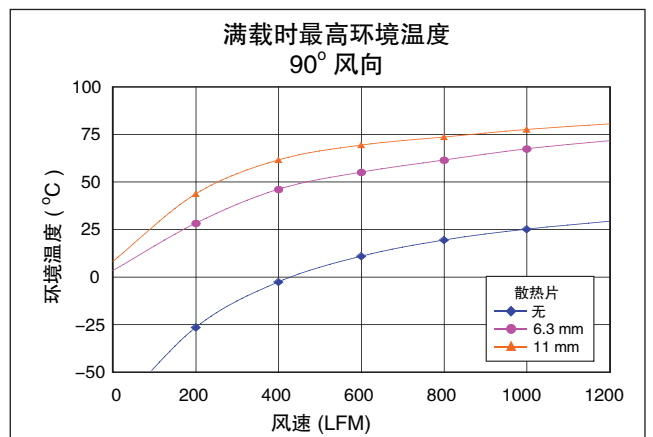
不带散热片之降额线, 90° 风向



带6.3mm散热片之降额线, 90° 风向



带11mm散热片之降额线, 90° 风向



满载时, 晶片之最高工作温度