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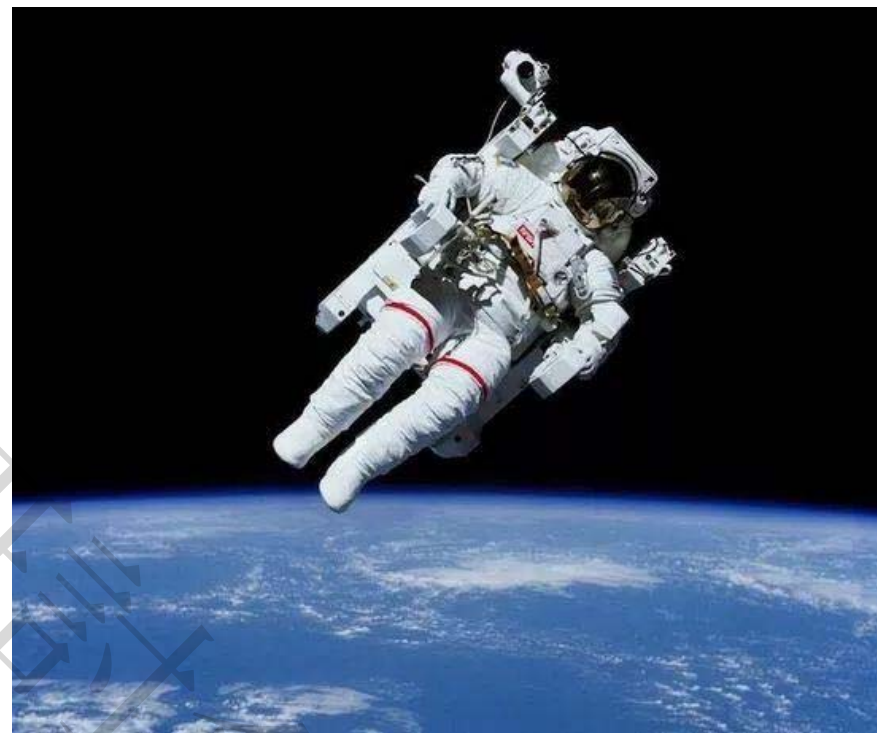
相變化材料於散熱之應用

Hank Chung
v1 – 2018/11/9



摘要

- 相變化材料(PCM)之應用
 - 恆溫
 - 節能
 - 散熱應用
- 相變化材料主要參數對散熱之影響
 - 潛熱
 - 熱傳導係數



相變化材料之應用領域- 恆溫

- 涼感塗料PCM (phase change material)即是其中一種降溫材質，PCM是一種高科技的特殊織料，以固體的形態吸收熱氣後PCM會轉變成液態，在這轉換的過程中會降低周圍溫度(Yi,2009)，PCM吸收熱氣的過程可視為熱傳導。(2017,財團法人紡織產業綜合研究所)
- 將微粒狀PCM注入熱流管路的流體中，以增強熱傳效益；相變化材料與微粒包覆技術的研究已各自發展相當長的一段時間，然而結合兩者之優點以高分子包覆相變化材料，以形成“相變化材料微膠囊(mPCM)”之相關研究，卻是近年來備受關注的課題 (2013, 南台科技大學 施泓銘)

絲織園地 2011.10

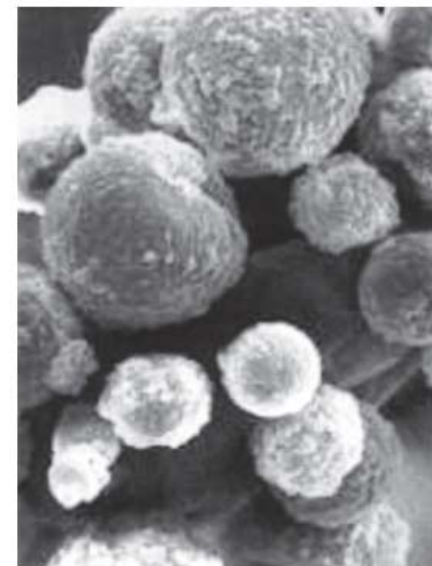
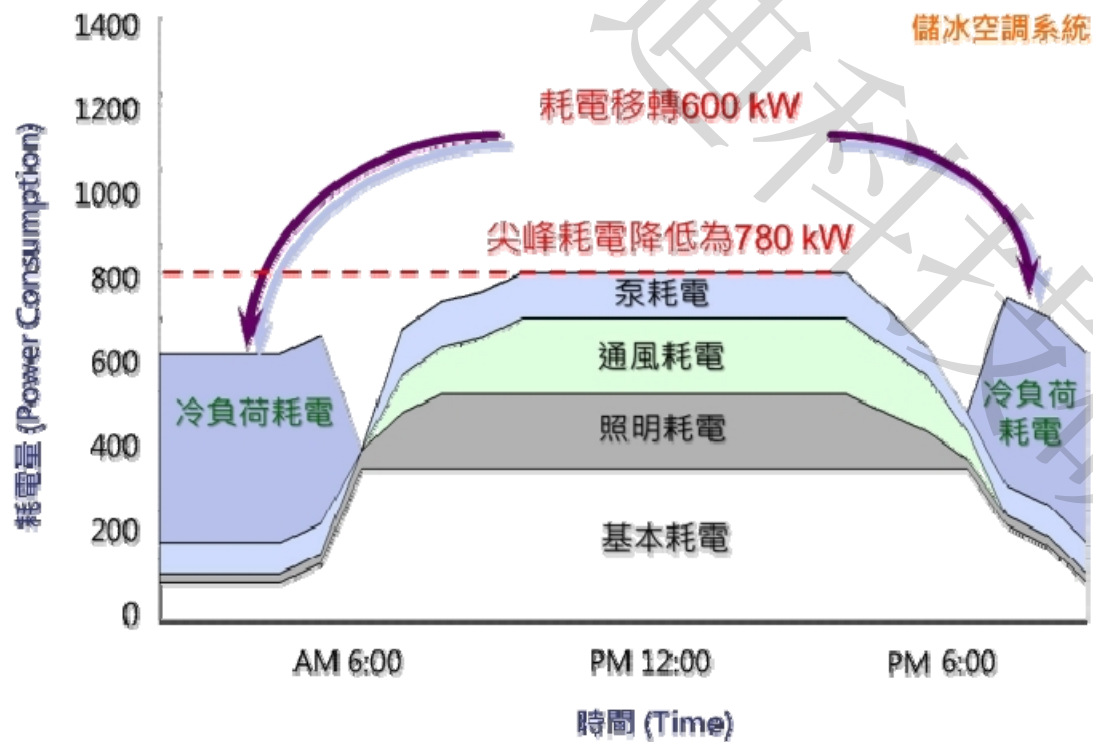


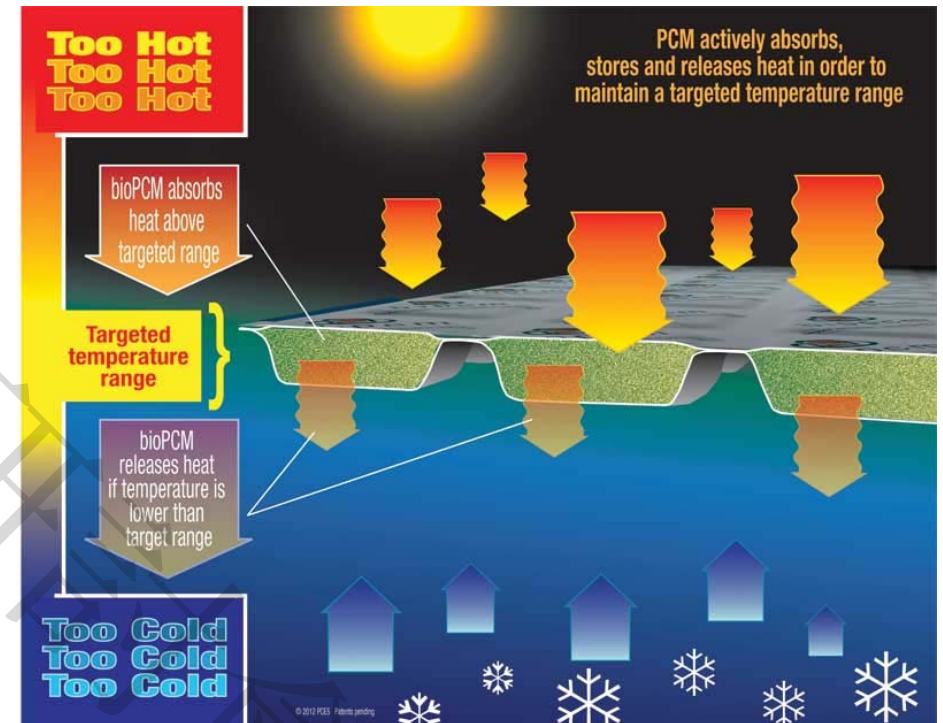
圖70. Schoeller®-PCM™ 微膠囊

化合物	含碳原子數	結晶溫度(°C)	融點(°C)	熱儲存量(J/g)
正十六(碳)烷 (n-Hexadecane)	16	16.2	18.2	237
正十七(碳)烷 (n-Heptadecane)	17	21.5	22.0	213
正十八(碳)烷 (n-Octadecane)	18	25.4	28.2	244
正十九(碳)烷 (n-Nonadecane)	19	26.4	32.1	222
正二十(碳)烷 (n-Eicosane)	20	30.6	36.8	247

相變化材料之應用領域- 節能

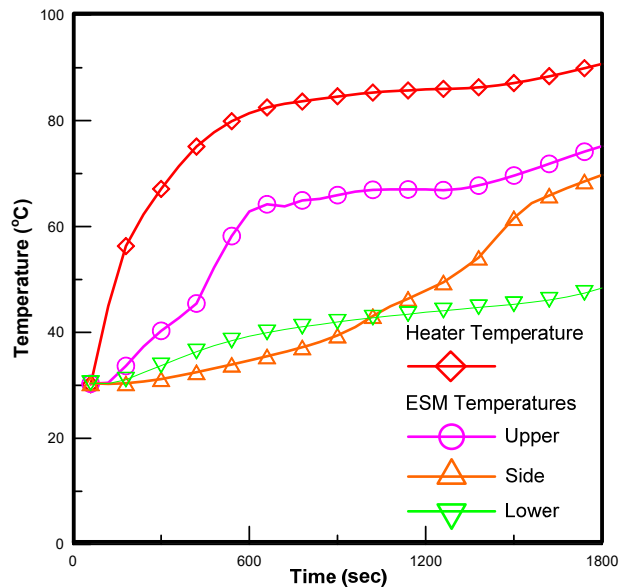
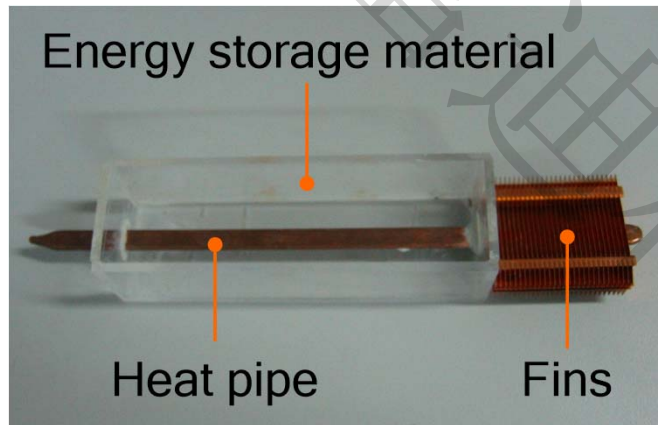


冰水主機



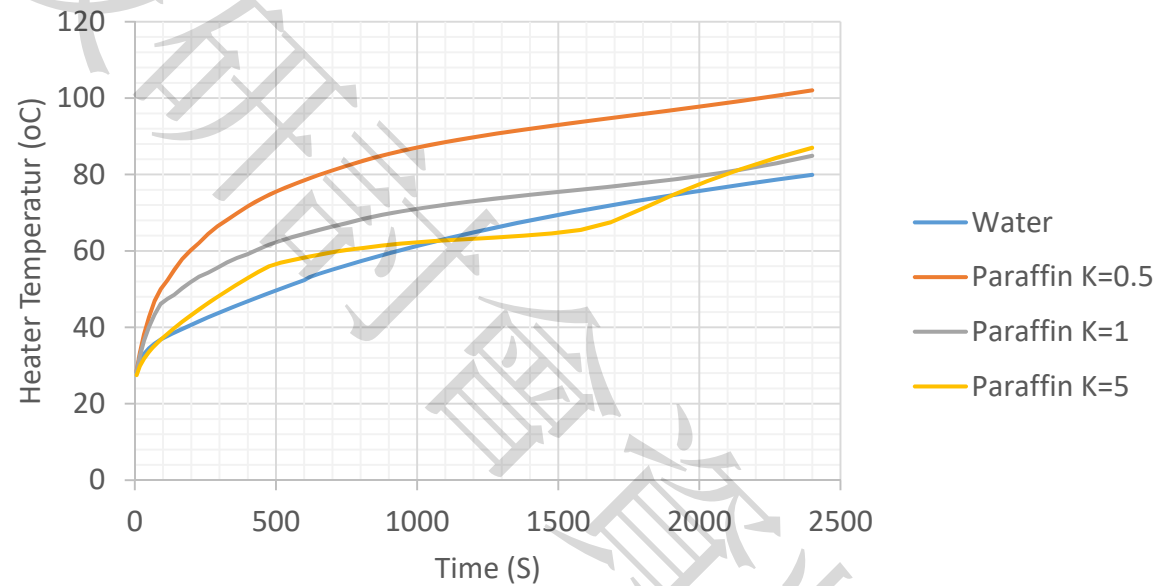
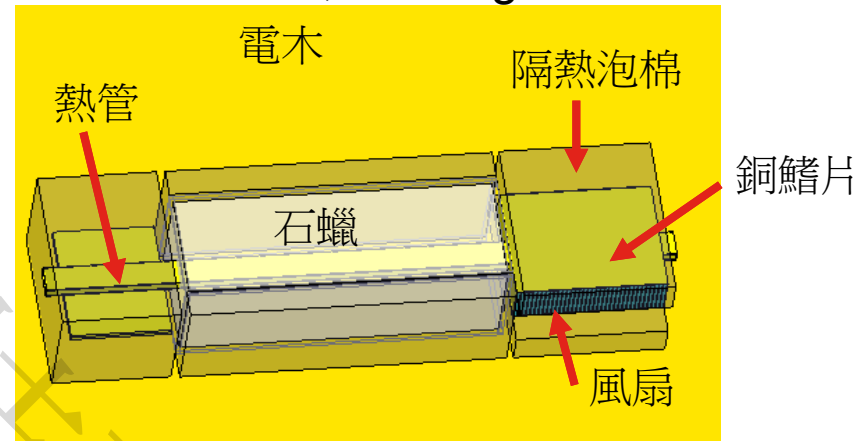
綠建築

Simulation Model



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Paraffin 116, Heating Power 20W



儲能材料特性

	Water	Paraffin K1	Paraffin K0.5	Paraffin K5
密度 (kg/m ³)	1009	934.5	934.5	934.5
熱傳導係數 (W/mK)	0.634	1.0	0.5	5
比熱 (J/kgK)	4179	2366	2366	2366
潛熱 (kJ/kg)	N/A	229	136.45	136.45
相變化溫度 (°C)	N/A	46	48	56.42

Attribute Data Notes

Name: Paraffin

Conductivity Type: Constant

Conductivity: 0.1364 W/(mK)

Electrical Resistivity: Constant

Resistivity: 0 Ohm m

☐ Transparent Material

Density: 934.5 kg/m³

Specific Heat: 2692 J/(kg K)

☒ Phase Change

Liquid Specific Heat: 775 J/(kg K)

Latent Heat: 123300 J/kg

Melt Temperature: 45 °C

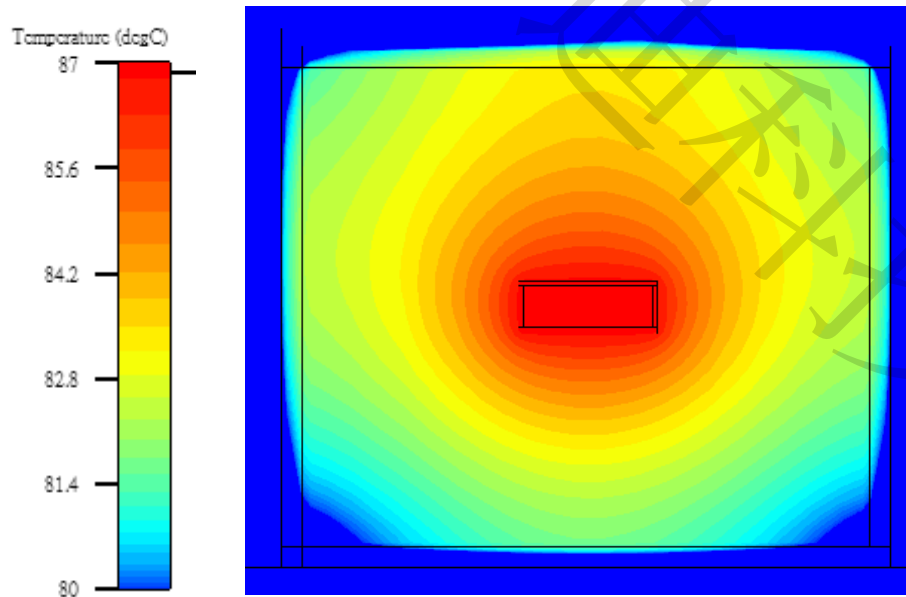
Melt Temperature Band: 1 °C

Surface: 0.9

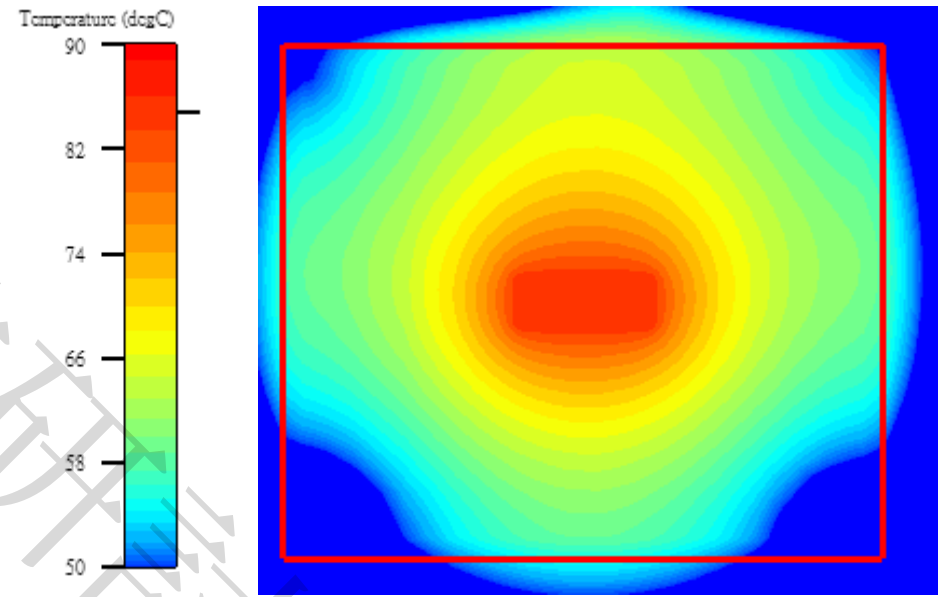
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FloTHERM Material Attribute Data

熱傳導係數之影響



K=5 @ 2400S

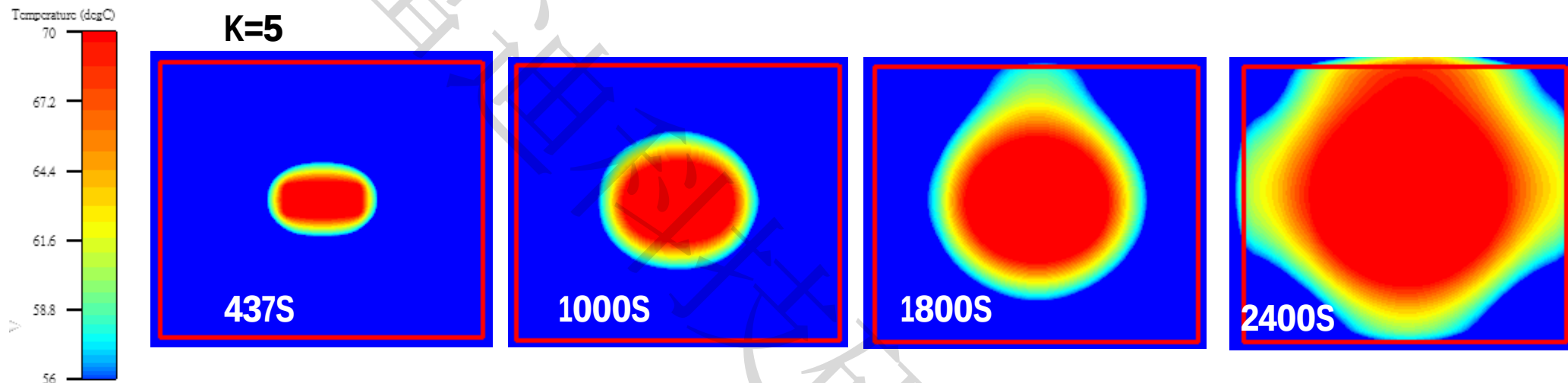


K=1 @ 2400S

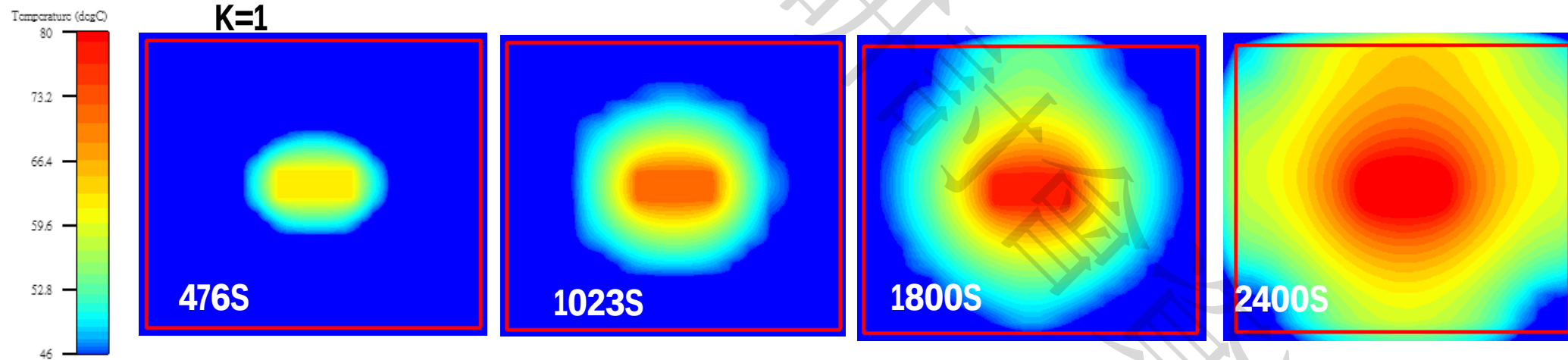
- Rayleigh number of paraffin $\approx 870 < 1708$
- Rayleigh number of water $= 10 \ll 1708$
- 只需要考慮熱傳導，不需考慮流體對流現象

PCM溫度分布

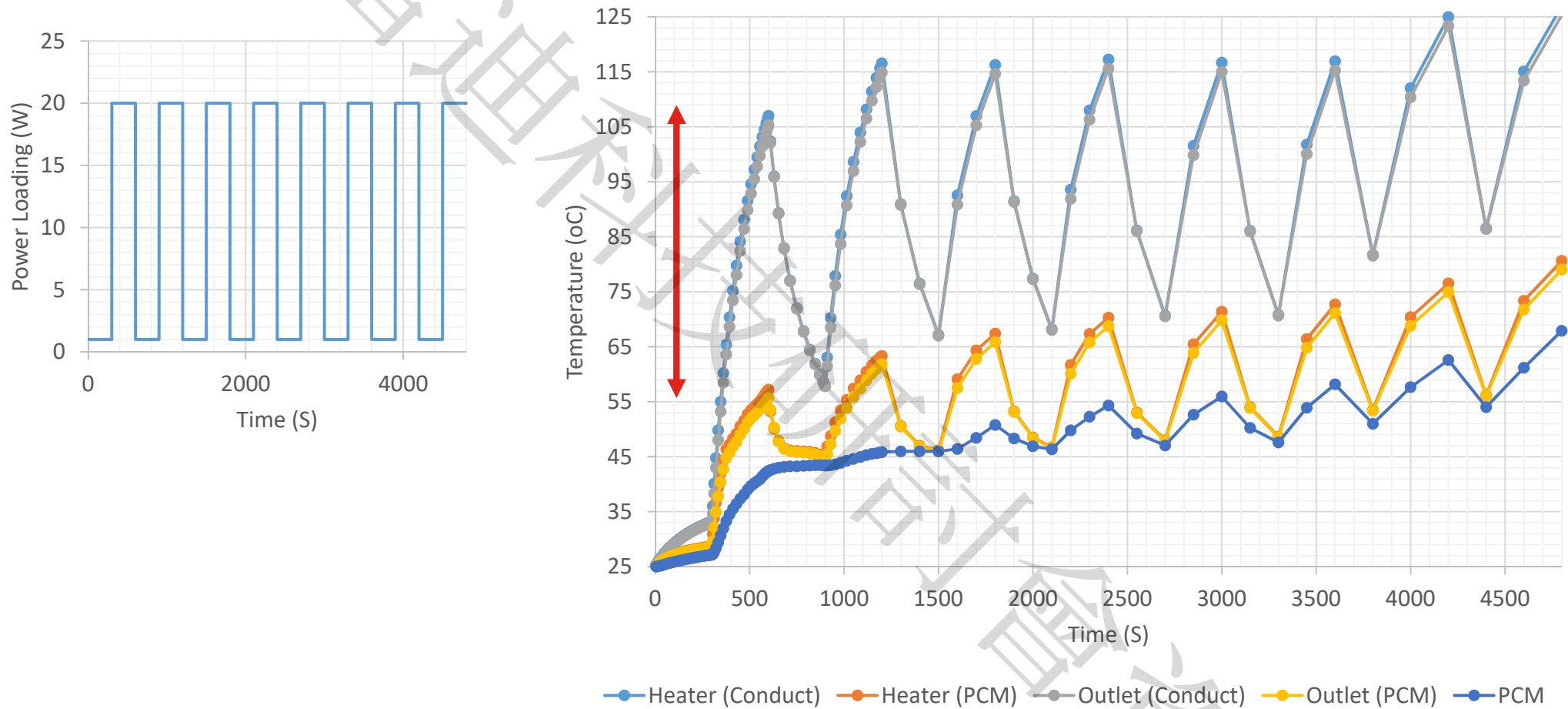
K=5



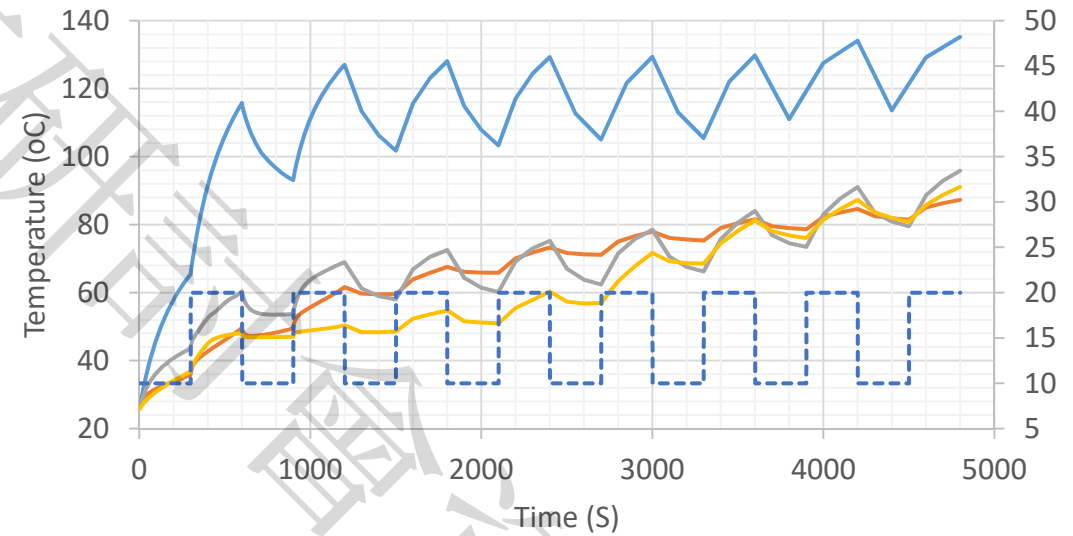
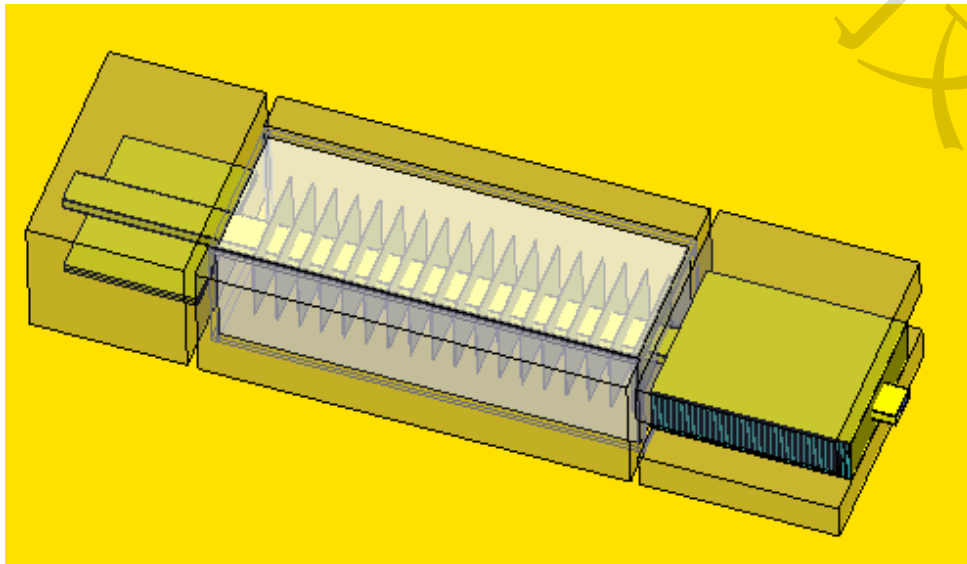
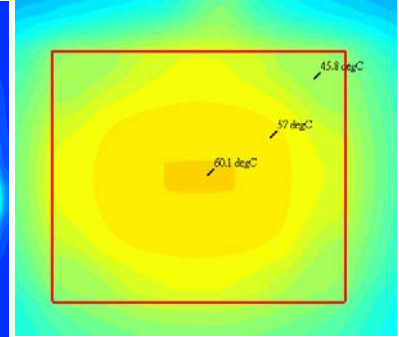
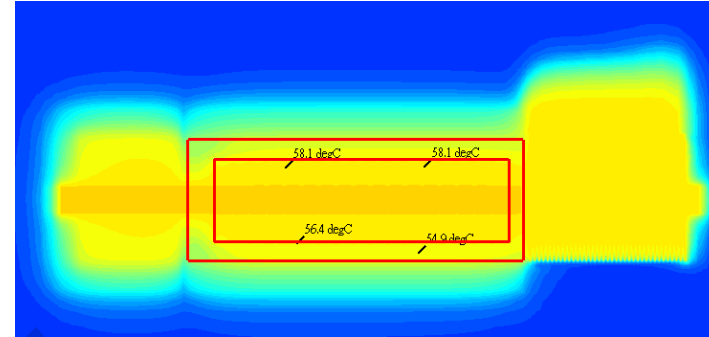
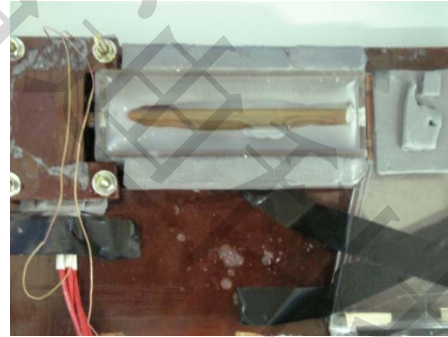
K=1



動態輸入功率



改善方案

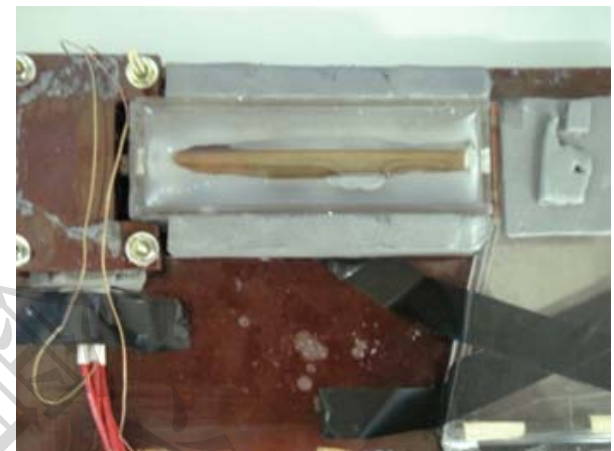
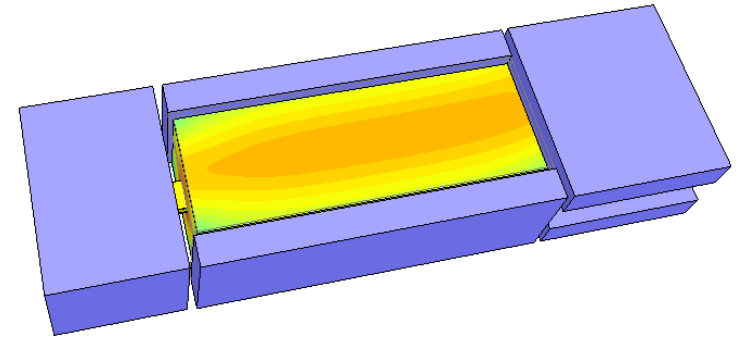
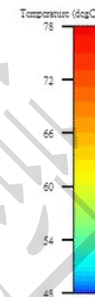
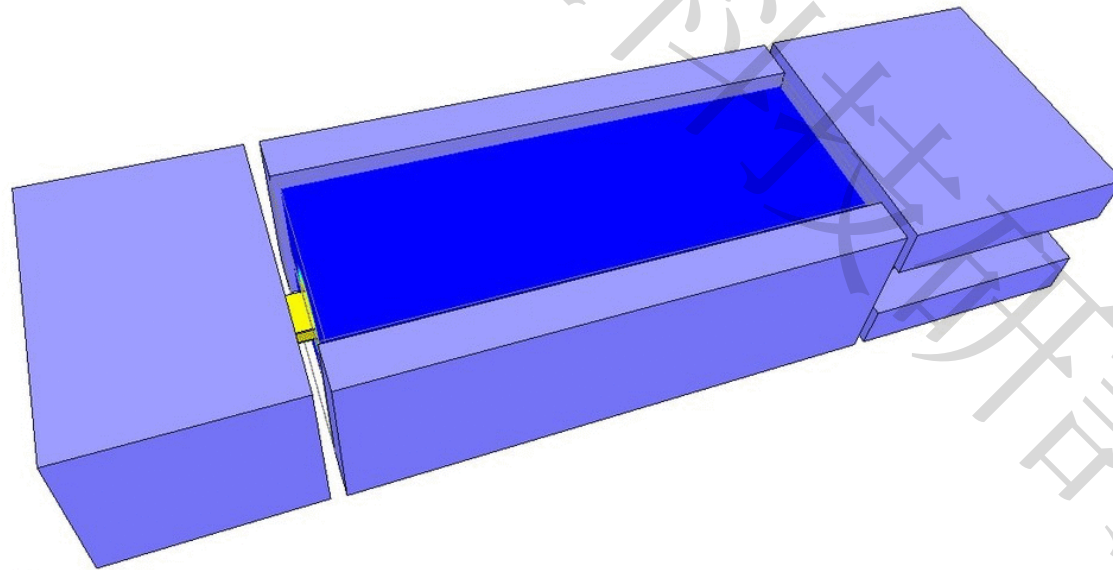


— Conduction Only — Water — Paraffin
 — Paraffin with Fin — Loading

溫度分布

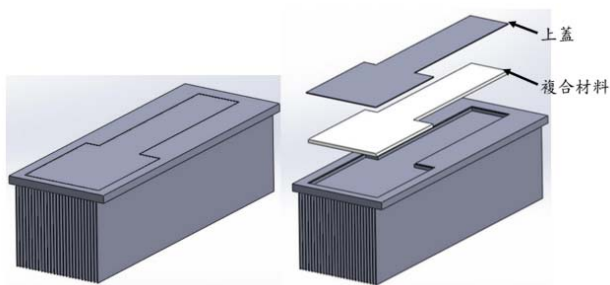
Mentor
A Siemens Business

paraffin+gf k05
6.1870e+002 s



文獻參考(以石蠟/奈米石墨片相變化材料提升 IGBT 熱管理- 中央大學彭雅琪)

- 由於其導熱率較低約為 $0.2\text{W/m}\cdot\text{K}$ ，為了克服其導熱係數較低的問題，會加入高導熱係數的材料來提升熱傳導。Sari 和 Karaipekli 研究將膨脹石墨(expanded graphite, EG)加入石蠟的影響，發現隨著 EG 的重量百分比上升，相變材的潛熱性質會跟著降低 (A. Sari and A. Karaipekli, " Thermal conductivity and latent heat thermal energy storage characteristics of paraffin/expanded graphite composite as phase change material." Applied Thermal Engineering, Volume 27, pp.1271–1277, 2007.)



樣品名稱	石蠟重量 百分比 (%)	熔化		凝固	
		熔點 (°C)	熔化潛熱 (J/g)	凝固點 (°C)	凝固潛熱 (J/g)
純石蠟	100	53.50	160.51	48.07	163.20
Sample 1	91.70	56.50	147.20	46.07	148.93
Sample 2	85.01	56.42	136.45	45.32	138.14

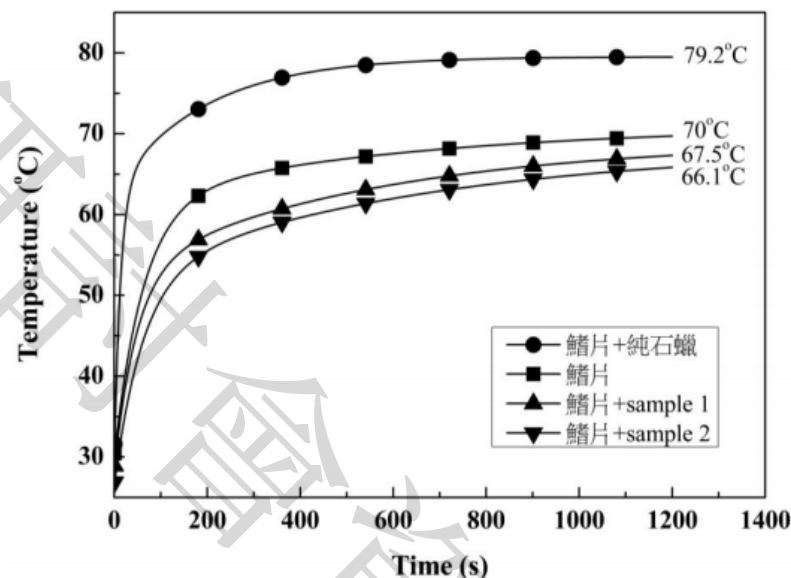
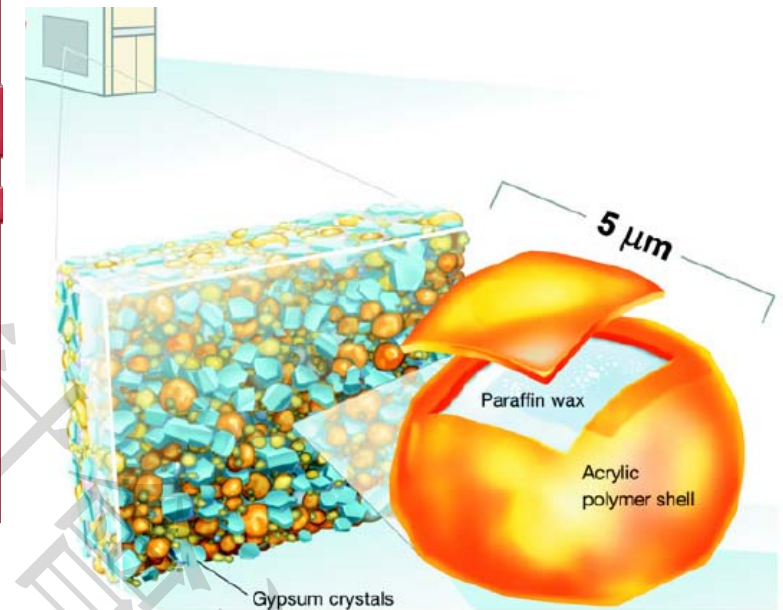


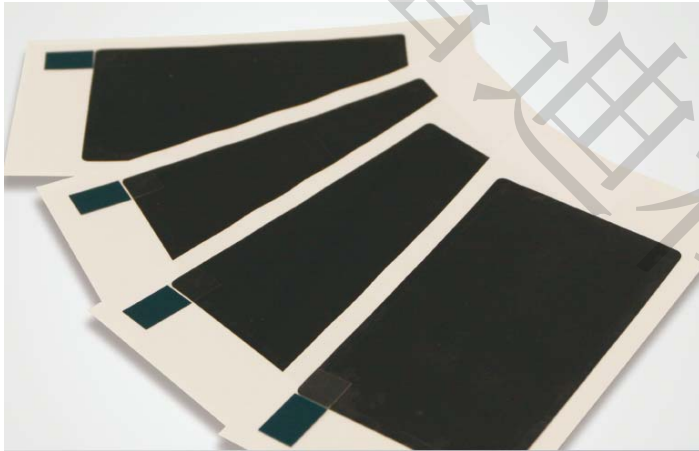
圖4-7. 複合相變化材料添加於鰭片之實際量測溫度圖

相變化材料之應用領域- 散熱應用

- 華為將用於航空航太的PCM材料放於膠囊中，置於手機內部，用於吸收手機高功耗工作時產生的大量熱能量，等手機溫度正常時，再將熱能量慢慢釋放到外部，維持手機溫度正常。



TAF-8800



PET
Substrate 1
Heat Absorber
Substrate 2
Adhesive

Design Flexibility	
PET	With or without
Substrates	With or without Cu, Al or Graphite at various thicknesses
Heat Absorber	Thickness and J/g grade
Adhesive	With or without PSA or ePSA
X-Y Dimensions	Customized
Z Dimension	Total thickness and ability for Multi-Axis Contourability

Material Properties

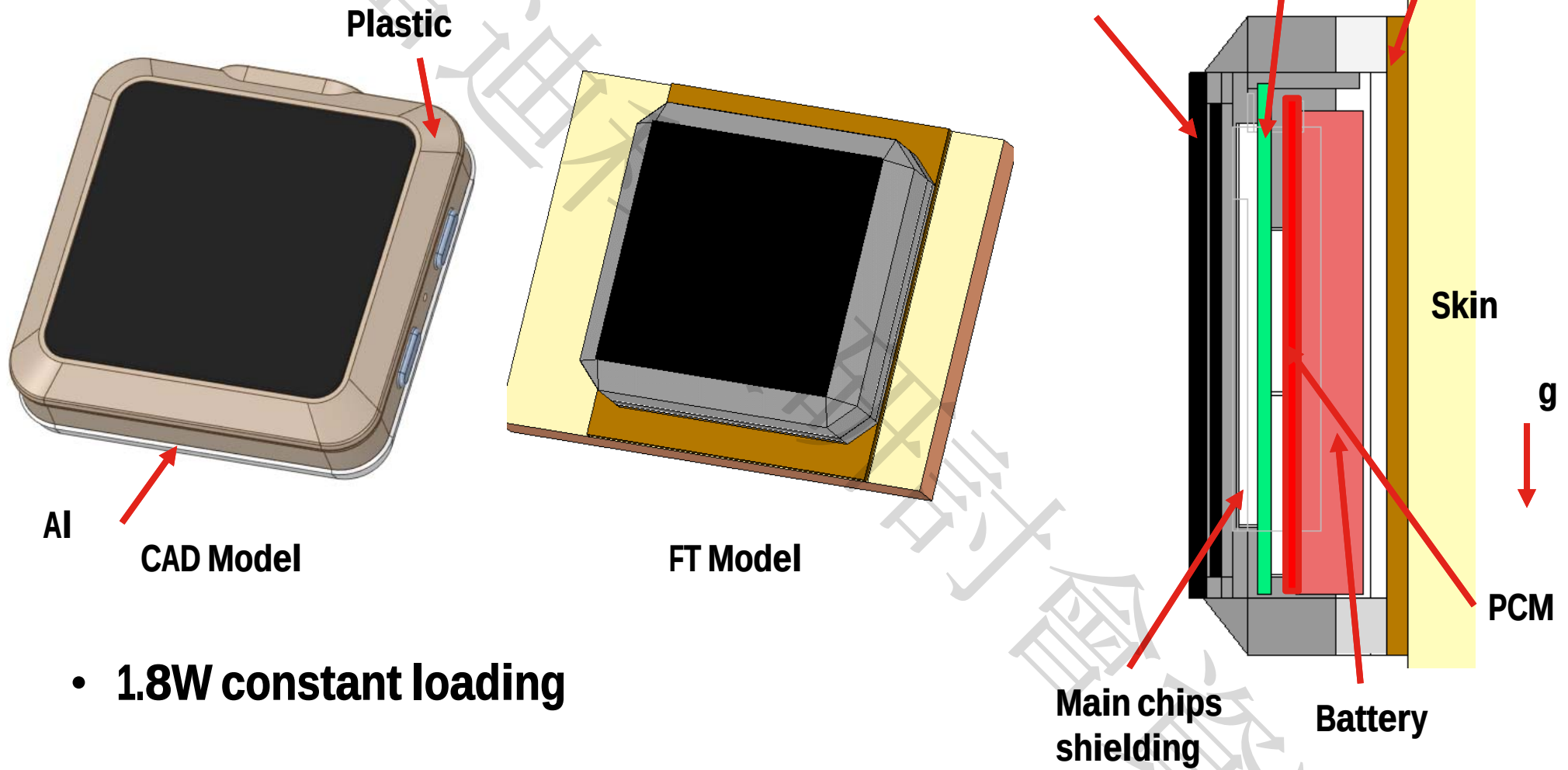
Absorber Properties

Density (g/cc)	0.36 – 0.64
Heat of Fusion (J/g)	115 – 205
Thermal Conductivity (W/(m-k))	0.1
Thickness Range (mm)	0.012 – 0.15

Substrate Material

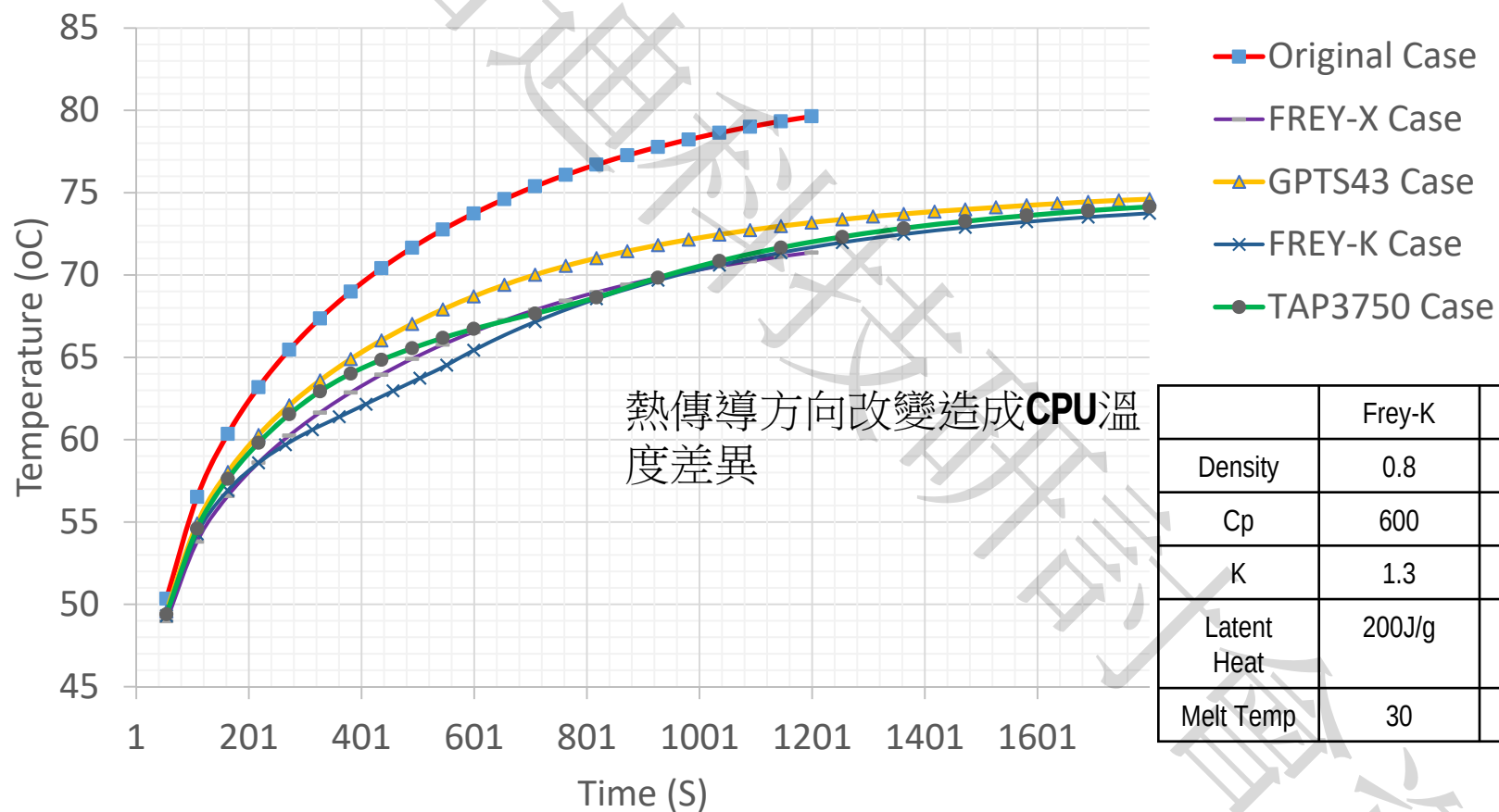
Substrate Type	Cu or Al
Thickness Range (mm)	0.012 – 0.10
Final Product Thickness Range (mm)	0.047 – 3.0

Smart Watch 模擬



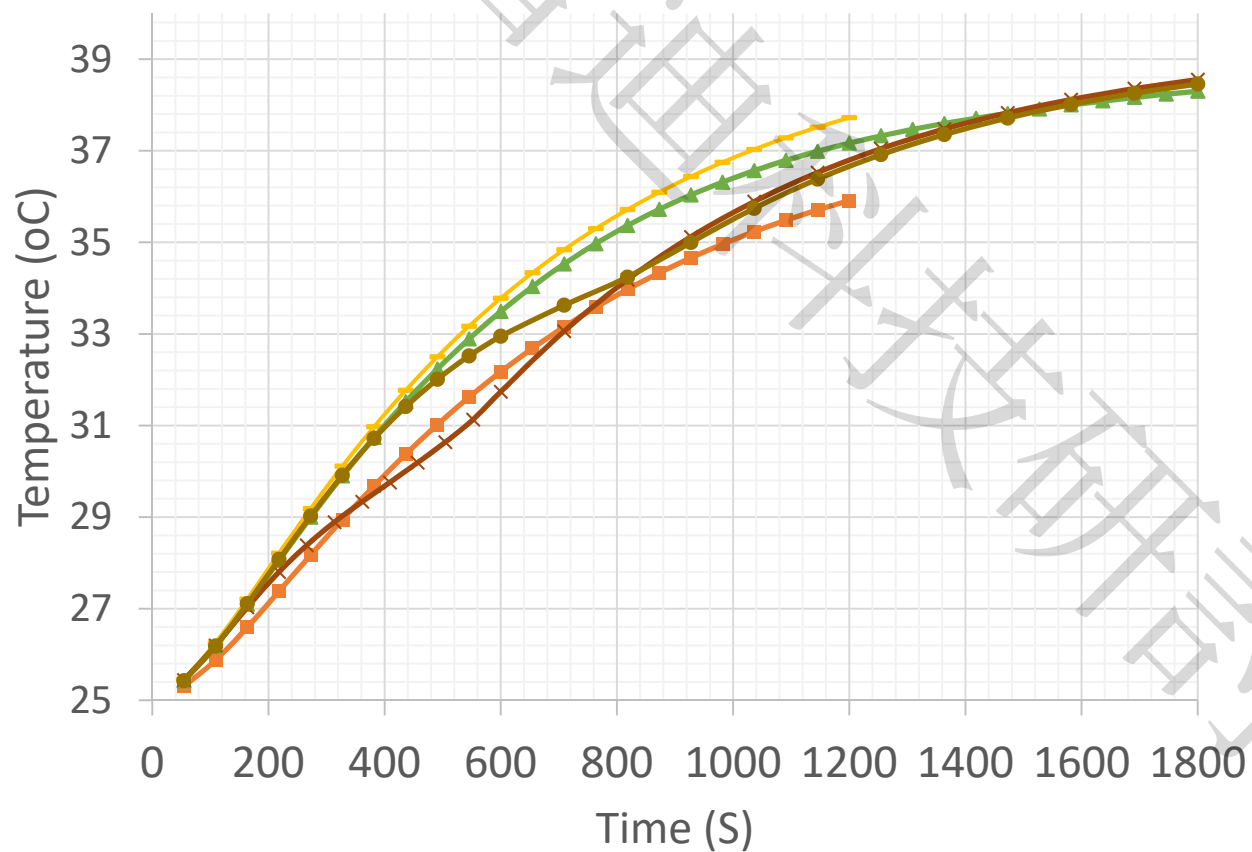
- **1.8W constant loading**

CPU溫度差異



	Frey-K	Frey-X	GPTS43	TAP3750
Density	0.8	1.5	0.94	0.91
Cp	600	700	600	200
K	1.3	4	0.3	0.1
Latent Heat	200J/g	1100J/g	110J/cc	200J/g
Melt Temp	30	65	43	37

皮膚接觸溫度



- Original Bottom
- FREY-X Bottom
- GPTS43 Bottom
- FREY-K Bottom
- TAP3750 Bottom

	Frey-K	Frey-X	GPTS43	TAP3750
Density	0.8	1.5	0.94	0.91
Cp	600	700	600	200
K	1.3	4	0.3	0.1
Latent Heat	200J/g	1100J/g	110J/cc	200J/g
Melt Temp	30	65	43	37

結論

- 相變化材料應用於散熱
 - 週期性附載，能實現蓄熱與放熱的應用
 - Paraffin本身熱傳導係數僅0.2W/mK，對熱傳幫助低，添加Graphene可提高熱傳導係數
 - 相變化材料參數影響
 - 暫態情況下有影響，穩態狀況下差異性僅有熱傳導係數
- $$\rho C_p \frac{DT}{Dt} = K \nabla^2 T$$
- 密度高，比熱大，對恆溫幫助高 (溫度隨時間變化梯度低)

Q&A

易世達科技(香港)有限公司 金寶利

Thank you!



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