(Thermal Management)

1.

1   . LED   ,   ,
                              . LED   LED
   Array   LED   LED
                     LED   .   LED
            70%   40000   .   LED
      LED   ,   LED
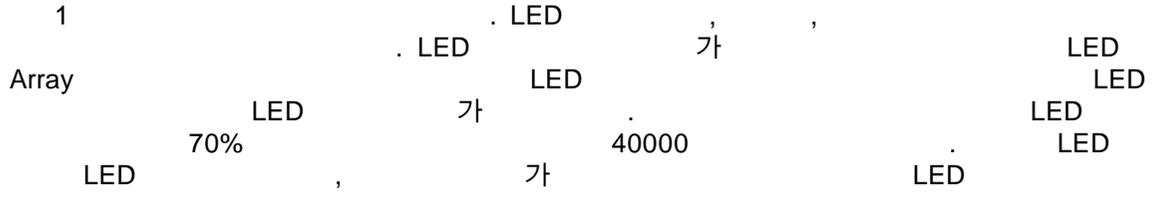   .

1.   (Power conversion of Light source)

Sources	Incandescent (60W)	Fluorescent	Metal Halide	LED
Visible Light	8%	21%	27%	15-25%
Infra red	73%	37%	17%	~0%
Ultra Violet	0%	0%	19%	0%
Total Radiant Energy	81%	58%	63%	15~25%
Heat (Conduction + Convection)	19%	42%	37%	75~85%
Total	100%	100%	100%	100%

2. LED

   LED   LED   (T_J)   . LED
    (T_A),   (R_{th})   (P_D)   .
   .

$$T_J = T_A + R_{thJ-A} \times P_D = T_A + R_{thJ-A} \times (I_F \times V_F)$$

      (P_D, Power Dissipation)   LED   (I_F)   (V_F)   .
                                          (Thermal resistance)   ,
   .   .

$$R_{th} = \frac{1}{\rho} \times \frac{L}{A}$$

   ρ : Thermal conductivity$(W / m \bullet K)$

   L : Length(m)

   A : Cross section(m^2)

         (, Thermal conductivity)
                  .   LED   .   2
                                                     .   LED
      (Copper)   .

2.

	Material	Thermal Conductivity (W/mK)
	Beryllium oxide	260
	Aluminium nitride	320
	Silicon carbide	270
	Alumina	24- 35
Grease	Air at 0°C	0.025
	Glass	0.8
	Water	0.6
	Ice	1.6
	Fiber- reinforced, Plastic	0.23~ 1.06
	Diamond	2000
	Polyethylene HD	0.5
	Styrofom	0.01
	Thermal grease, Ag based	2~ 3
Metal	Aluminium	237
	Gold	315
	Copper	386
	Lead	35
	Steinless steel	16.3
	SS316	14- 16
	Silver	406, 418, 429
	Steel	50.2
Solder	Pb- Sn	50
	Sn- Ag- Cu	55
	Sn- Zn- Al	66
	Sn- Bi- Ag	21
Paste	Clear paste (silicone, epoxy)	~ 0.2

LED   PCB   .

3. PCB

PCB	Thermal conductivity
FR2	0.2W/mK
FR4	0.35W/mK
MCPCB	1W/mK

LED   ,   .

$$R_{thJ-A} = R_{thJ-S} + R_{thS-A}$$

LED (R_{thJ-A}) (T_S) (R_{thJ-S})
                                (R_{thS-A}) .

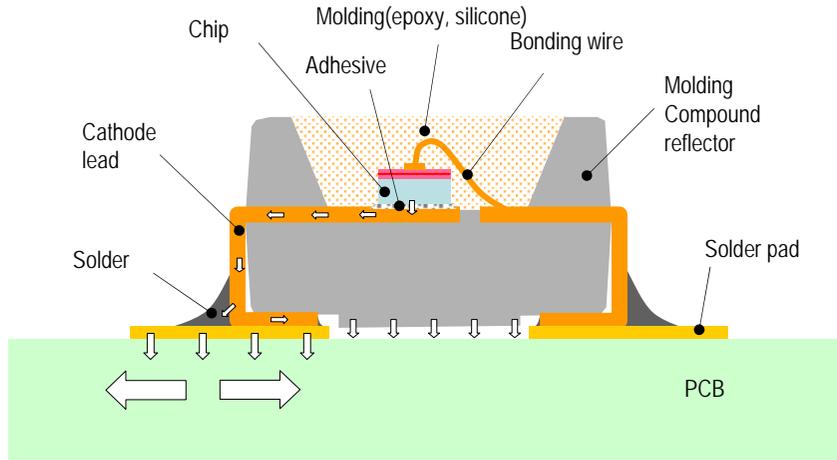$$R_{thJ-S} = R_{th,DIE} + R_{th,adhesive} + R_{th,frame} + R_{th,solder}$$

$$R_{thS-A} = R_{th,solder} + R_{th,PCB}$$

          (T_J) LED
          .

$$T_J = T_S + R_{thJ-S} \times P_D$$

1   PLCC type   LED   PCB   .
.

LED Die →   (Die adhesive) →   (Copper lead) →   (Solder)
→   (Solder pad) → PCB   →

.

Chip   Molding(epoxy, silicone)
                           Bonding wire
        Adhesive
                                                    Molding
                                                    Compound
Cathode   reflector
lead

                                                    Solder pad
Solder

                                              PCB

1. PCB   PLCC   LED

3.

LED

.

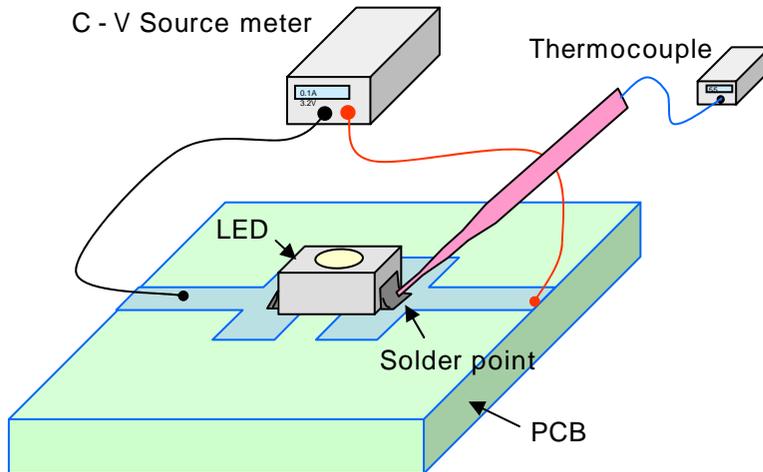$$T_J = T_S + R_{thJ-S} \times P_D$$

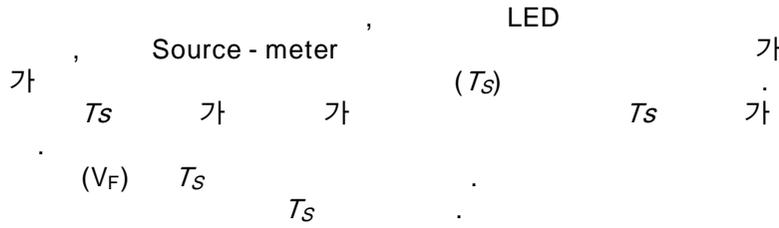2   LED   TEST   . PCB   LED
.   Source meter
Thermocouple   .

C- V Source meter
                              Thermocouple

        LED

                      Solder point
                                   PCB

2. LED   TEST

LED   .

    2   TEST Set- up   .
  Thermocouple   .
        .
                                      ,   LED   .
        ,   Source- meter   .
                                              (T_S)   .
        T_S T_S
        .
        (V_F) T_S .
                              T_S .

                                                        .

            LED   100mA   ,   (Max T_J)
  125   PN   ($R_{thJ- S}$)   40K/W   .
                                                    (T_S)   70
      3.4V   .   ?

              ,

        $T_J = T_S + R_{th\,J- S} \times P_D = T_S + R_{th\,J- S} \times (I_F \times V_F)$
            $= 70 \quad + 40K/W \times (0.1A \times 3.4V) = 70 \quad + 13.6$
            $= 83.6 \qquad (T_J < max\ T_J = 125 \quad)$

4. LED

    PCB   (LED,   , Driver   )   ,   (Power
  Dissipation)   .
                        PCB   . T_D ,
  PCB   (mW/mm²)   (Solder pad)   (T_D)
            .

$$\Delta T_D = k \times P_{den} - k_0$$

                          PCB   ,   ,   PCB
                            .

            LED   MCPCB   FR- 4 PCB   , PCB   LED
        (T_D)   .   1mW/mm²   , MCPCB
        $T_D = 30$, FR- 4 PCB $T_D = 15$`~ 25   .

$$\Delta T_D = 30 \times P_{den}\ \text{(for MCPCB)}$$
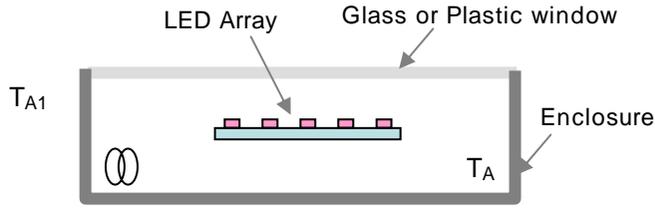
$$\Delta T_D = 22.4 \times P_{den} - 3.58\ \text{(for FR - 4 PCB)}$$

      , FR- 4 PCB   3 x 3 = 9 LED   . LED   20mm
                . PCB   400mm²   . LED $I_F= 13mA$, $V_F= 3.1V$.
    LED   (Power dissipation) $P_D= 13mA \times 3.1V = 40.3mW$.   9   LED
                    (Total Power Dissipation) $P_T= 40.3mW \times 9 = 362.7mW$.
              (Power density) $P_{den} = 362.7mW/400mm² = 0.91\ mW/mm²$. FR- 4
  PCB   = 1.0mW/mm²   (T_D)   20   .
        ,   LED   LED   20   .

5.   (Enclosure)

LED   .
, LED   ,   ,
.   3

LED   .

LED Array   Glass or Plastic window

T_{A1}

Enclosure

T_A

3.   LED   (   )

(T_A) (T_{A1}) $(R_{th,en})$,

$$R_{th,en} = \frac{T_A - T_{A1}}{P_T}$$

, $R_{th,en}$, T_A , T_{A1}
, P_T .

LED   .

$$T_J = T_{A1} + \left(P_D \times R_{thJ-A}\right) + \Delta T_D + P_T \times R_{th,en}$$

6. MCPCB Sub- metal

Power LED   Al MCPCB   .   LED
.   LED   1W   IWS- M506- UW   .   LED
.

4. M506- UW

Model	Id(mA)	Vf(V)	P(W)	$R_{th\,J-B}$ (K/W)	T_A( )	Point of temp.
M506- UW- 3Q with sub- mount	350	3.1	1.085	12	22	T_S, T_B

650   x 650
3   .

MCPCB   4
. MCPCB
Al   1.5t,
80 , Cu 70   485mm²
.
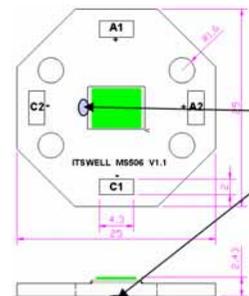
4. MCPCB   Layout

LED   MCPCB   (T_S)   MCPCB   (T_B)
Thermocouple   .
2   . T_S= 52.5 , T_B= 50.4   .

                              ,   .

$$T_J = T_A + P_D \times R_{thJ-A}$$

$$R_{thJ-A} = R_{thJ-S} + R_{thS-B} + R_{thB-A}$$.

T_S T_B R_{thS-B} R_{thB-A} .

$T_S = T_B + P_D$ x R_{thS-B} → $R_{thS-B} = (T_S - T_B)/P_D = (52.5 - 50.4)/1.085 = 1.94$ [K/W]
$T_B = T_A + P_D$ x R_{thB-A} → $R_{thB-A} = (T_B - T_A)/P_D = (50.4 - 22)/1.085 = 26.18$ [K/W]

LED $R_{thJ-B} = 12$K/W   ,

$R_{thJ-B} = R_{thJ-S} + R_{thS-B} = 12$k/W → $R_{thJ-S} = R_{thJ-B} - R_{thS-B} = 12 - 1.94$
        $= 10.06$ [K/W]

        ,

$R_{thJ-A} = R_{thJ-S} + R_{thS-B} + R_{thB-A} = 10.06 + 1.94 + 26.18 = 38.18$ [K/W]

        LED T_J ,

$T_J = T_A + P_D$ x $R_{thJ-A} = 22$ + (1.085W) x (38.18K/W) = 63.4

        .

                MCPCB   MCPCB R_{thB-A} ,

        $(R_{thB-A})/$ = 26.18[K/W]/485[mm^2] = 0.054 (K/W)/mm^2 .

6.

                                                                                    T_A = 25

ITEM	IWS- L506- UW - J7	IWS- P351- UW - Q	IWS- M351- UW - Q	IWS- M506- UW - 3Q
Chip size	300 x600 x3ea	650	650	650 x3ea
P_E(W)	0.19	0.32	0.51	1.16
Rth(K/W)	25	42	35	11
T_J( )	30 at I_F= 60mA	39 at I_F= 100mA	42 at I_F= 150mA	37 at I_F= 120mA/chip

        : T3STER (KOPTI)