

---

# LED System Reliability

---

# Failure analysis of LED array due to rapid power cycling

Adapted from Yinan Wu's M.S. Thesis Presentation  
September 7, 2010

Lighting Research Center  
Rensselaer Polytechnic Institute

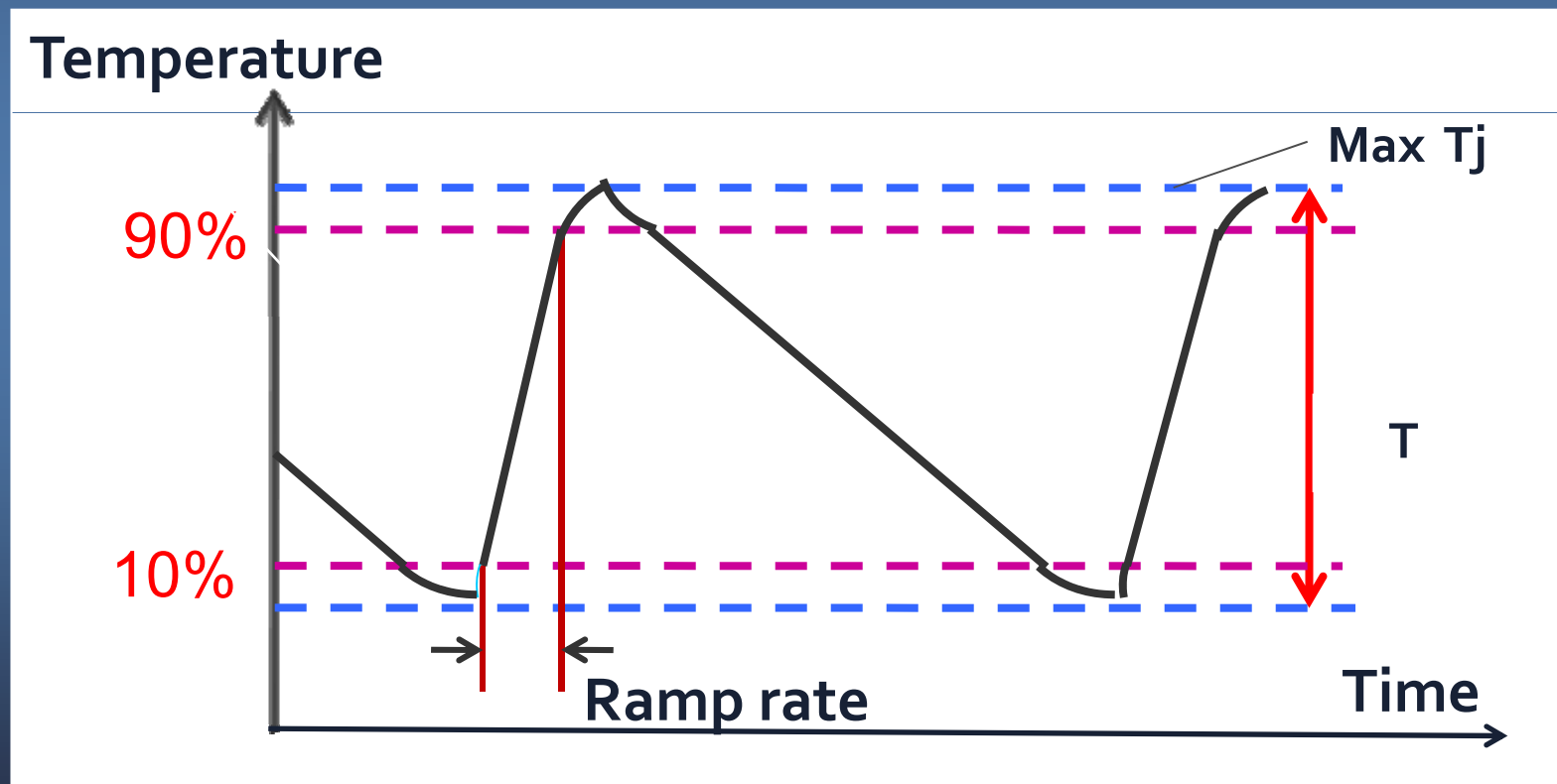
# Literature search

---

- ◆ Many papers on other types of semiconductor failure analysis with power cycling
  - › Two main failure mechanisms: Wire bond lift-off and solder interconnection failure
  - › Possible failure accelerating factors:  $\Delta T$ , MaxTj, and Ramp rate

# Literature – Power Cycling Test

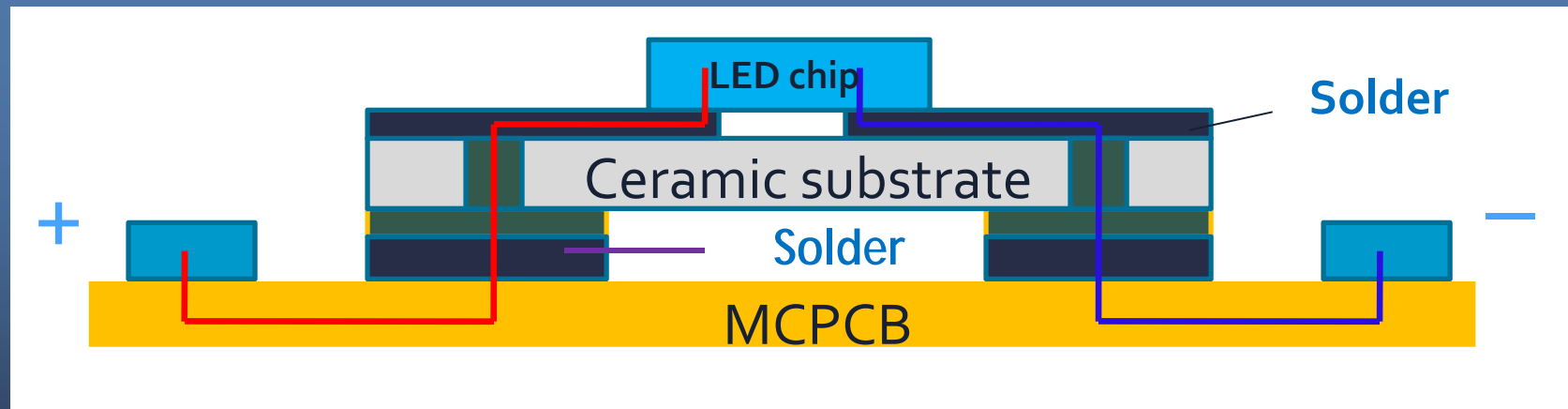
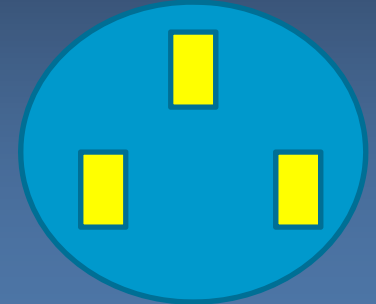
- ◆ Temperature profile schematics in power cycling test [JESD22-A105C,2004]



# Structure of a Sample LED Array

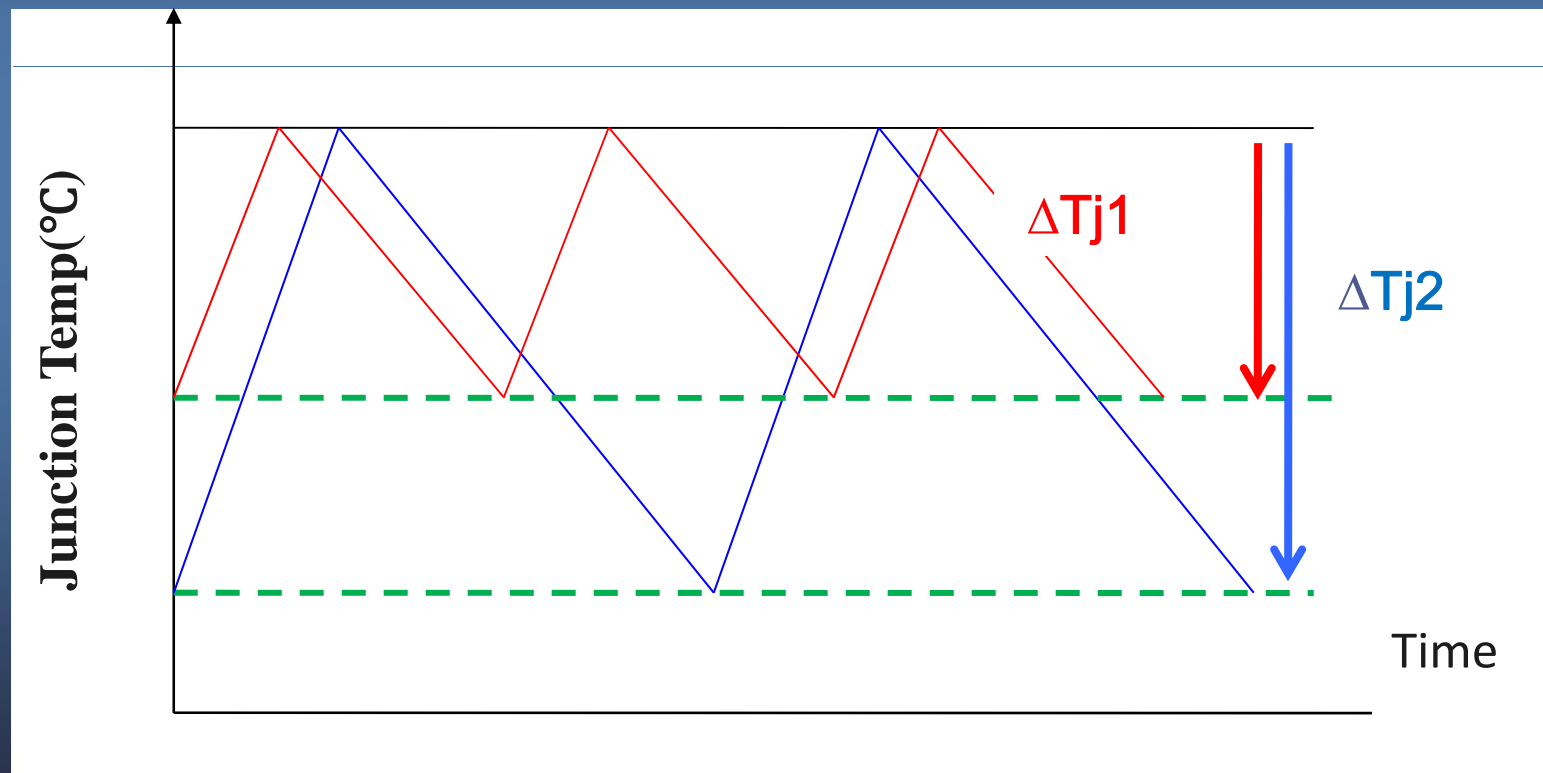
- ◆ LED array

- › Three high-power white LEDs mounted in series connection on a MCPCB



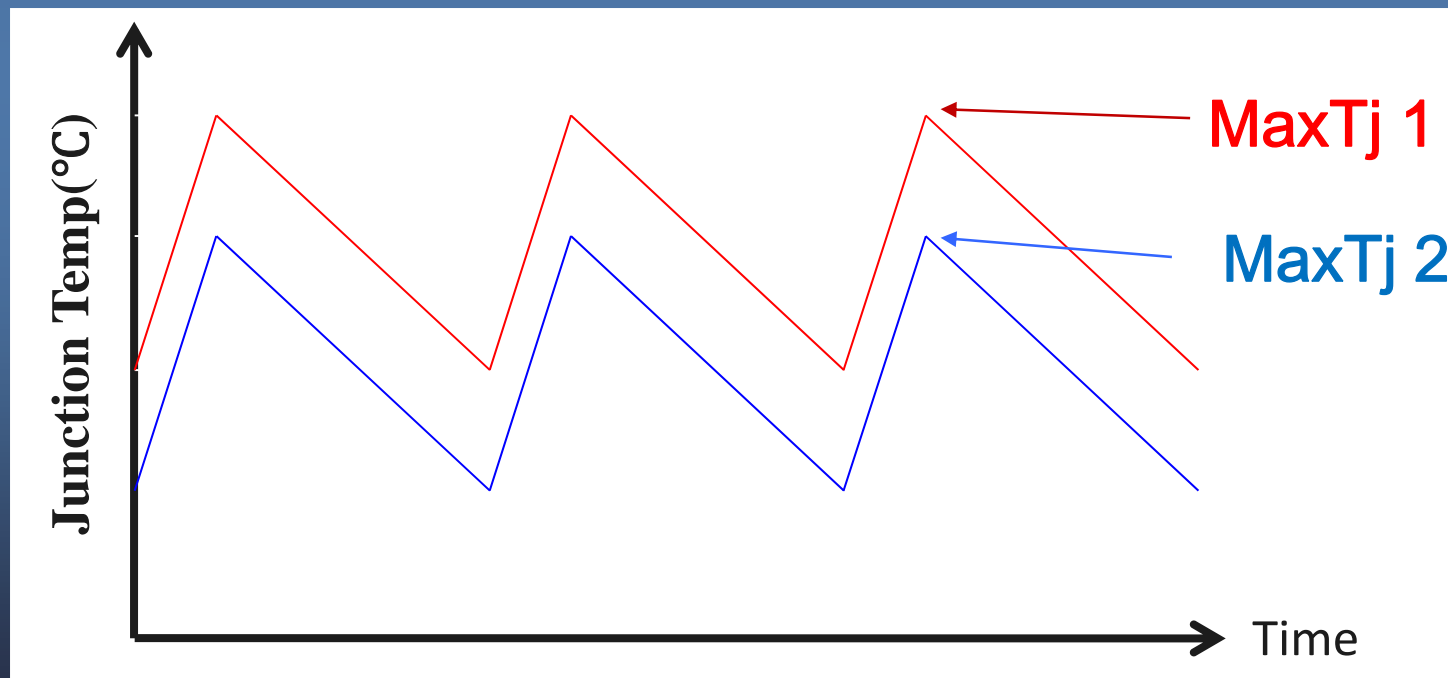
# Hypotheses

- > Hypothesis 1: Under the same driving current, same heat extraction conditions and the same  $\text{Max}T_j$ , If  $\Delta(T_j)$  increases then the number of cycles to failure decreases.



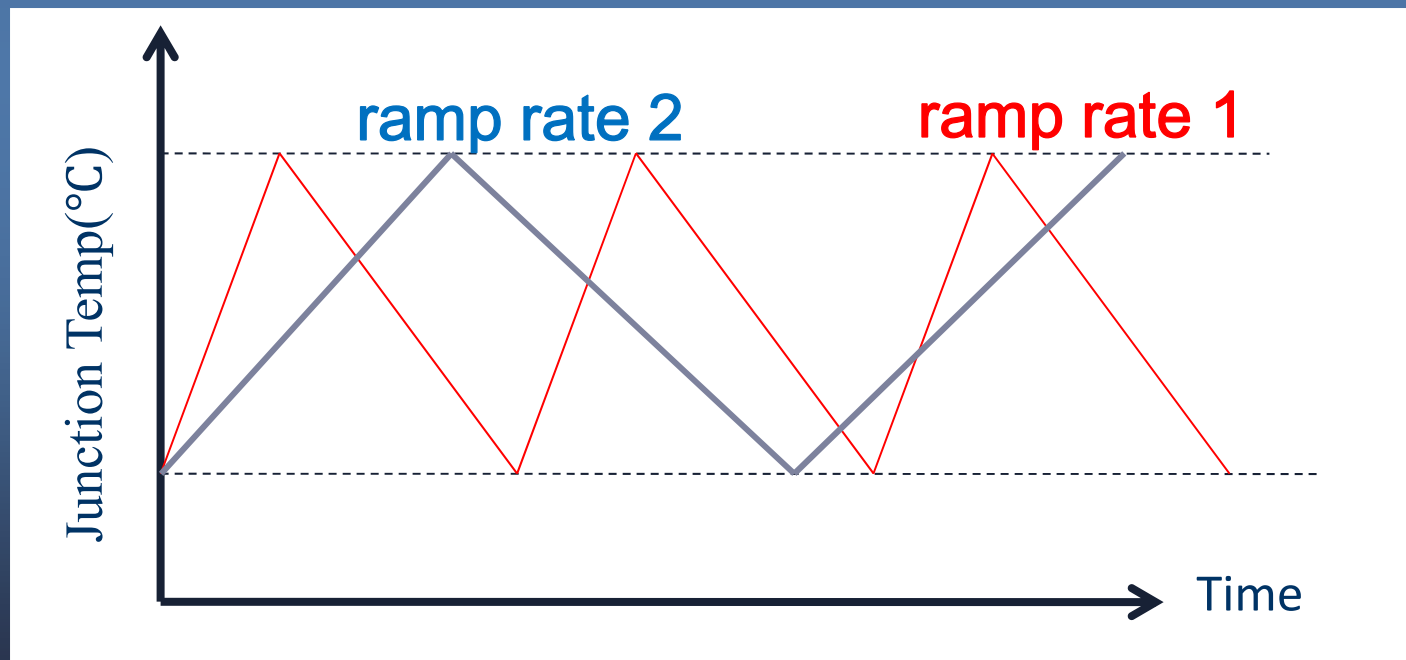
# Hypotheses

- › Hypothesis 2: Under the same driving current, same heat extraction conditions and the same delta  $T_j$ , if  $MaxT_j$  increases then the number of cycles to failure decreases.



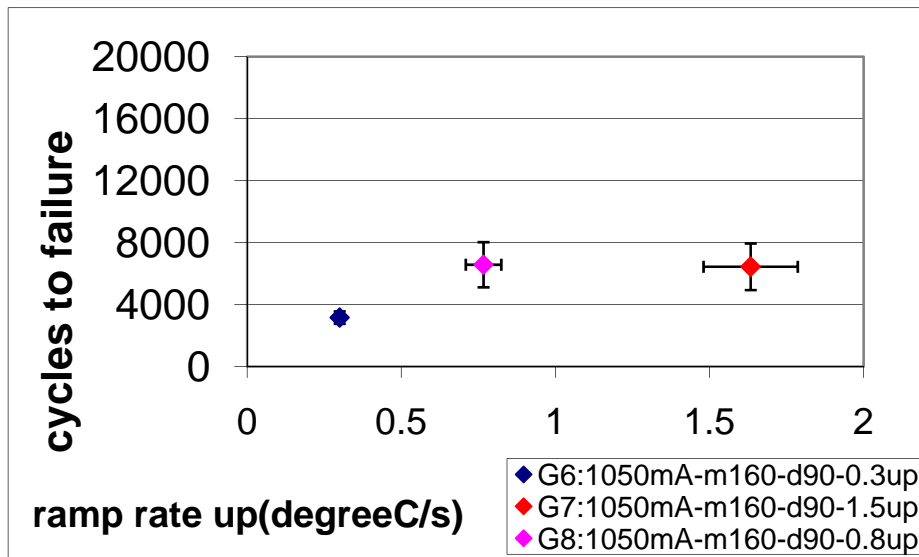
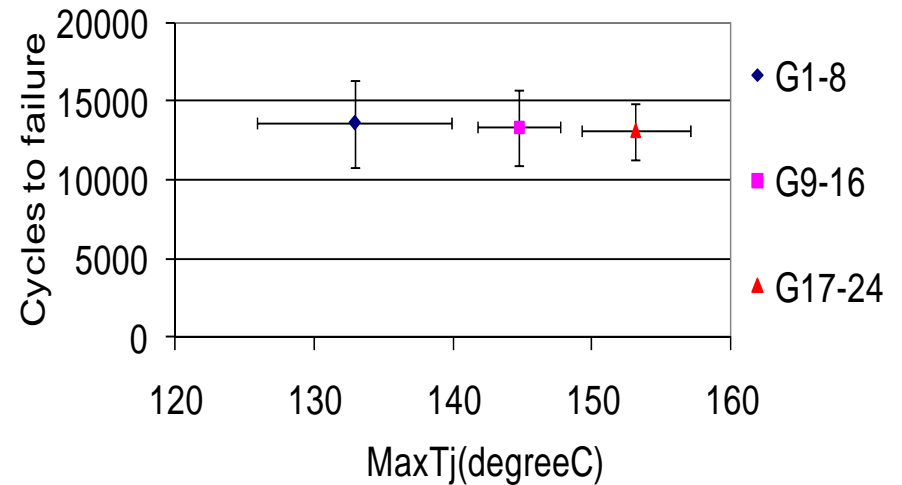
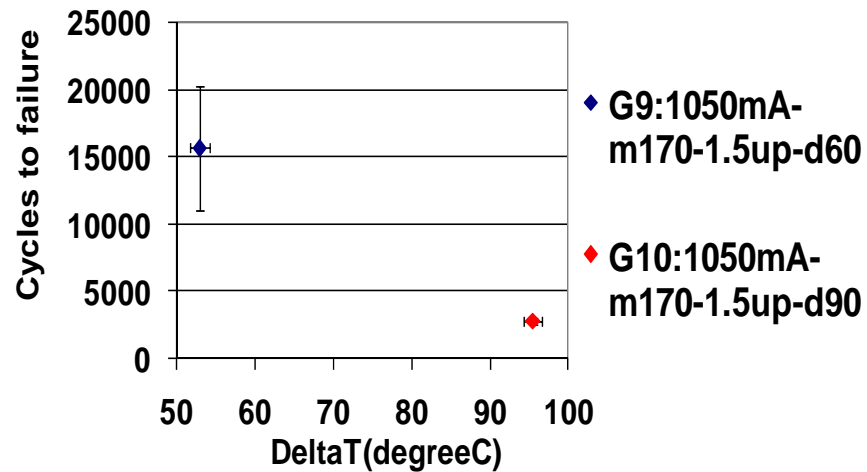
# Hypotheses

- › Hypothesis 3: Under the same driving current and the same  $\Delta T_j$  and Max  $T_j$ , if temperature ramp rate increases then the number of cycles to failure increases.





# Results

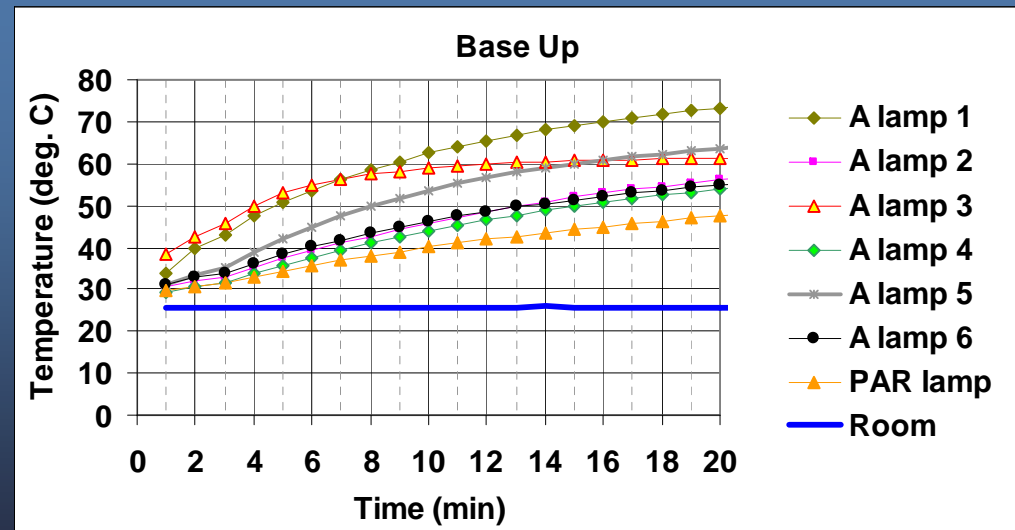
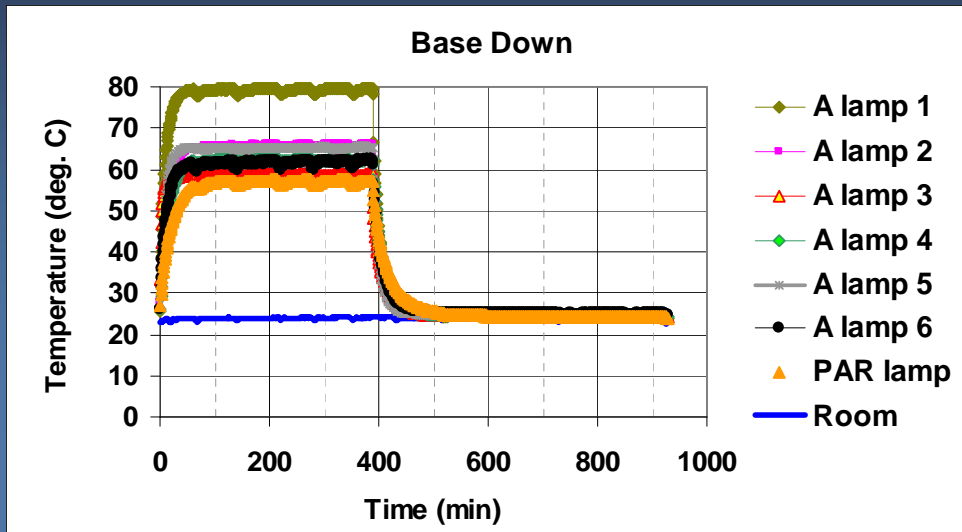


# Conclusions

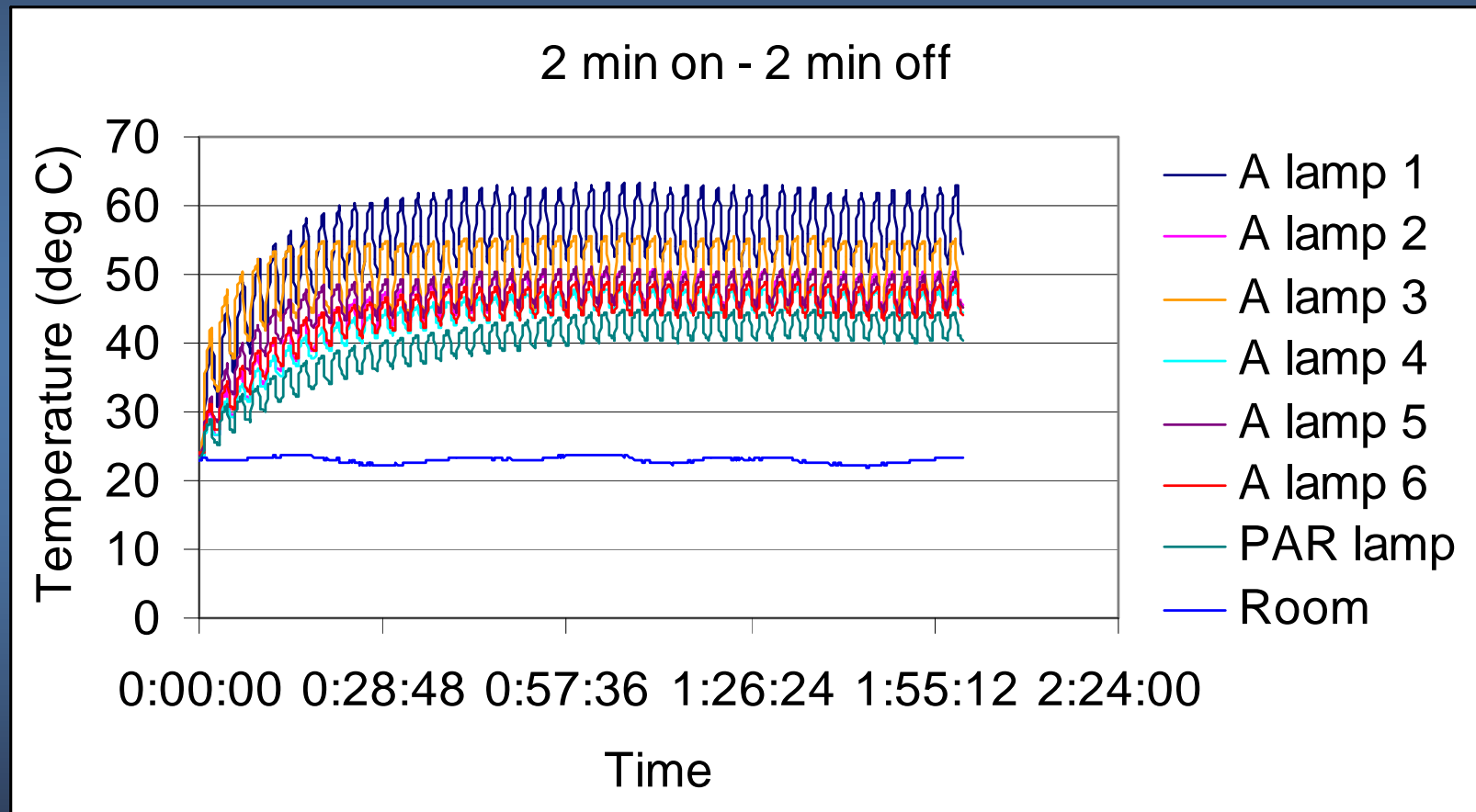
---

- ◆ When power cycling high-power LEDs:
  - › Delta T has strong correlation with cycles to failure
  - › Max T<sub>j</sub> has very little effect on cycles to failure
    - Less than breakdown temperature of high-power LED
  - › Ramp rate on cycles to failure is weak
    - With increasing ramp rate the cycles to failure increases

# Lamp Warmup and Cool Down



# Rapid Cycling of Lamps



# Proposal for Testing LED Systems

---

- ◆ Power cycle the systems
  - › At elevated temperatures (TBD)
    - Three temperatures
  - › On-off cycle time to obtain maximum delta T
    - Three cycles
- ◆ ASSIST sponsors requested that LRC form a group with manufacturers and test systems to identify a protocol for life-testing LED systems