



# UVFL Inspection

## Drone and Tools

PV Guider

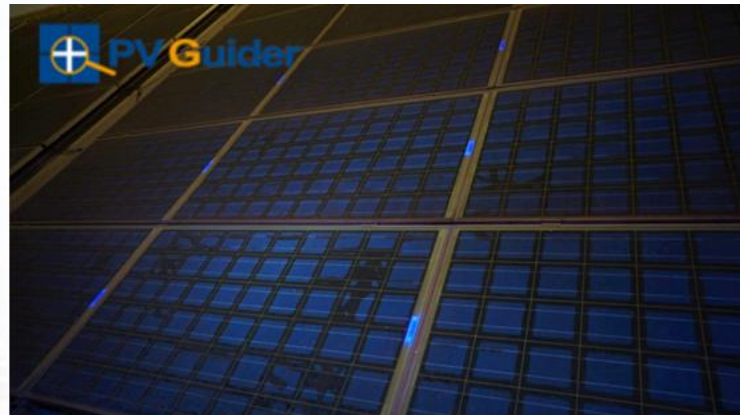


Keep Green **Gold** Shining!

# Content



- u Drone for UVFL Inspection – capability and limits
- u Tools for UVFL Inspection
- u Inspection Result and Discussion
- u Future of UVFL – opportunity and limits





# Target of Development

- u Achieve UVFL inspection with commercial drones
- u Low skill demand for pilot
- u Limited investment
- u Assess the PV plant condition in a short time
- u Find cracks and hot spot



DJI Inspire

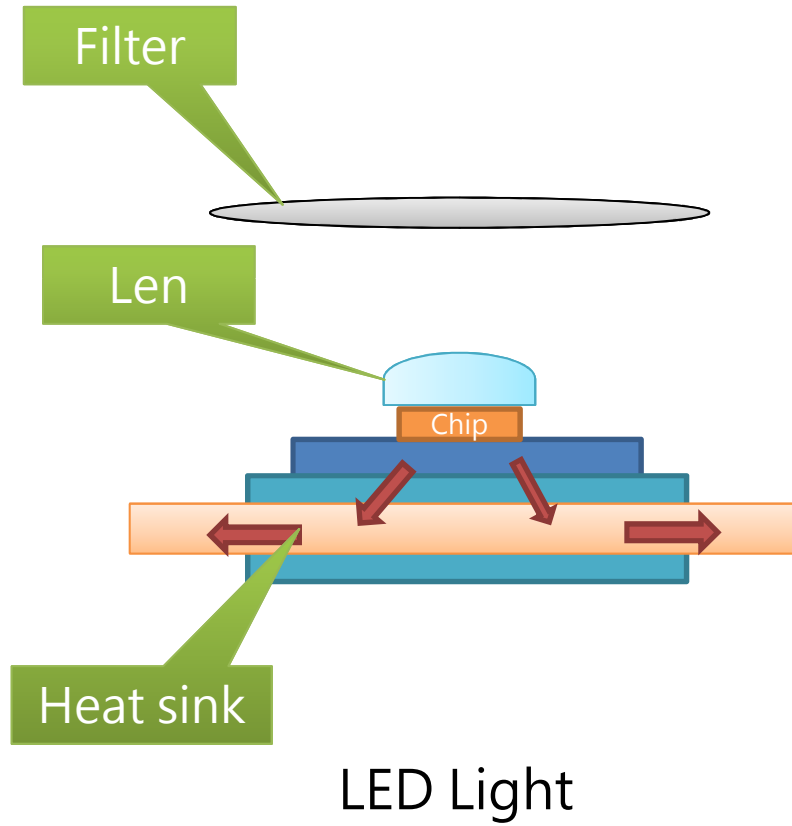
# Apparatus



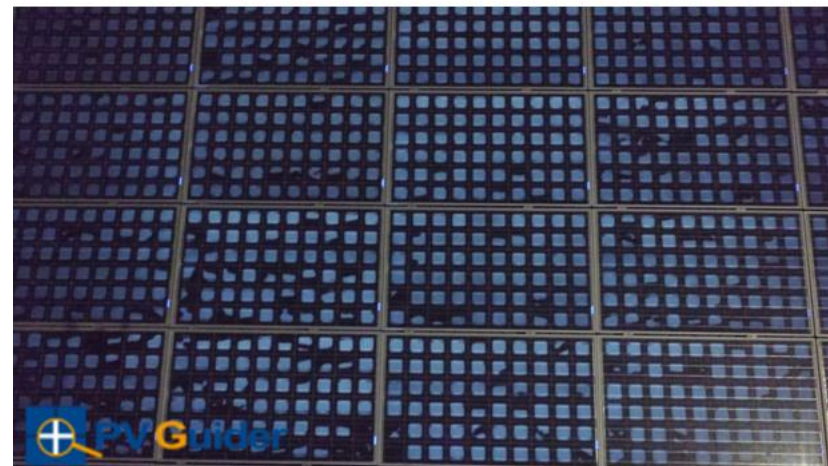
- u One pilot concentrate on flying, one photographer control camera
- u A lot batteries, and quick charger
- u Planned route (but frequently useless)
- u Drink....to keep you awake



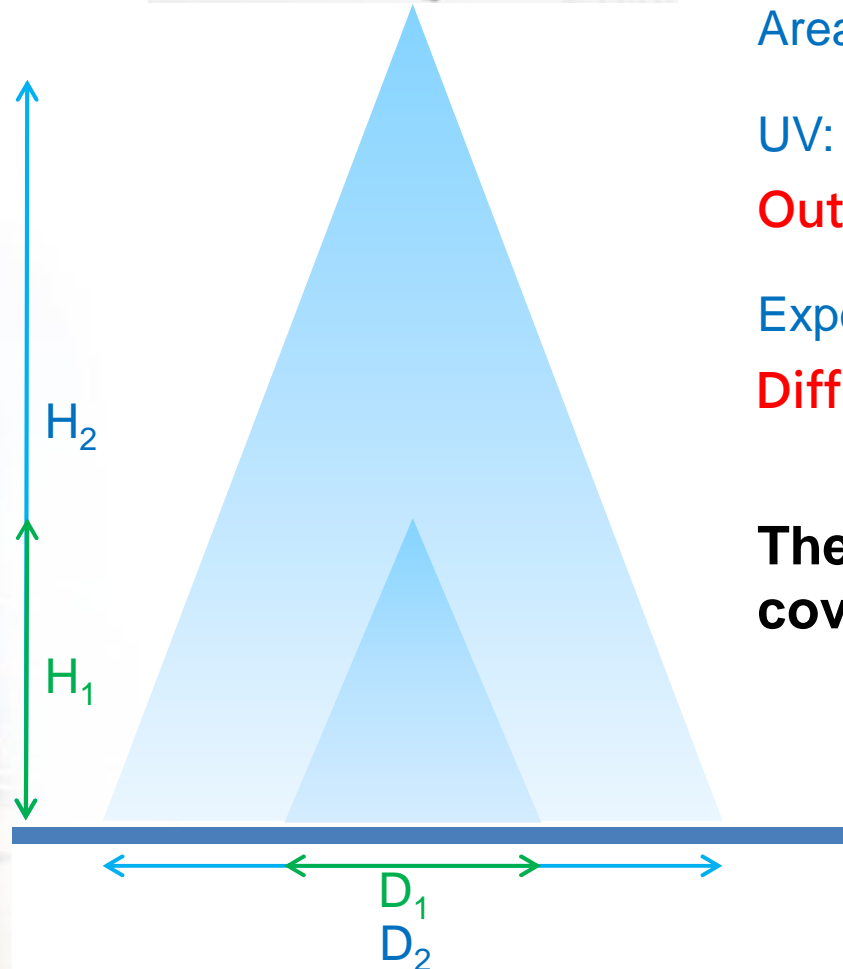
# UV Lamp



# Successful Result



# Influence of distance



When drone fly **twice** higher:

Diameter:  $D_2 = (H_2 / H_1) D_1 = 2 D_1$

Area:  $A_2 = (H_2 / H_1)^2 A_1 = 4 A_1$

UV:  $I_2 = (H_1 / H_2)^2 I_1 = I_1 / 4$

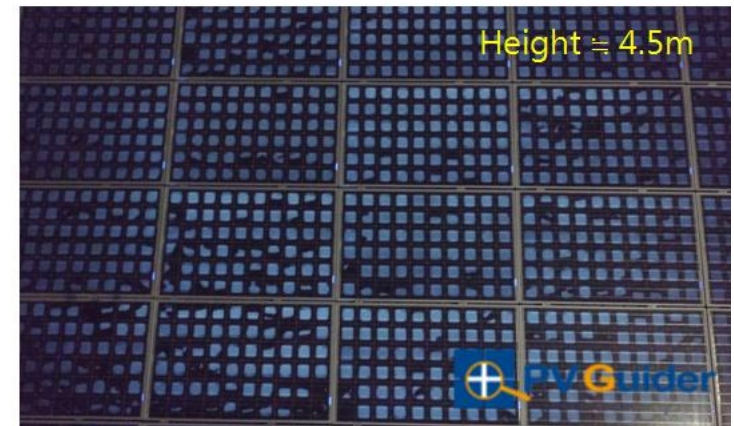
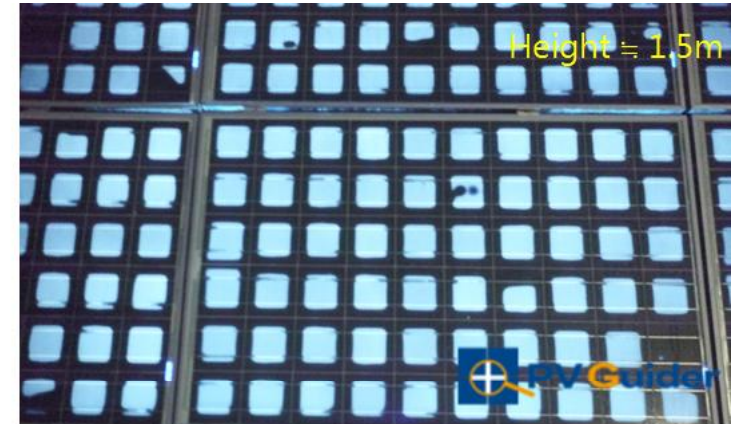
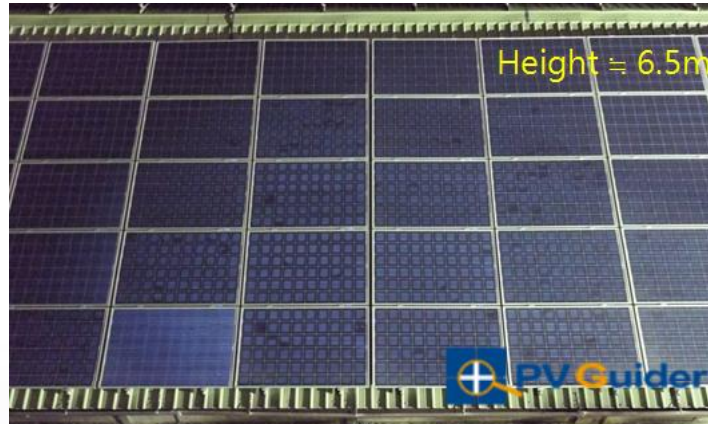
**Outer area is even weaker**

Exposure time:  $t_2 = (H_2 / H_1)^2 t_1 = 4 t_1$

**Difficult to take pictures**

**The upper limit is about 5m,  
covers 20 modules (6x10).**

# How far can it go?



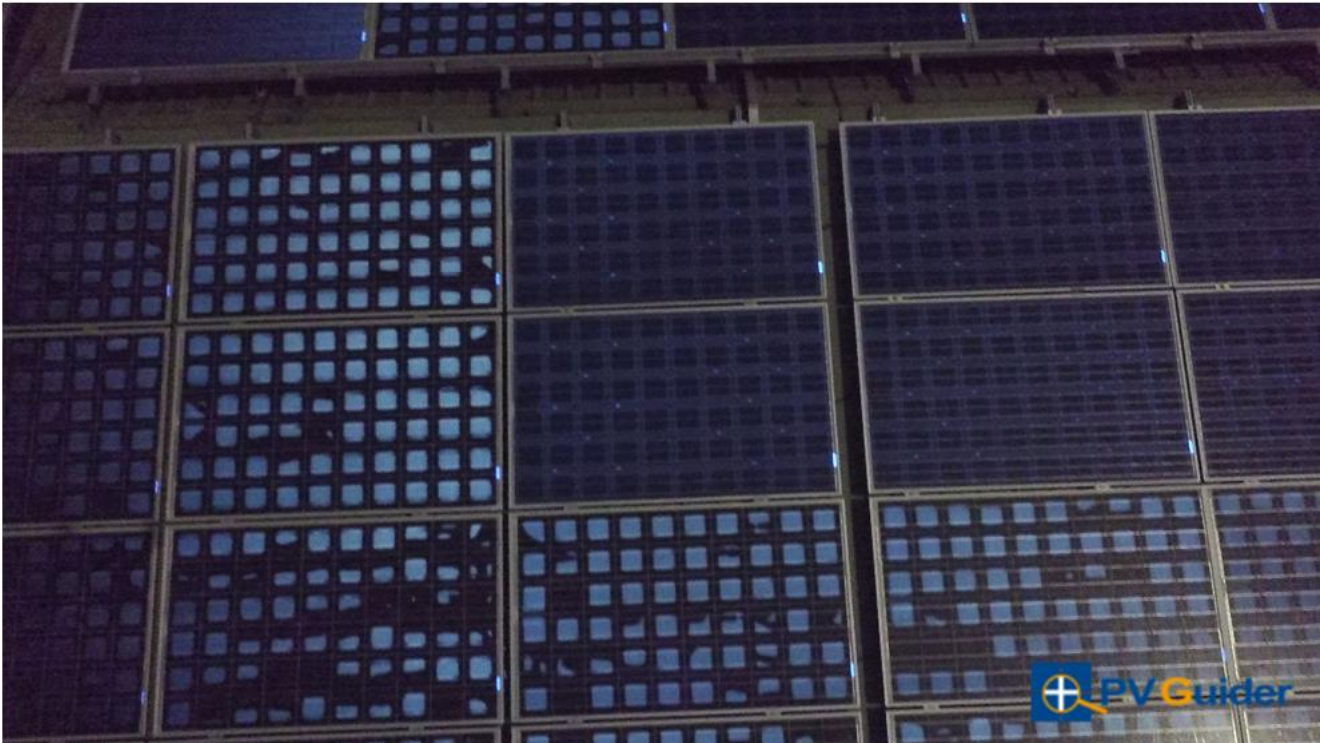




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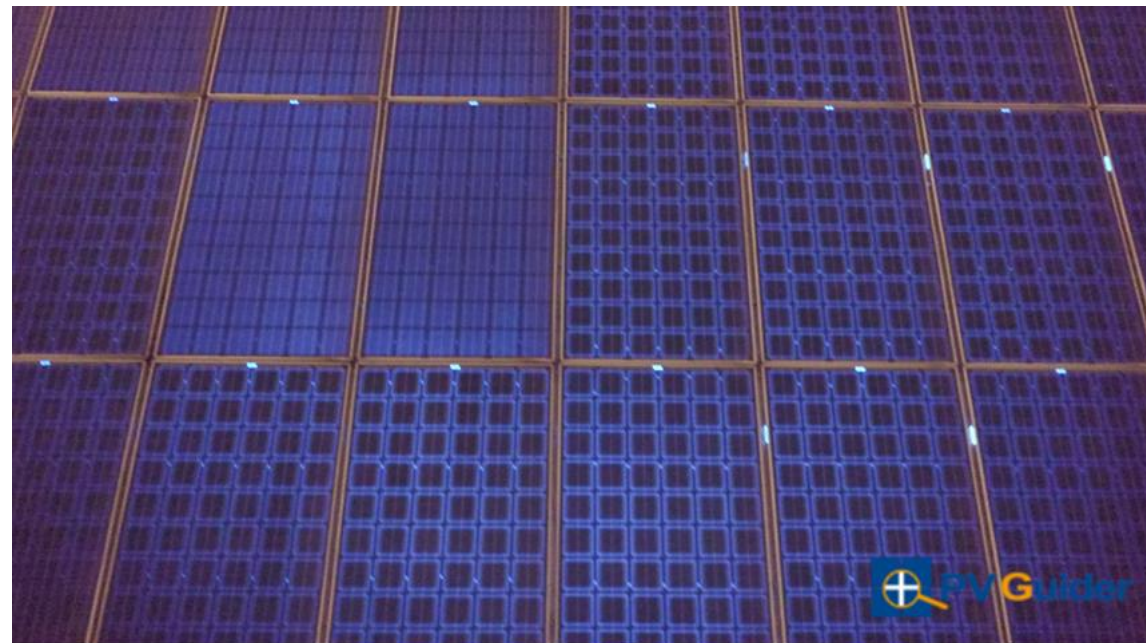
Life in never easy

# Low UVFL modules

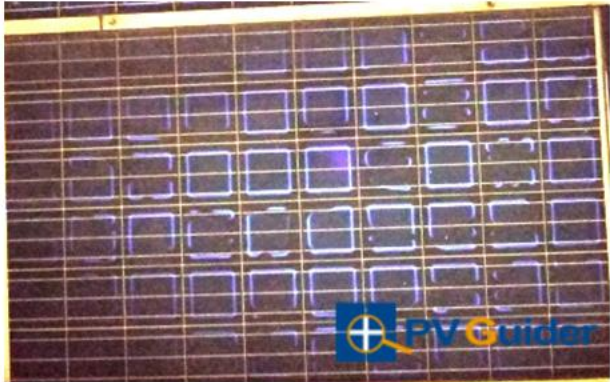
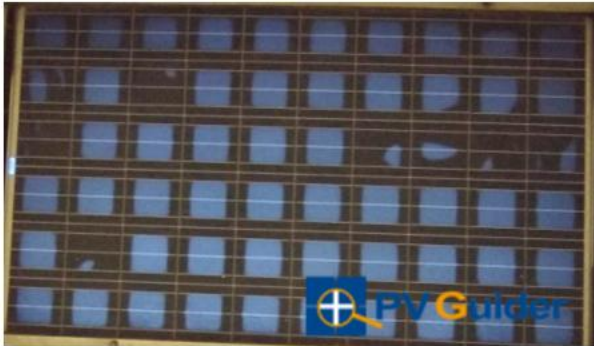
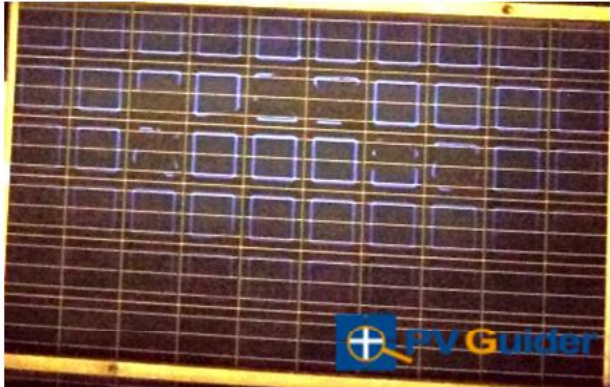
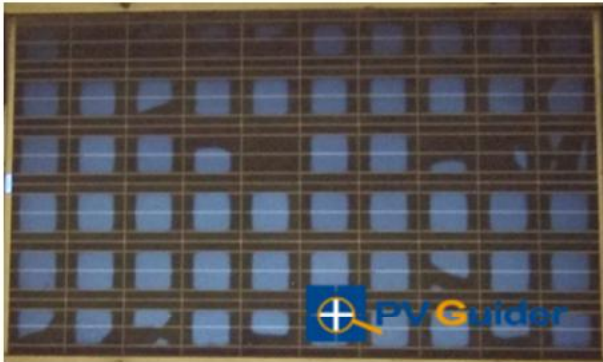


# Weak UV at outer area

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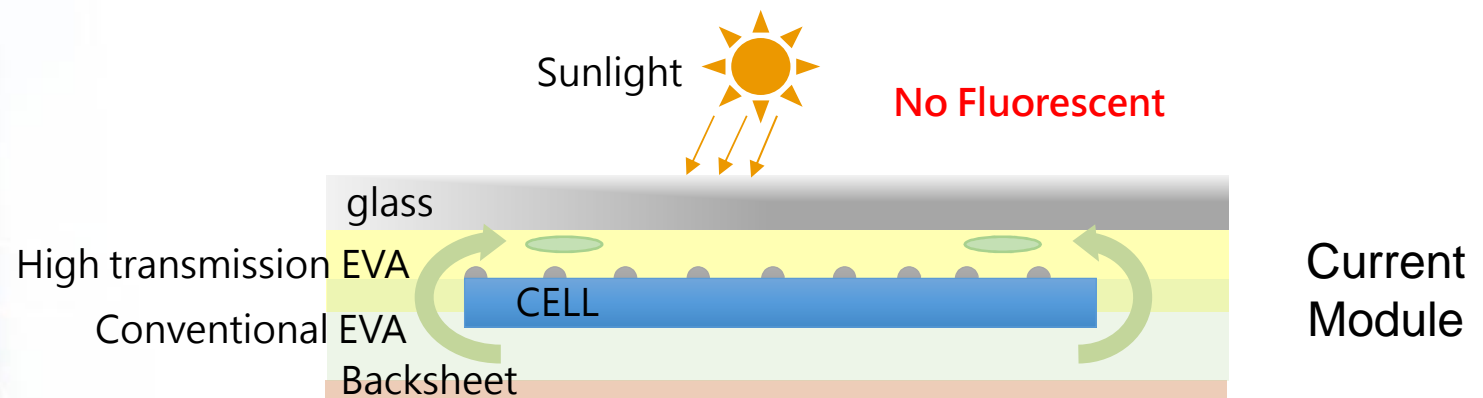
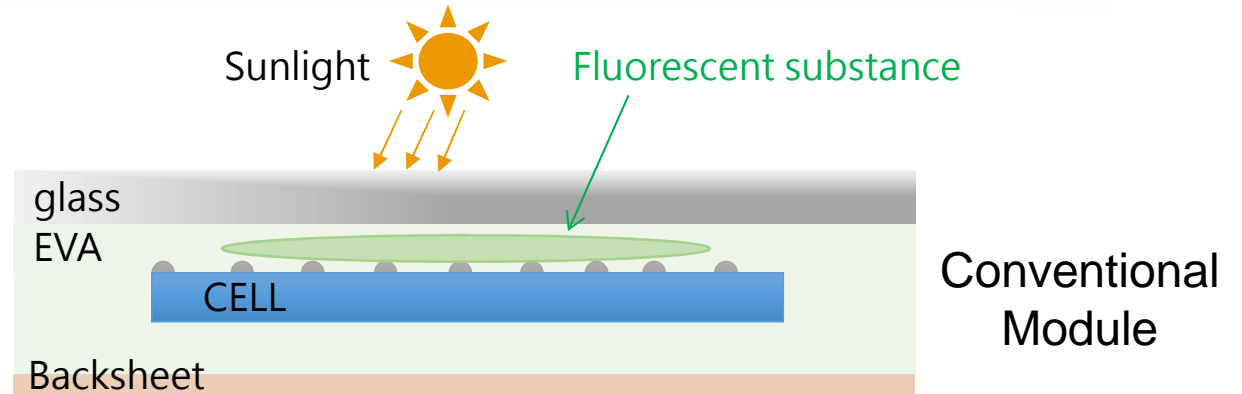


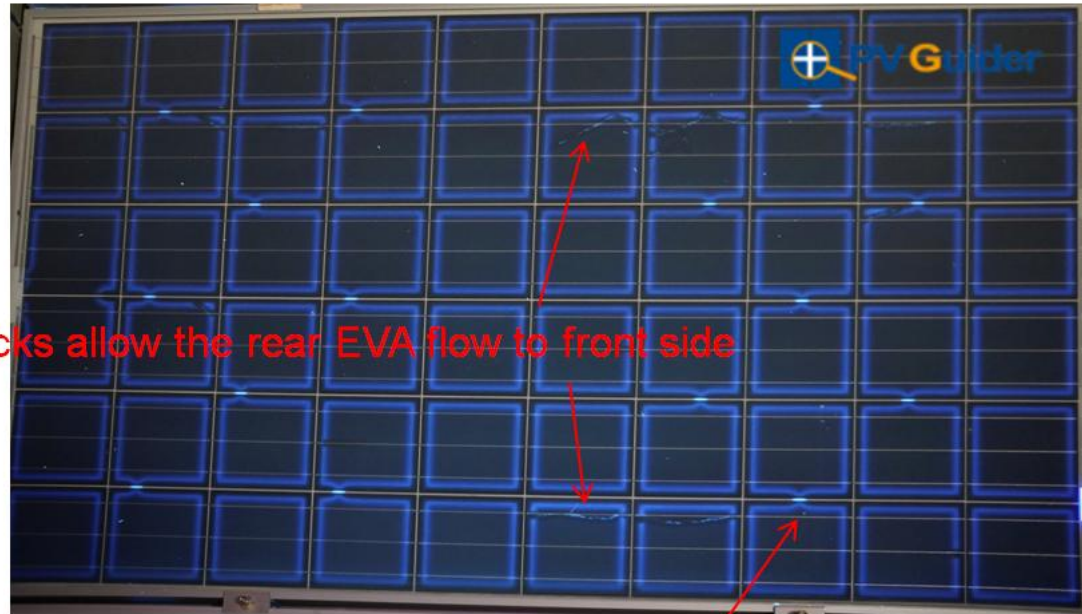
# Low UVFL modules





# Reason for low UVFL

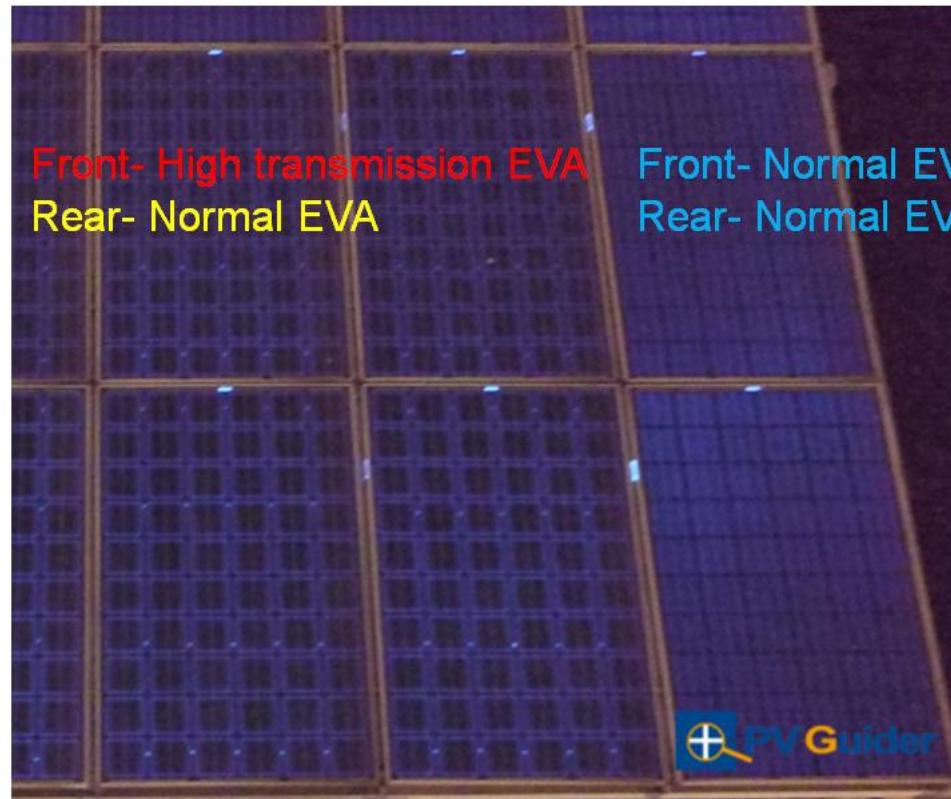




Cracks allow the rear EVA flow to front side

Tape block EVA flow to front side

# Verify EVA





# The disadvantage of flying low



- u Dangerous, especially in windy days
- u Image quality is not good
- u Difficult to locate the defect module
- u Inspection speed too low
- u Consume more power for flying
- u Need more battery and quick charger





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# Tools for UVFL Inspection



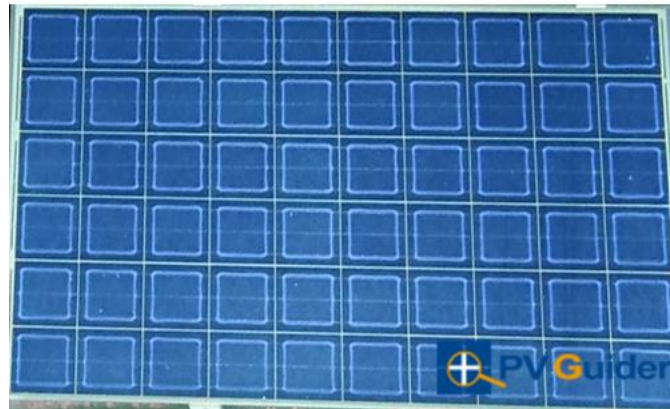
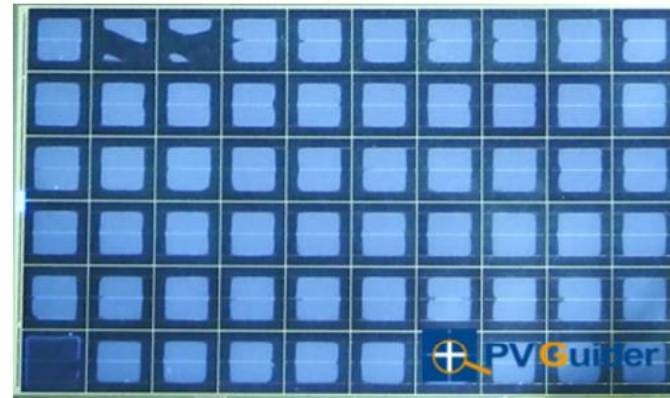
# Additional Lamp

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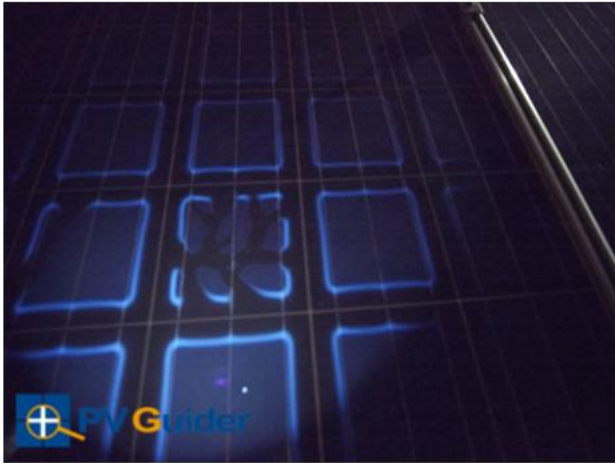


UV LED Lamp

# Image after processing



# Handheld Detector

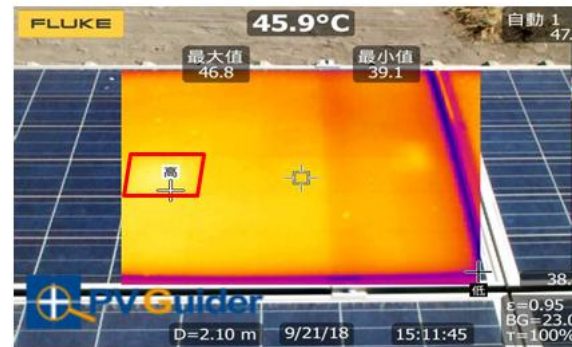
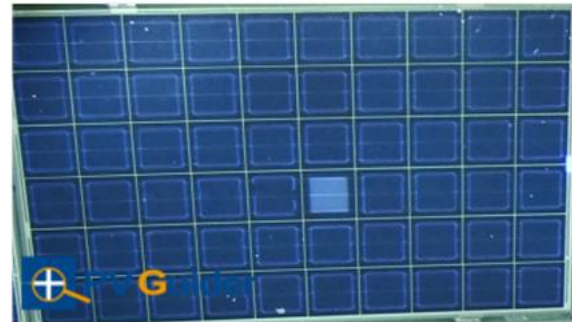




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# Special Phenomenon

# Single cell with difference

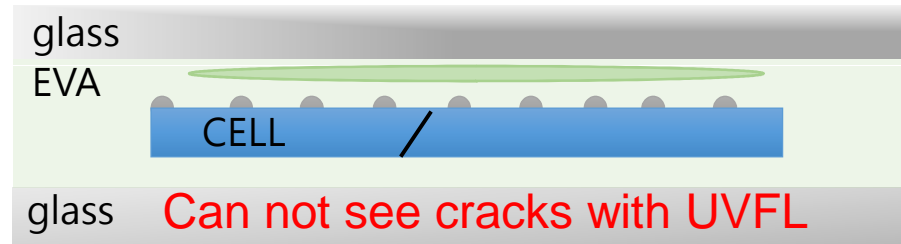
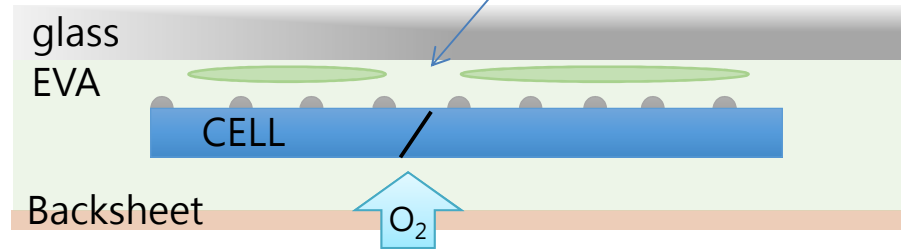


Module rework, but not hot spot

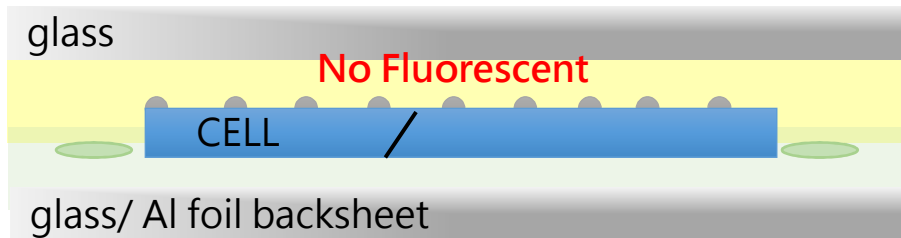


# UVFL of Double glass/ Al Foil backsheet

No fluorescent at crack position

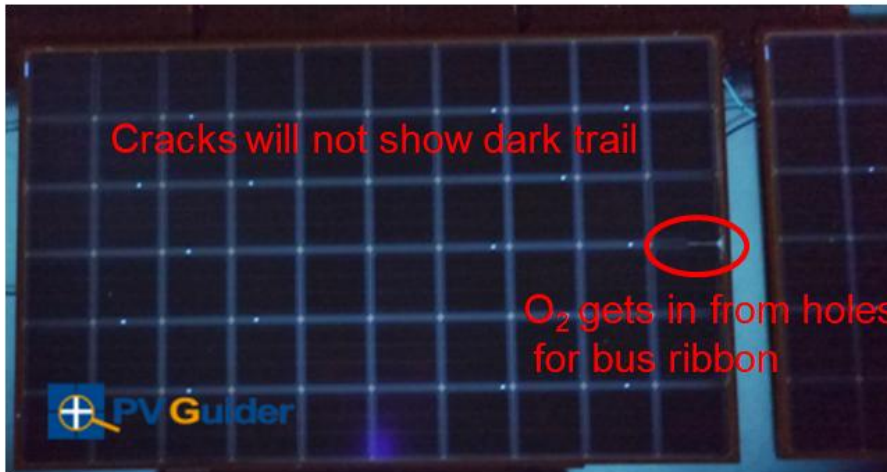


High transmission EVA  
Conventional EVA



Can not see cracks with UVFL  
Fluorescence only appear between cells

# Double glass/ Foil backsheet







# Conclusion

- u It is possible to achieve UVFL Inspection with low cost commercial drones.
- u High transmission EVA at front side greatly influences UVFL inspection.
- u For high transmission EVA, higher UV power and closer to module are required.
- u Future of UVFL – 3 main constrains:
  - Ø High UV transmission EVA- **Commonly used now**
  - Ø Double glass module/ Al foil backsheet- **Commonly used now, especially floating systems**
  - Ø Polyolefin?- **HJT, N-type cells**



# Thanks for your attention

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