Partial Shading in TFPV Modules

Partial shading can induce reverse stress

1. Reverse stress is important reliability concern

2. Unique challenges for TFPV modules

3. No integrated bypass diode

4. Size and shape of individual cells

5. 2D connectivity plays important role

6. Full SPICE simulation must be used

Shade Tolerant TFPV Modules

1. Radial design

2. Rectangular cells transformed into two triangular half cells

3. Area is conserved, cells arrange radially

4. Minimum 4.2% shadow tolerance as well as output power

5. No linear scale of symmetry in the shape

Shade Tolerant Module Efficiency

1. Shear resistance loss in non-rectangular geometry

2. \( \sigma_{sh} = f_{sh} \sigma \cdot \frac{E_{sh}}{E_{c}} \)

3. \( P_{sh} = \int f_{sh} \cdot \frac{E_{sh}}{E_{c}} \cdot I_{abs} \cdot V_{sub} \)

4. Change in cell geometry can induce overall sheet resistance loss as well as provide shade tolerance

Effect of shadow geometry

1. Typical module with N series cells in series

2. Symmetric shade: benign

3. Asymmetric shade: catastrophic

4. External bypass diodes cannot prevent worst case reverse stress, as they turn on for larger shadows

Summary and Conclusions

1. Shade tolerance design

2. Geometry can be used as a design parameter to avoid shadow performance

3. Radial and spiral designs improve shade tolerance as well as power output

4. Shadowing the cells can also lead to improved module efficiency through reduced series resistance

References


