PERFORMANCE ANALYSIS OF CIGS THIN-FILM PHOTOVOLTAIC SYSTEM AFTER 10 YEARS IN THE HOT AND HUMID CLIMATE OF FLORIDA

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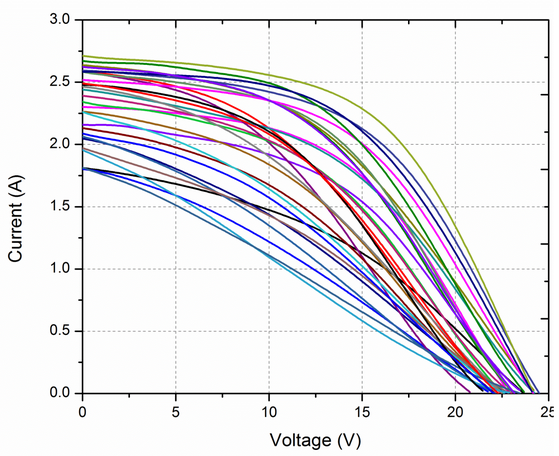
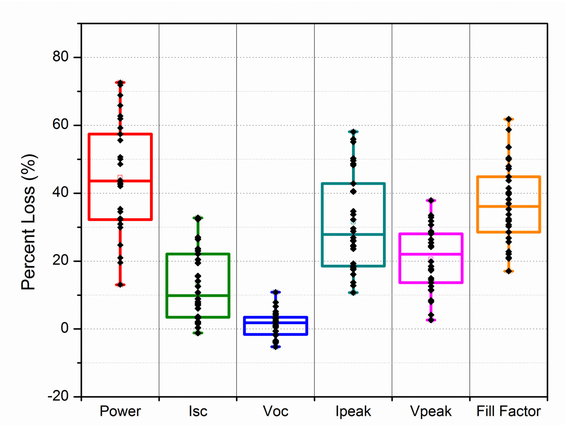
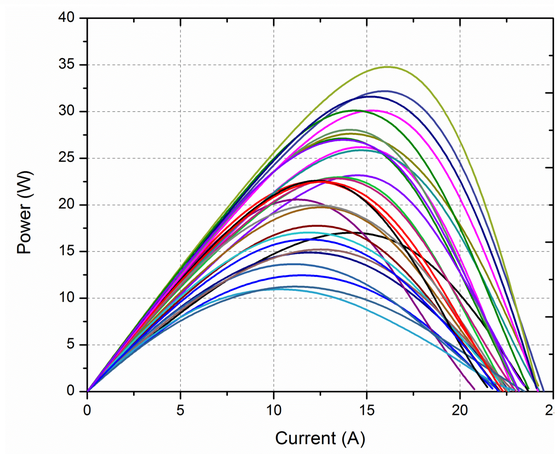
INTRODUCTION

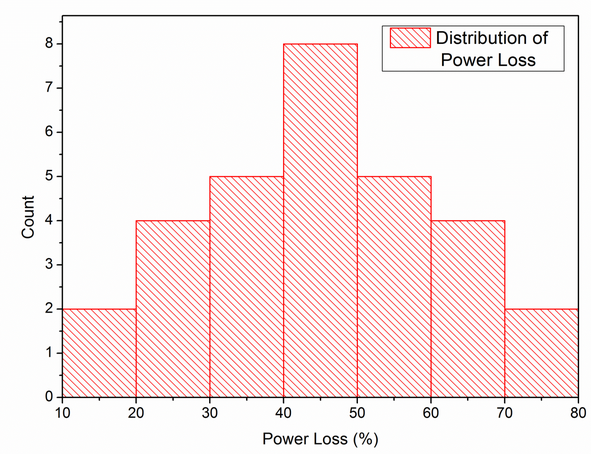
A CIGS thin-film photovoltaic array has been deployed at the Florida Solar Energy Center for almost 12 years. This array consisted of 8 strings in parallel, each with of 4 modules. The open circuit voltage of the system was just under 100 V with an operating voltage of 60 V. Analysis of the array was performed including illuminated and dark I-V measurements, electroluminescence and infrared imaging, and visual inspection.

CURRENT-VOLTAGE CHARACTERISTICS



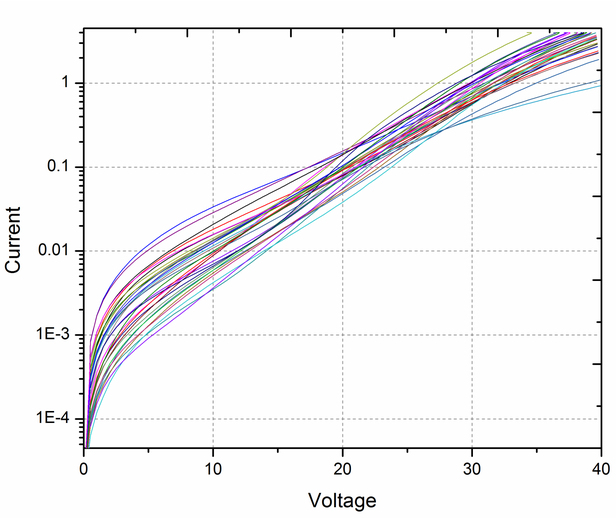


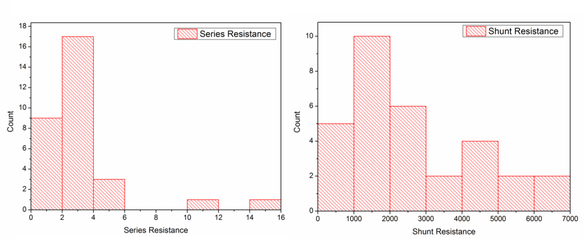




Outdoor I-V measurements were taken with a tolerance of 1000 W/m^2 ± 5 % and 25 ^{o}C ± 1 ^{o}C. The percentage loss of each parameter was calculated with reference to the nameplate ratings for the modules. The large variation in power loss among the modules exhibited a normal distribution with an average power loss of 44.6 %. This loss was mainly a result of decrease in fill factor and more specifically the operating current.

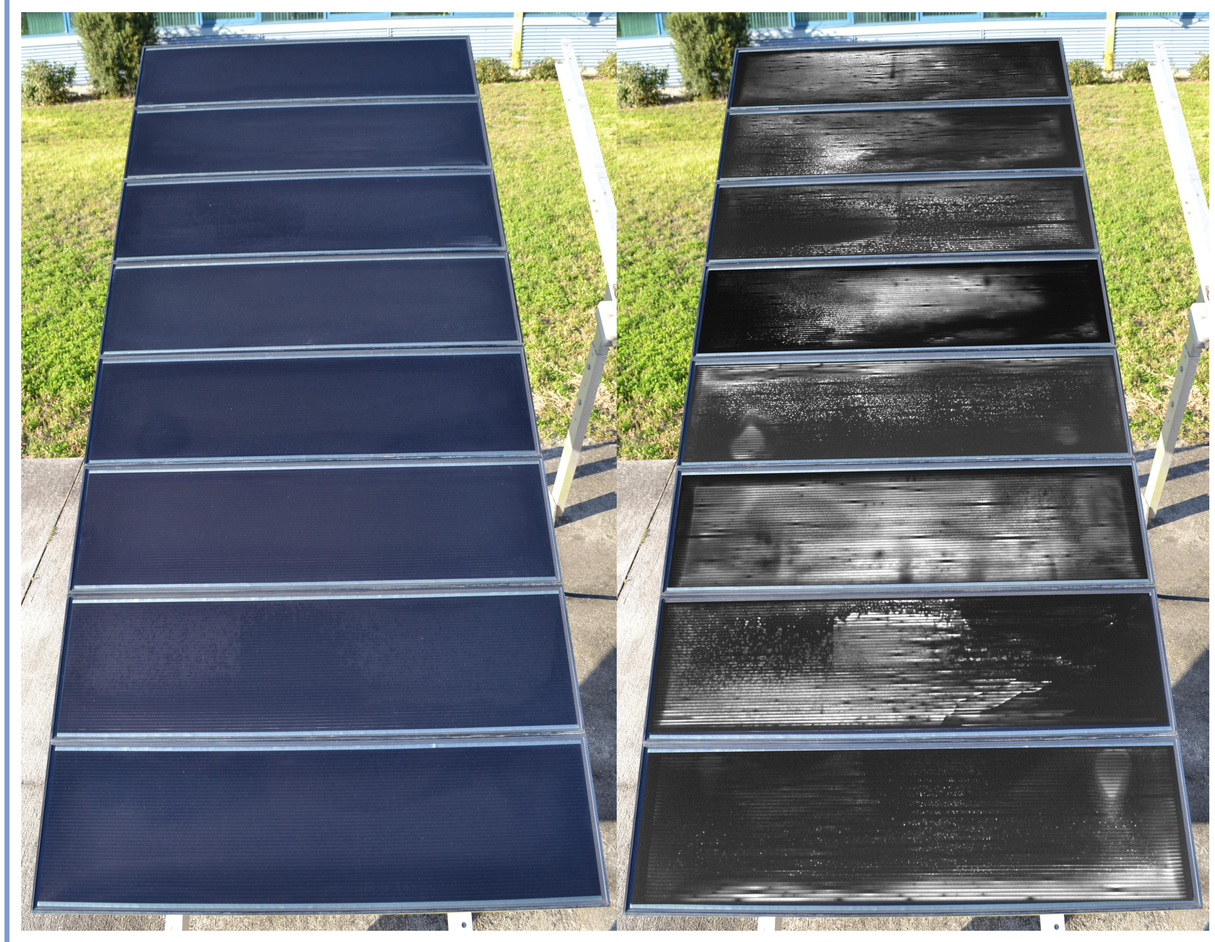
DARK I-V CHARACTERISTICS





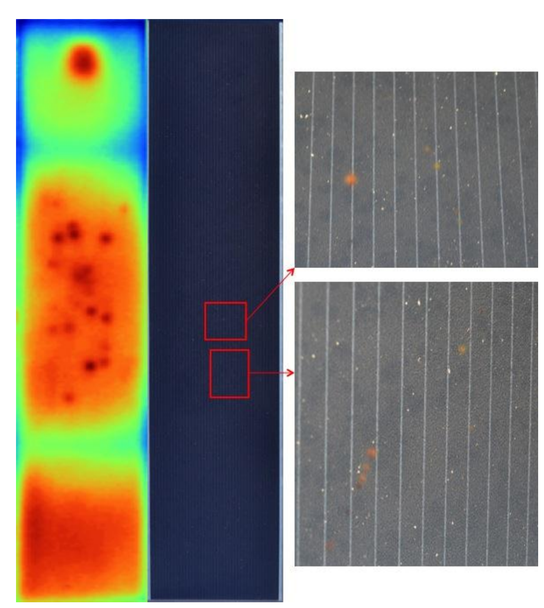
Dark I-V characteristics were measured for all modules at a temperature of and 25 ^{o}C ± 1 ^{o}C. Values for series and shunt resistance were extracted from these characteristics. The distribution of resistances is shown above. The few modules with very high series resistance corresponded to modules in which severe interconnect corrosion/ delamination had occurred.

VISUAL DISCOLORATION



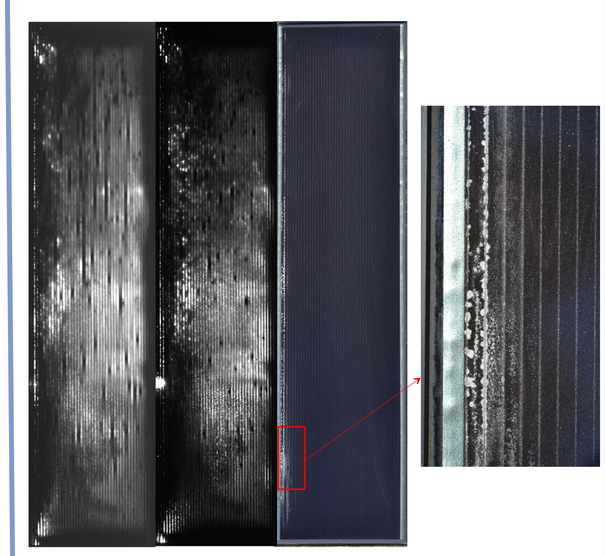
Visual image (left) and imposed electroluminescence images of corresponding modules (right). Distinct features and severe discoloration were observed on several modules. It was found that this directly correlated with underperforming regions of the device as shown in the EL images. This was attributed to issues within the front Transparent Conducting Oxide (TCO).

HOT SPOTS



Outdoor infrared image showing multiple hotspots within the module and corresponding visual image highlighting visible browning of the encapsulant.

DELAMINATION AND INTERCONNECT CORROSION



Electroluminescence images and corresponding visual image highlighting corrosion of the interconnects along the bottom edge of the module.

CONCLUSIONS

Analysis of a CIGS thin-film photovoltaic array has been carried out to quantify the electrical performance and identify the degradation modes. The three main defects included visual discoloration, hot-spots and interconnect corrosion/delamination. Further investigation to correlate the observed defects with the electrical performance as well as destructive testing and materials characterization would lead to a better understanding of specific degradation mechanisms.

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