Optical Characterization Techniques for Optimizing Organic Photovoltaic Systems for Indoor Applications

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The rapid development of Internet of Things (IoT) technology has spurred increased research on energy sourcing for small and autonomous devices. Indoor photovoltaics offer an elegant solution by harnessing ambient light within their working environment. However, implementing photovoltaic systems under indoor conditions presents challenges due to differences in light spectra and lower power densities compared to sunlight.

To address these challenges, organic semiconductors provide versatility in tailoring light absorption properties. Nevertheless, selecting suitable donor-acceptor systems amidst a growing pool of materials can be complex and resource-intensive. Fabricating and optimizing each system for photovoltaic devices requires significant effort and resource expenditure.

This study highlights the potential of optical characterization techniques, specifically Photoluminescence (PL) and Raman spectroscopy, for optimizing blend parameters in organic photovoltaics (OPVs) targeted for indoor applications. These techniques offer non-destructive, rapid, and contactless means to assess the quality of active layers throughout the fabrication process. PL quenching serves as a straightforward method to analyze charge separation performance by measuring the decrease in PL emission as excitons are successfully separated at blend interfaces. Additionally, Raman spectroscopy provides valuable insights into domain structuration and quality, with smaller Full Width at Half Maximum (FWHM) peaks indicating better domain organization and charge transport characteristics.

This paper proposes the use of PL and Raman spectroscopy to optimize blend parameters such as donor/acceptor ratios, temperature annealing, and solvent choices in two different donor-acceptor systems with high potential for indoor applications. By leveraging these optical characterization techniques, the electrical performance of active layers can be predicted and fine-tuned. Furthermore, the obtained results will be compared with the actual performance of the final devices under indoor conditions, with achieved efficiencies around 20%. The findings will inform optimization strategies aimed at further enhancing the performance of OPVs for indoor energy harvesting applications.

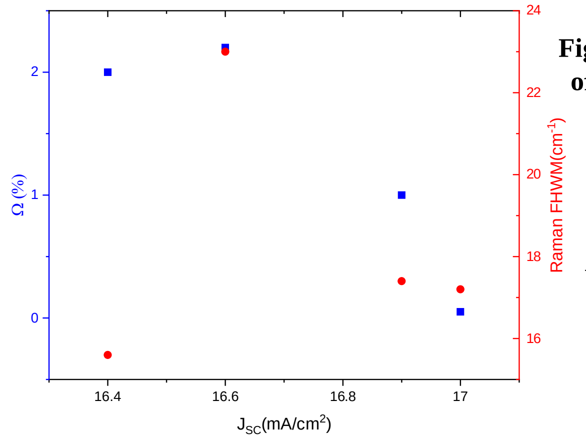

Fig.1 Quenching of luminescence (Ω, blue) and FHWM of the main TDPD:3F raman peak (red) on a TPD-3F: ITIC-4F blend as a function of J_{sc} under AM1.5G condition on the resulting devices. While crystalline quality is an important parameter on J_{sc}, it is not the only factor to guarantee a high performing device. Charge extraction plays also a main role, as it is stated by the evolution of the quenching of luminescence.