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Small-perturbation analysis and numerical modeling of third generation solar cells

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Abstract:

In this course, I will present the basics of small-perturbation analysis of solar cells, with a focus on impedance spectroscopy and optically-modulated spectroscopies. I will illustrate the concepts with examples in dye sensitized solar cells and perovskite solar cells. The course will also include experimental protocols and basic numerical modeling (drift-diffusion) to provide a consistent interpretation of the signals observed in the small-perturbation spectra. Based on that, I will present procedures to extract relevant information from the spectra, such us charge collection efficiencies, ideality factors and recombination mechanisms, ionic diffusion coefficient and ion vacancy concentrations.

References:

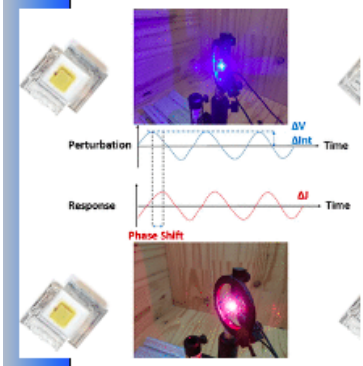
1. Stijn Lammar, Renán Escalante, Antonio J. Riquelme, Sandra Jenatsch, Beat Ruhstaller, Gerko Oskam, Tom Aernouts and Juan A. Anta. **Impact of non-stoichiometry on ion migration and photovoltaic performance formamidinium-based perovskite solar cells**. Journal of Materials Chemistry A, (**2022**), 10, 18782 - 18791. DOI: 10.1029/D2TA04840J.

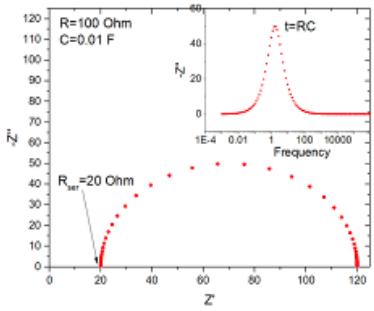
2. Antonio J.Riquelme, Valid Mwatati Mwalukuku, Patricia Sánchez-Fernández, Johan Lioter, Renán Escalante, Gerko Oskam, Renaud Demadrille, and Juan A. Anta, **Characterization of Photochromic Dye Solar Cells Using Small-Signal Perturbation Techniques**, ACS Applied Energy Materials, 4,9, 8941-8952 (**2021**). DOI: 10.1021/acsaem.1c01204

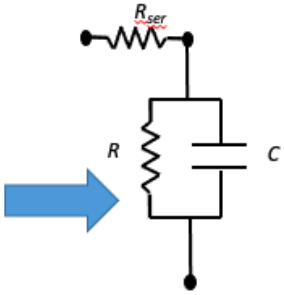
3. Lidia Contreras-Bernal, Susana Ramos-Terrón, Antonio Riquelme, Pablo P. Boix, Jesús Antonio Idígoras, Iván Mora Seró and Juan A. Anta, **Impedance analysis of perovskite solar cells: a case study**. J. Mater. Chem. A, (**2019**), 7, 12191 - 12200. DOI: 10.1039/C9TA02808K

4. Lidia Contreras-Bernal, Jesús Idígoras, Anna Todinova, Manuel Salado, Samrana Kazim, Shahzada Ahmad, Juan A Anta **Origin and Whereabouts of Recombination in Perovskite Solar Cells**, Journal of Physical Chemistry C (**2017**), 121 (18), pp 9705–9713 DOI: 10.1021/acs.jpcc.7b01206

$$Z(\omega) = \frac{V(\omega)}{J(\omega)} = \frac{\Delta V \sin(\omega t)}{\Delta J \sin(\omega t + \varphi)} \rightarrow |Z| \exp(i\varphi) = Z'(\omega) - iZ''(\omega)$$







$$Z_{RC} = R_{ser} + \left(\frac{1}{R} + i\omega C\right)^{-1}$$

Physical meaning ?