High Speed and Sensitive Absorption Coefficient Characterizations on Multi-Cations Perovskite Thin Films

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In the field of semiconductor material characterizations, spectroscopic methods have been widely applied. It is especially important for the optoelectronic devices such as solar cells and light emitting diodes. Since the photo-effect phenomenon is highly sensitive to scanning wavelengths, the material spectral photoresponse bridges illumination light and its photoconductivity. Besides the semiconductor band structure diagram can be also associated closely with light absorption and photocurrent. Obtaining the absorption spectrum is therefore an essential way for understanding the band structure information such as energy bandgap and Urbach tail edge. The determination of the material absorption spectrum can be done directly by optical spectroscopy subtracting the measured reflection and transmission spectra. However, when considering a very weak light absorbance, as in the case of below gap photon energy, it becomes very hard to be measured. To overcome this issue in weak absorption region, another way of measuring photocurrent spectrum upon light illumination is required.

Among the photoconductivity-based methods such as Constant Photocurrent Method (CPM) and Dual Beam Photoconductivity (DBP), the more recent method is Fourier Transform Photocurrent Spectroscopy (FTPS) which presents at least two advantages. First the Fourier transform method can provide the fastest measuring time with only few minutes. Indeed, in the CPM method, each monochromatic wavelength is selected from the light source, which is time consuming and will require few hours of measurement. Second, the FTPS can perform the absorption measurement with very high sensitivity. It is especially important when considering the region of low photon energy with weak absorption.

In this study, we have used FTPS to investigate the variations in the energy band gaps of different perovskite thin films. In particular, we aimed to characterize the last generation of multications perovskite thin films, with a particular focus on the bandgap shifts that might be induced by the presence of different amounts of Cs or Rb in the crystal structure. Moreover, the influence of PbI_2 excess on the perovskite optoelectronic properties has been studied in detail. In order to investigate the band structure of various perovskite thin film, we present variations of the absorption coefficient in the photon energy range of 0.7eV (≅1770 nm) to 2.5 eV (≅500 nm) with a dynamic range of 10^6 cm^{-1}. Therefore, our study points out important perspectives for efficiently understanding the band diagram of perovskite active layers. FTPS appears as a fast and sensitive characterization technique that can be used as a systematic evaluation of some optoelectronic properties of perovskite films.

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