Probing water vapor-induced modulation of charge carrier dynamics in mesoporous TiO_2 using ultrafast transient absorption spectroscopy

Zuarez-Chamba, Michael[1]; Tettart, Darius[2]; Mendioroz, Lucas[1]; Boissiere, Cedric[3]; Soler-Illia, Galo[1]; Corthey, Gastón[1]

[1] Instituto de Nanosistemas, Universidad Nacional de Sán Martín, Avenida 25 de Mayo 1169, General San Martín, Provincia de Buenos Aires, Argentina.
[2] LTE, Observatoire de Paris, Université PSL, CNRS, Sorbonne Université, 61 avenue de l'observatoire, F-75014 Paris, France
[3] Laboratoire de Chimie de la Matière Condensée, Université Pierre et Marie Curie, 4 Place Jussieu, 75252 Paris Cedex 5, France

mzuarez@unsam.edu.ar

Área temática: C. Propiedades de nanomateriales

Mesoporous titanium dioxide (TiO_2) thin films exhibit unique properties due to their high surface area and porous structure, making them highly sensitive to environmental conditions. In this work, we investigate the influence of water vapor on the ultrafast charge carrier dynamics of mesoporous TiO_2 films using transient absorption spectroscopy in the femtosecond–picosecond regime. Measurements were performed at an excitation wavelength of 325 nm under controlled relative humidity (RH) conditions ranging from low (~5–6%) to near-saturation (~94–95%). The transient absorption response shows a pronounced dependence on RH, with clear modifications in both spectral features and decay kinetics as humidity increases. These changes indicate that water adsorption within the mesoporous network strongly affects charge carrier lifetimes and recombination pathways. The observed behavior is attributed to the interaction of water molecules with the TiO_2 surface, which can introduce or modify surface trap states, influence charge separation, and alter recombination dynamics. The high internal surface area of mesoporous films enhances these effects, leading to a marked sensitivity to humidity variations. These results demonstrate that water vapor is a key factor governing the charge carrier dynamics in mesoporous TiO_2, highlighting the importance of conducting characterization under operando conditions in applications such as photoelectrocatalysis.