Ultrafast dynamics of carrier relaxation in PdO thin films

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Nanoscale semiconductor structures are an active field of research due to their spesific posibilities to change physical properties their bulk counterparts. PdO is a p-type semiconductors with a band gap that can couple efficiently to the solar spectrum are of interest for energy conversion applications either as photovoltaics, photocatalysts or as electrodes for photoelectrolytic cells semiconductor with rather narrow bandgap energy and for optoelectronic applications because of the high nonlinear optical properties found [1].Although the nonlinear optical properties of PdO thin films have been investigated [1], it appears that poorly researched ultrafast carrier dynamics, despite their potential for using in optoelectronic devices.

In our work we have used the pump-probe method to detect changes in the 2.5 eV absorption band of 120 nm films when exposed to, 180 fs, 10 μJ pulsed excitations at 800 nm and 400 nm.

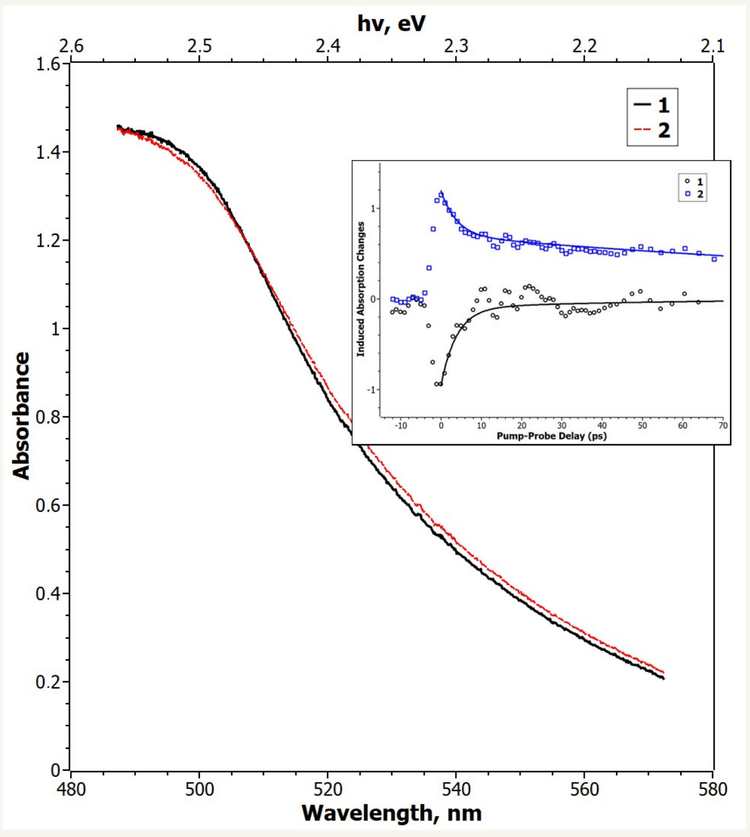

Fig.1. Absorption spectrum of PdO film (curve 1) and its evolution after femtosecond laser irradiation at 800 nm (curve 2).

At 800 nm excitation (Fig.1), subtle changes in absorption can be noticed, especially in the spectral range of 487-505 nm. It can be seen that while the absorption around 500 nm decreases after excitation, on the contrary, it increases at longer wavelengths above 510 nm. These changes, although subtle, were reproducible and much larger than the spectral noise. The maximum decrease in absorption is observed at 498 nm (2.49 eV), i.e., close to the absorption band maximum of 2.5 eV.

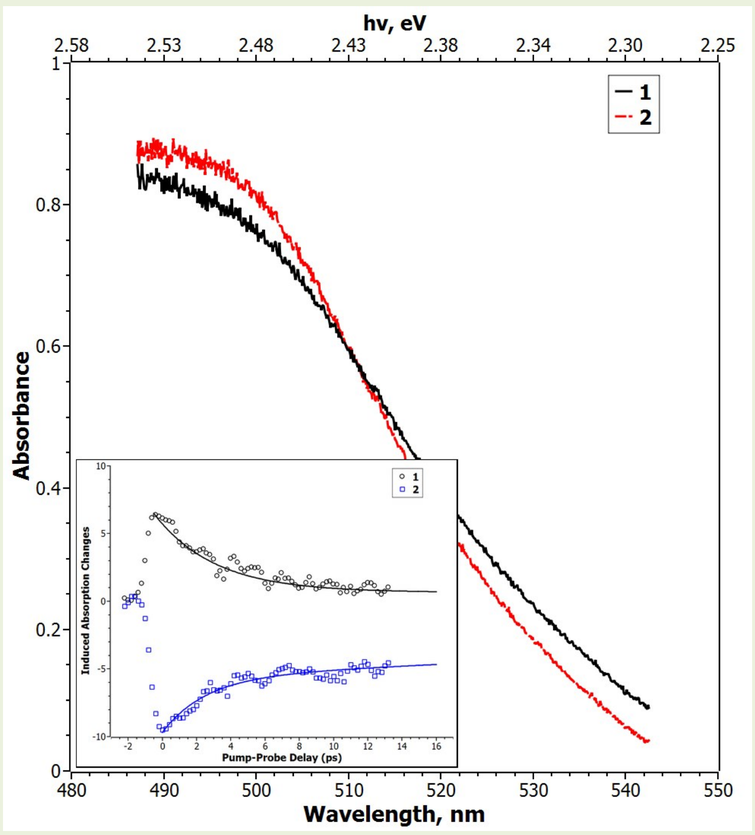

Fig.2. Absorption spectrum of PdO film (curve 1) and its evolution after femtosecond laser irradiation at 400 nm (curve 2).

At the same time, when excited at a wavelength of 400 nm, we have the opposite effect (Fig. 2). In the region of 500 nm the absorption increases and in the region >510 nm it decreases.

Conclusions

Time-resolved absorption measurements within the 2.5 eV absorption band under 800 nm excitation revealed subtle changes of the absorption that exhibit two-step relaxation with relaxation times of 2 ps and 1 ns. At the same time, the increased absorption in the region of 2.5 eV with 400 nm excitation can be caused by interband single-photon transitions, because the energy of the excitation quantum (hv = 3.1 eV) is greater than the bandgap width (~2.3 eV).

[1] *M. S. Brodyn, V. I. Volkov, V. I. Rudenko, V. R. Liakhovetskyi, and A. O. Borshch,* "Large third-order optical nonlinearity in PdO thin films" J. Nonlinear Opt. Phys. Mater. 26, 1750037 (2017).