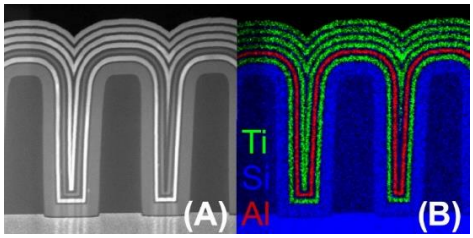
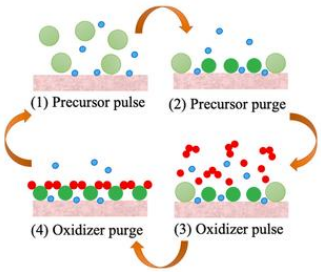
Atomic layer deposition of titanium dioxide

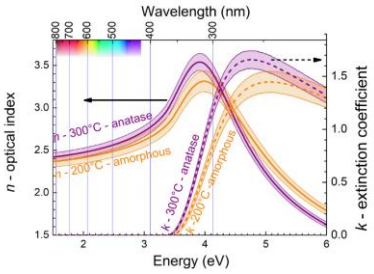
Supervisor: Dr. Luca Mascaretti (luca.mascaretti@cvut.cz)

Titanium dioxide (TiO_2) is a wide-bandgap semiconductor with countless applications in sunscreens,[1] photocatalysis,[2] and antireflection coatings.[3] Thin films based on TiO_2 can be modified with intrinsic defects[4] or dopants[5,6] to increase their *n*-type conductivity and optical properties to improve their performance in energy-conversion devices. Therefore, thin-film deposition methods allowing production of TiO_2 films with controlled functional properties are essential for the realization of various devices.

The subject of the student work will consist of an experimental investigation on the growth of TiO_2 films by atomic layer deposition (ALD),[7,8] where different ALD process parameters will be explored to tune the properties of the growing films. The TiO_2 films will be characterized from the structural and optical point of view by means of various techniques, including X-ray diffraction and reflection experiments and spectroscopic ellipsometry. The optical properties will be of particular interest in view of applications in solar-energy conversion devices.







References

(1) Weir, A.; Westerhoff, P.; Fabricius, L.; Hristovski, K.; von Goetz, N. Titanium Dioxide Nanoparticles in Food and Personal Care Products. *Environ. Sci. Technol.* **2012**, *46* (4), 2242–2250. https://doi.org/10.1021/es204168d.

(2) Fujishima, A.; Zhang, X.; Tryk, D. A. TiO2 Photocatalysis and Related Surface Phenomena. *Surf. Sci. Rep.* **2008**, *63* (12), 515–582. https://doi.org/10.1016/j.surfrep.2008.10.001.

(3) Richards, B. S. Single-Material TiO2 Double-Layer Antireflection Coatings. *Sol. Energy Mater. Sol. Cells* **2003**, *79* (3), 369–390. https://doi.org/10.1016/S0927-0248(02)00473-7.

(4) Chen, X.; Liu, L.; Huang, F. Black Titanium Dioxide (TiO2) Nanomaterials. *Chem. Soc. Rev.* **2015**, *44* (7), 1861–1885. https://doi.org/10.1039/C4CS00330F.

(5) Asahi, R.; Morikawa, T.; Irie, H.; Ohwaki, T. Nitrogen-Doped Titanium Dioxide as Visible-Light-Sensitive Photocatalyst: Designs, Developments, and Prospects. *Chem. Rev.* **2014**, *114* (19), 9824–9852. https://doi.org/10.1021/cr5000738.

(6) Mazzolini, P.; Gondoni, P.; Russo, V.; Chrastina, D.; Casari, C. S.; Li Bassi, A. Tuning of Electrical and Optical Properties of Highly Conducting and Transparent Ta-Doped TiO2 Polycrystalline Films. *J. Phys. Chem. C* **2015**, *119* (13), 6988–6997. https://doi.org/10.1021/jp5126156.

(7) Niemelä, J.-P.; Marin, G.; Karppinen, M. Titanium Dioxide Thin Films by Atomic Layer Deposition: A Review. *Semicond. Sci. Technol.* **2017**, *32* (9), 093005. https://doi.org/10.1088/1361-6641/aa78ce.

(8) Jolivet, A.; Labbé, C.; Frilay, C.; Debieu, O.; Marie, P.; Horcholle, B.; Lemarié, F.; Portier, X.; Grygiel, C.; Duprey, S.; Jadwisienczak, W.; Ingram, D.; Upadhyay, M.; David, A.; Fouchet, A.; Lüders, U.; Cardin, J. Structural, Optical, and Electrical Properties of TiO2 Thin Films Deposited by ALD: Impact of the Substrate, the Deposited Thickness and the Deposition Temperature. *Appl. Surf. Sci.* **2023**, *608*, 155214. https://doi.org/10.1016/j.apsusc.2022.155214.