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# Luminescence crystals

In the last years a significant interest has been motivated in development of the novel rare earth doped crystals based upon infrared to visible frequency up-conversion with potential applications in various optoelectronic devices, e.g. high density memories, 3D displays, optical amplifiers for fiber-optic communication, visible up-conversion lasers, or white light emission materials [1,2].

During the lecture the spectroscopic properties of $KGd(WO_4)_2$ crystals doped with selected $Pr^{3+}$, $Eu^{3+}$, $Tb^{3+}$, $Ho^{3+}$, $Er^{3+}$, $Tm^{3+}$ and/or $Yb^{3+}$ ions will be presented. It was shown that all investigated systems exhibited multicolor up-conversion fluorescence under 980 nm laser irradiation [3]. The investigated materials are very promising as a new generation energy converters with significant potential applications in novel optical devices.

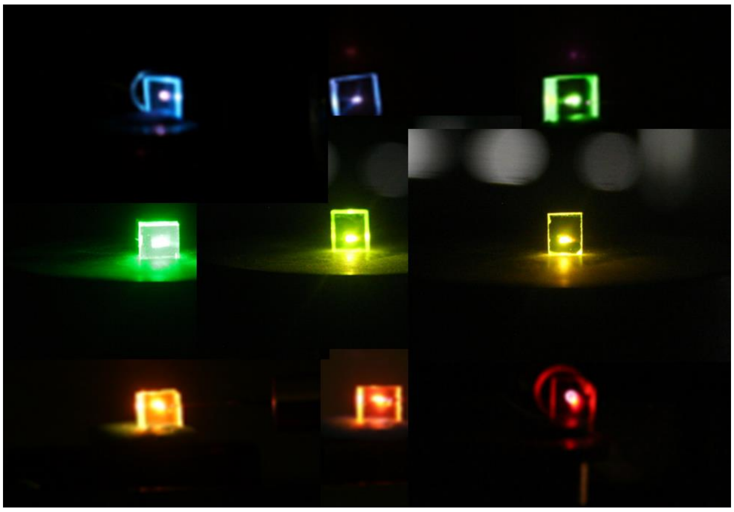

Figure 1. Up-conversion luminescence of rare earth doped $KGd(WO_4)_2$ crystals.

[1] W. Lü, X. Ma, H. Zhou, G. Chen, J. Li, Z. Zhu, Z. You, C. Tu, *White Up-Conversion Luminescence in Rare-Earth-Ion-Doped $YAlO_3$ Nanocrystals, J. Phys. Chem. C*, 112, 38 (**2008**) 15071–15074.

[2] Z. Zhao, X. Zhou, H. Xia, J. Hu, J. Zhang, B. Chenb, H. Songc, *Adjustable multicolor emission from the combination of up-conversion in $Tm^{3+}/Tb^{3+}/Yb^{3+}$ tri-doped $Na_5Lu_9F_{32}$ single crystals, Opt. Materials*, 96 (**2019**) 109294.

[3] D. Kasprowicz, P. Głuchowski, B. M. Maciejewska, M. Chrunik, A. Majchrowski,

*Up-conversion luminescence of rare earth-doped $KGd(WO_4)_2$ phosphors for tunable multicolour light generation*, *New J. Chem.*, 41 (**2017**) 9847–9856.

# Looking inside the materials

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We live in a world of materials. From materials is fabricated everything that we use in everyday life. We surround ourselves with various materials every day, and their existence seems obvious to us and in most cases we do not even pay attention to them. However, what materials we have at our disposal shapes our reality to such an extent that even the era in human history are named after the materials available in them. Can we imagine life today without various metal alloys, polymers, semiconductor or liquid crystal materials? The field of science whose task is to study the influence of material structure on their properties and on this basis to design new materials is called Materials Engineering. It is a field whose work will never end because humanity will always need new and better materials. In addition, the goal of material engineering is also to look for materials having the same properties, which are easier to manufacture or inexpensive. However, this would not be possible without direct observation of the structure of matter, i.e. without electron microscopy. The use of an electron beam instead of visible light allows to increase the resolution and the range of obtained magnifications this allows observation of matter at any scale: macro, micro or nano.

The wavelength of visible light is several hundred nanometers, so to observe the atomic structure of matter radiation with a much shorter wavelength is needed. X-rays would be adequate, unfortunately, due to the refractive index almost equal to 1 X-ray lenses are very impractical. With the moving particles de Broglie's wave is associated. The electron is the perfect choice because it is a light particle. It has an electric charge so it can be easily controlled. In addition, it is relatively easy to obtain an electron beam by thermoemission. The accelerated electrons in the electron microscope obtain a wavelength of the thousandths of a nanometer. The first electron microscope was created in the late 1930s but the state of art reached in recent years The construction principle of the transmission electron microscope is analogous to the light microscope. An electron emitter instead of a visible light source, electromagnetic instead of optical lenses and a fluorescent screen or CCD camera to record the obtained images are used. The electron microscope of the Institute of Materials Science, University of Silesia is equipped also with an attachment for the precession of the electron beam. It allows conducting unique research on mapping of crystallographic orientation at the nanometric scale and for measurements of reciprocal space tomography, which can be used to determine the crystal structure of materials at the nano scale.

Nickel-titanium shape memory alloys can occur in three structural phases - in a low-temperature martensitic phase, in a high-temperature austenitic phase and in the intermediate R phase. These alloys owe their unique properties to thermoelastic, reversible martensitic transformation, which can be induced by thermal or external stress. This transformation reorganizes the positions of the atoms inside the material, and thus the material returns to its programmed shape. The temperature of the martensitic transformation strongly depends on the nickel content and on the thermomechanical treatment carried out, so one can control the temperature at which the alloy changes its shape. These alloys also show the effect of super-elasticity, therefore they potentially arouse interest as materials for the construction of e.g. Mars rover wheels, which are destroyed when driving on rocky or stony ground. Due to the need for miniaturization of instruments, NiTi alloys with nanometric grain size are being studied, so that the finished element can contain a large number of grains in its volume despite the micrometric dimensions. Thanks to the use of plastic processing at cryogenic temperatures, it is possible to obtain an amorphous-nanocrystalline NiTi alloy. Then, by heating the material at specific temperatures, the average grain size can be controlled. This allows to properly shape the properties of the alloys, which may determine their subsequent usage in specific industrial applications.