MnSe – molecular beam epitaxy growth and optical characterisation

Julia Kucharek, Rafał Bożek, Wojciech Pacuski

Institute of Experimental Physics, Faculty of Physics, University of Warsaw, Pasteura 5, PL-02-093 Warszawa, Poland

Monolayers of van der Waals $MnSe_2$ provide an opportunity for exploring two-dimensional (2D) magnetism for scientific and technological advances. It holds promise for potential applications in energy efficient information storage and processing [1].

Here, we report on the optical properties of manganese selenide ($MnSe_x$) layers grown by molecular beam epitaxy (MBE). We compare $MnSe_x$ films growth on Si substrate with 90 nm buffer of SiO_2 (Si/SiO_2) with growth on c-plane Al_2O_3. We have grown a series of samples in a various conditions on each substrate to optimize growth and optical properties. We have found that Si substrate with 90 nm thick SiO_2 buffer is very convenient for optical study, because of constructive optical interferences enhancing photoluminescence in visible spectral range. On the other hand, such kind of polycrystalline buffer gives no hope for growth of large monocrystalline layers. This is why we decided to work also on Al_2O_3 substrates.

Samples grown on c-plane Al_2O_3 were analyzed in situ using Reflection High Energy Electron Diffraction (RHEED). This technique confirmed that in particular conditions growth of crystals well oriented to the substrate is possible and surface of such crystals became flat after tens of nm. Further analysis with optical microscopy and atomic force microscopy showed that crystals have typical sizes of 1 micrometer, so structure is not a monocrystal. Thanks to transparency of Al_2O_3, transmittance measurements were performed on obtained layers, revealing broad absorption band in blue spectral range, what explain yellow color of $MnSe_x$ layers.

All samples were studied using room temperature optical spectroscopy: Raman scattering and photoluminescence. We find that, on Al_2O_3 substrate we can obtain strengthened and more narrow $MnSe_x$ peak in contrary to samples on Si/SiO_2. Further work will be needed to distinguish between various compounds of Mn and Se, therefore we note only $MnSe_x$.

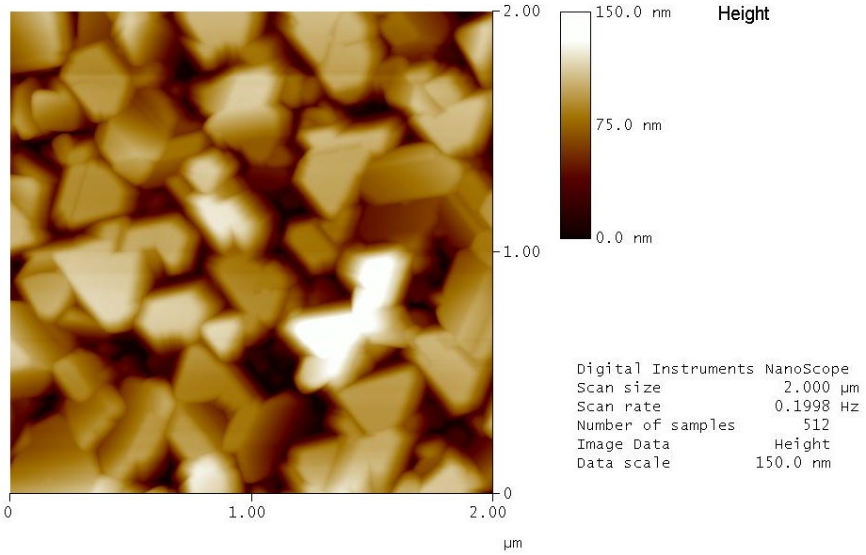

Fig. 1. Atomic force microscopy image of $MnSe_x$ crystals grown epitaxially on Al_2O_3

[1] Dante J. O'Hara et. al., *Nano Lett.*, 2018, 18 (5), pp 3125–3131.