

Emission peculiarities in undoped SnO₂ layers

Poting Liu^{1,2}, Anjana Baby², Anna Makarova³, Mohammed A. Aly^{4,5}, Stefan Brackmann⁴, David C. Grinter⁶, Pilar Ferrer⁶, Martin Koch⁴, Vaidas Klimkevicius⁷, Vladimir Sivakov¹

¹Leibniz Institute of Photonic Technology, Jena, Germany. ²Friedrich-Schiller University Jena, Jena, Germany. ³Helmholtz-Zentrum für Materialien und Energie, Berlin, Germany. ⁴Philipps-Universität Marburg, Marburg, Germany. ⁵Ain Shams University, Cairo, Egypt. ⁶Diamond Light Source, Didcot, United Kingdom. ⁷Vilnius University, Vilnius, Lithuania

Abstract

SnO₂ thin films are widely used as electron-transport layer in optoelectronics, due to the high electron mobility, which makes them key to such devices [1-3]. In the present paper, we report that planar tin oxide layers deposited by CVD demonstrate significant light emission in visible spectral range. At the excitation with Xe-lamp in the range of 250-325 nm, the SnO₂ layers exhibited broad red-orange photoluminescence with emission maximum above 600 nm and tunable emission intensity as shown in Fig. 1. A variety of surface and bulk sensitive techniques such as electron microscopy, X-ray diffraction, synchrotron radiation-based X-ray photoelectron and near edge X-ray absorption fine structure spectroscopies were applied to study the atomic and electronic structure of the deposited layers. Blue-green (450-550 nm) emission, associated with the presence of bulk-related oxygen vacancies for undoped 2D SnO₂ layers, has been widely described in the literature. On the other hand, red-orange emission (580-650 nm) is poorly reported and observed mainly for 1D SnO₂ nanowires and is explained as an effect of deeply trapped states associated with surface-related oxygen vacancies or tin interstitials defects. In addition, we observed a new phenomenon related to surface- and bulk-related defects in the tin oxide layers, which can be activated by different excitation sources depending on the photon flux. Our studies can provide a deep fundamental understanding of the relationship between the structural features of SnO₂ thin film and its optoelectronic properties, which will provide a theoretical basis for further applications of SnO₂ layers in various functional devices.