二次元層状半導体 InSe 結晶の低温液相成長とその特性評価

Low temperature liquid phase growth and characterization of 2D layered semiconductor InSe crystal

東北大工 [1] ○唐 超 [1], 佐藤 陽平 [1], 渡辺 克也 [1], 陳 明曦 [1], 田邉 匡生 [1], 小山 裕 [1]

Tohoku Univ. [1], ○Chao Tang[1], Yohei Sato[1], Watanabe Katsuya[1], Mingxi Chen[1], Tadao Tanabe[1], Yutaka Oyama[1]

E-mail: tang.chao.s5@dc.tohoku.ac.jp

Indium selenide (InSe), which is one of the most promising 2D layered III-chalcogenide compounds, is an attractive material for applications in infrared detection, solar energy conversion and high mobility transfer devices etc. To fabricate high efficiency optical devices and explore the field of spintronic and quantum hall effect, the high quality crystals with less defects, which allow carriers travels freely for a long distance and a long spintronic lifetime, is highly necessary. In this study, we attempted to use a unique method to grow high quality InSe crystal. Samples were grown from the liquid phase using the temperature difference method under controlled vapor pressure (TDM-CVP) [1] at a growth temperature of 582 ℃, which is lower than that of the Bridgman-Stockbarger technique. Low and constant growth temperature ensure favorable crystallinity of grown crystals (Fig. 1). X-ray diffraction (XRD) and Raman spectroscopy results indicate that the grown crystal was γ-InSe with R3m space group symmetry. Photoluminescence measurements (Fig. 2) were carried out to determine the optical properties, from which it was confirmed that the sample had a direct bandgap of 1.32 eV, an indirect bandgap of 1.28 eV and an exciton binding energy of 20 meV. Moreover, the interlayer van der Waals bonding force in crystalline InSe was directly measured using a mechanical test equipment. The measured bonding force in the crystal was 20.8 N/cm2, which is greater than that in 2D crystalline GaSe. We also made theoretical discussion of the van der Waals forces in InSe, based on the fluctuations in the electron cloud distributions around the atoms.

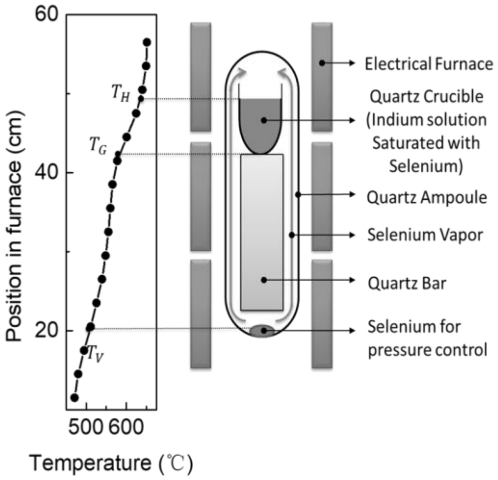

Fig. 1. Schematic diagram of the temperature difference method under controlled vapor pressure

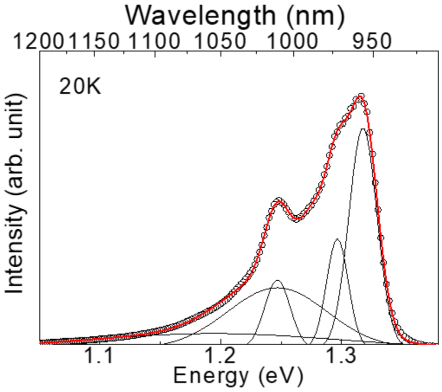

Fig. 2. PL spectra of InSe crystal at 20K

[1] C. Tang, Y. Sato, T. Tanabe, Y. Oyama, *J. Cryst. Growth*, **495** (2018) 54-58