横方向成長した球晶状 GeS 薄膜の複屈折効果

The birefringent effect in laterally grown spherulite-like GeS thin films

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【Background】

Two-dimensional layered semiconductors, i.e., germanium monosulfide (GeS), have been considered as one of the candidates for developing next-generation functaional electronics and optoelectronics [1]. Previously, lateral growth of GeS thin films using the pre-deposited amorphous GeS method and fabrication of GeS field-effect transistors (FETs) have been investigated [2]. In this study, observation of the birefringent behavior in grown GeS thin films is demonstrated using the cross-polarizer of the optical microscope.

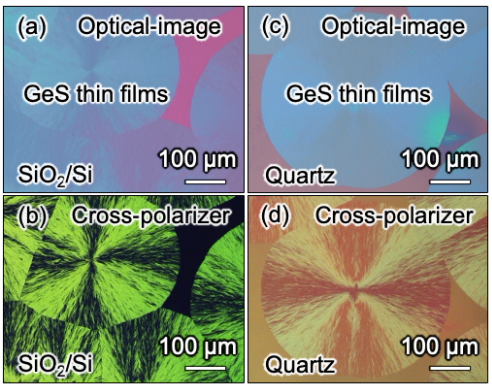

Fig. 1. Observation of the birefringent effect in spherulite-like GeS thin films

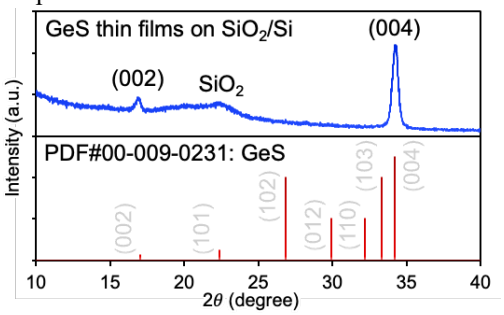

Fig. 2. XRD spectra of grown GeS thin films

【Experimental methods and results】

In experiment, a horizontal quartz tube with two independently controlled heating regions is utilized to facilitate the deposition and crystal growth of GeS thin films. The GeS powder is placed in the upstream heating region of the tube, while substrates (e.g., 300-nm-SiO_2/Si and quartz) are positioned in the downstream heating region. The optical micrographs of grown spherulite-like GeS thin films with and without cross-polarizer are shown in Fig. 1. The black, so-called Maltese extinction crosses are the familiar characteristic of any radial anisotropic body between crossed polarizers. The Maltese-cross is parallel to the polarizer/analyzer orientation of the microscope and independent of the stage orientation. Maltese-cross results from cancellation of birefringence every 90º, hence all the vertical and horizontal crystalline GeS are dark in the image. In addition, each spherulite-like GeS thin film exhibits a Maltese-cross pattern [3]. The X-ray diffraction spectra confirm the crystallized GeS as shown in Fig. 2. The peaks at 16.9º (002) and 34.2º (004) are observed suggesting that the grown spherulite-like GeS thin films are layered structure. The results suggest that laterally grown spherulite-like GeS thin films hold the potential to achieve single-crystalline GeS, as previously demonstrated with GeO_2 [4], paving the way for the development of next-generation GeS FETs.

[1] E. Sutter, et al, ACS Nano, 13, 9352, 2019. [2] Q. Zhang, et al., J. Mater. Chem. C, 12, 18101, 2024. [3] A. Shtukenberg, et al., Chem. Rev., 112, 1805, 2012. [4] S. Zhou, et al, Acta Mater., 215, 117069, 2021.