Growth and thermal properties of InSe crystal by using the ground simulation apparatus of China space station

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With the features of non-toxic, layered structure, appropriate band gap and high electron mobility, indium selenide (InSe) semiconductor has attracted much attention in the fields of diodes, photovoltaics, optics, thermoelectrics[1-2]. However, high quality crystals have rarely been obtained mainly due to the formation and propagating of high-density dislocations in the material. Fortunately, the establishment of China space station as well as the attached scientific experimental apparatus provide a great opportunity for InSe crystal growth in next years. Based on this situation, it is essential to carry out a series of ground simulation of InSe crystal growth before microgravity experiment[3].

In this work, InSe crystal was grown by using the ground simulation apparatus of China space station. The furnace was controlled at 715 °C and the temperature gradient for crystal growth was ~30 °C/cm. The as-grown InSe crystalizes in γ-phase with space group of R3m. The average etching pits density (EPD) is estimated to be about $10^4/cm^2$. Thermal analysis indicates a positive thermal expansion at 30-500 °C and no volatilization occurred even as high as 1000 °C. This work not only establishes a reliable process for preparing large-sized InSe single crystal but also creates a foundation for further work in outer space in the future.

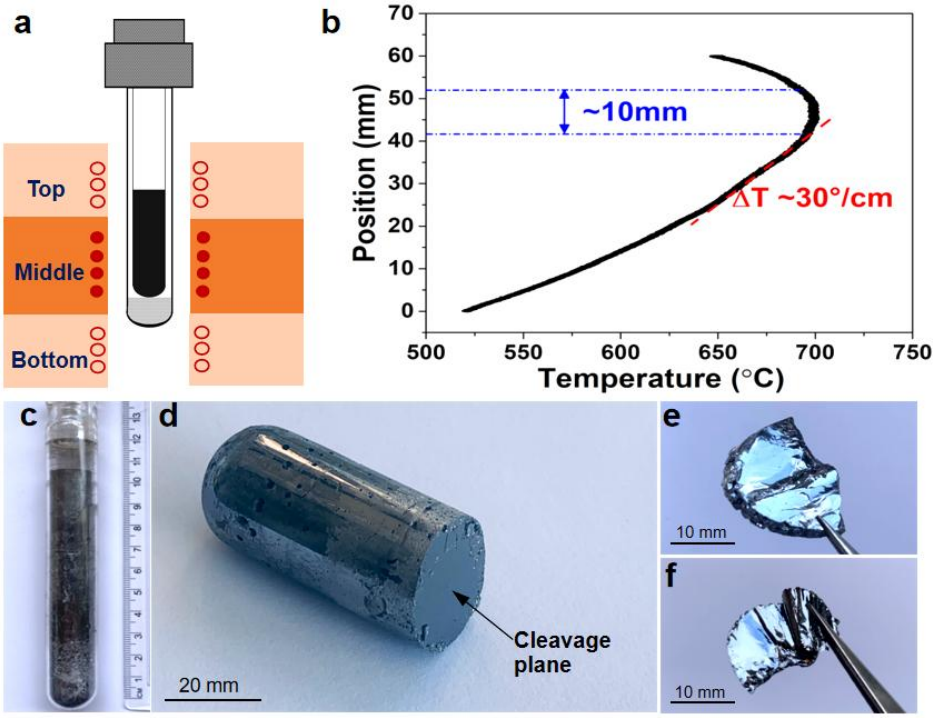

Fig. 1 Schematic diagram of InSe crystal growth by the ground simulation equipment of China space station (a), the actual temperature distribution of the furnace (b), InSe crystal with and without the quartz ampoule (c, d), cleavage wafer (e) and its layered structure (f).

References

[1] Wei TR, et al. Exceptional plasticity in the bulk single-crystalline van der Waals semiconductor InSe. Science. 2020;369:542-545.
[2] Sui FR, et al. Sliding ferroelectricity in van der Waals layered γ -InSe semiconductor. Nature Communications. 2023;14:36.
[3] Jin M, et al. Growth and thermal properties of InSe crystal by using the ground simulation apparatus of China space station. Materials Letters. 2023;337:133970.