A New Synthesis Technique for type-II Ge Clathrate Film

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Inorganic clathrates consisting of group IV elements (e.g., Si, Ge, Sn) have been actively investigated by the researchers across the globe due to its inherent promising properties such as unique electric, thermoelectric features etc. The inorganic clathrates exhibit a wide range of interesting attributes due to flexibility of sp^3 bonding of group IV elements leading to the cage like structure which can encapsulate guest atoms (mainly alkali and alkaline earth metals). The occupancy of guest atoms induces unique properties such as phonon glass electron crystal (PGEC) paradigm, superconductivity, while the unocupied clathrates are interested as new semiconductor materials[1]. Si or Ge based clathrates have been widely investigated in powder form. However, extensive analysis of its electric, optical properties as well as application in real devices, clathrate synthesis in film form serves the major challenge. Several reports are available for realization in film form, whereas lack of homogenous and uniformly grown films restrict its further analysis [2].

With the aim of homogenous and uniform growth of the clathrate film, a new simplistic technique of type-II Ge clathrate film synthesis has been explored which includes vacuum deposition of Na on amorphous Ge film and subsequent IR lamp heating. A new setup “Portable Vacuum Evaporation and Annealing System (pVEAS)” has been developed in our lab group for this purpose (Fig. 1). The pVEAS allowed us to synthesize the sample of which the x-ray diffraction (XRD) pattern shows the successful synthesis of polycrystalline type-II Ge clathrate on the sapphire substrate. The growth of the film appeared uniform and homogenous. Optical transmission spectra showed the periodic fluctuation due to interference in near infrared region.

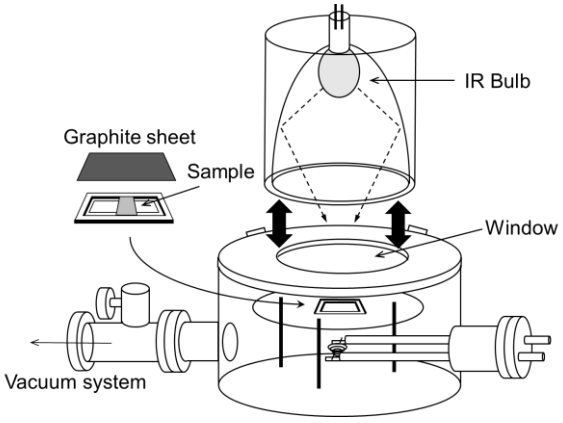

Figure 1: pVEAS setup.

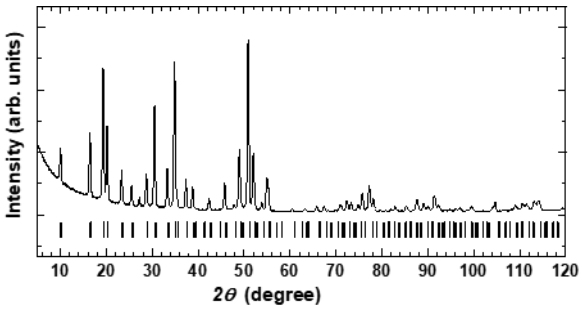

Figure 2: XRD pattern of the type-II Ge clathrate film grown on the sapphire substrate using pVEAS.

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References:

[1] D. Xue *et al*., Nanomaterials **9** (2019).

[2] T. Kume *et al*., Jpn. J. Appl. Phys. **56**, 05DA05 (2017).