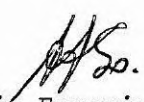




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14. Abstract/Notes <i>Large and homogeneous ternary alloys single crystals are a must for high performance optoelectronic devices such as diode lasers and infrared detective arrays. The best method available so far to obtain large and homogeneous crystal of lead-tin-telluride has been a technique called vapor-melt-solid (VMS) growth, where a very thin melt layer is formed in front of the crystal, reducing the convective flows. Still there is some mixing of the solute in the melt and, to completely suppress the convective flows, a growth in a zero g enviroment in proposed.</i>			
15. Remarks			

Large and homogeneous ternary alloys single-crystals are a must for high performance devices such as diode lasers and infrared detectors. One of the best candidates for infrared detectors in the wavelength range of 8-12 μ m is the narrow band-gap semiconductor $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$. So far several methods have been employed in order to achieve the desired homogeneity without much success.

A new technique called vapor-melt-solid (VMS) growth (Mateika, 1971, Kinoshita, 1982) seems to be, up to now, the best method available to obtain large and homogeneous single crystals of lead-tin-telluride. This technique consists in a modified vapor-liquid-solid growth (Wagner and Ellis, 1964) in the sense that a thin stoichiometric layer is formed in the interface between the solid and the vapor.

The vertical VMS method is shown in Figure 1 together with the furnace profile for $x = 0.20$.

The growth ampoule, made of a quartz tube with a diameter of 15mm, contains a second quartz tube with a diameter of 8mm (held by three indentations), which is the liquid reservoir. The alloy, inside the liquid reservoir, is heated at approximately 80°C above the liquids temperature in an isothermal region under vacuum.

Vaporization takes place and molecules of PbTe and SnTe are transported to the tip of the ampoule, maintained at the solidification temperature, where crystallization occurs. When the ampoule is lowered at a convenient speed, the vapor near the solid interface goes into a melt phase, forming a layer ahead of the crystallization front; then, by a continuous lowering of the ampoule, the crystal is formed.

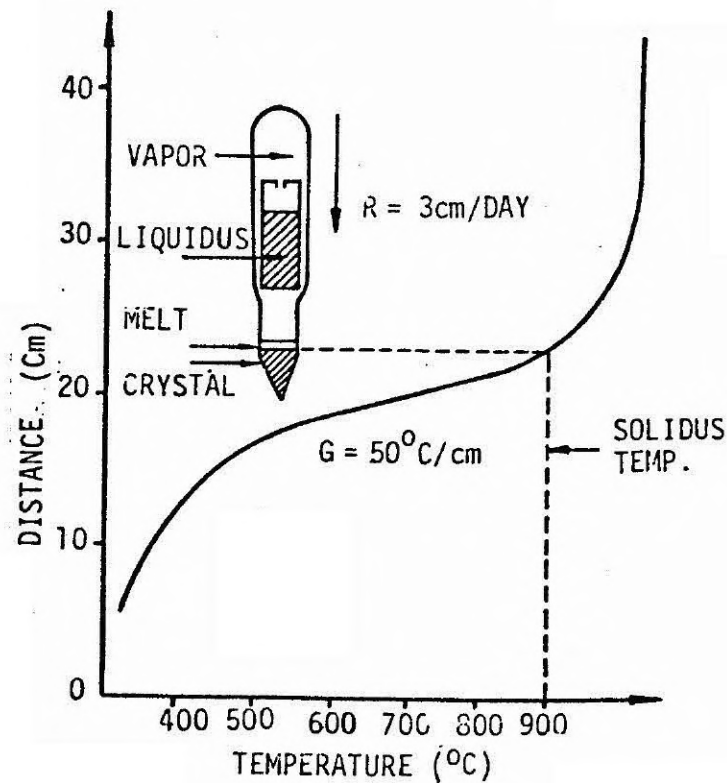


Fig. 1 - Schematic diagram of crystal growth by VMS mechanism.

The inhomogeneity along the growth axis is due to the segregation of the solute which will be mixed in the melt due to convective flows. This process can be seen with the help of Figure 2.

The solute is rejected into the melt when the solidification begins, due to a segregation coefficient, K , less than one ($X_S < X_L$) and a layer, rich in solute, is formed in the solid-liquid interface. After some time this layer will reach a concentration X'_L such as $X'_S = X'_L$ and the amount of solute rejected to the layer will be equal to the amount of solute that enters the solid, a steady-state growth being achieved.

To reach the equilibrium growth the solute cannot mix with the melt by convective processes, which would result in a continuous change in composition along the growth axis. This is what happens in the Bridgman growth crystals on earth.

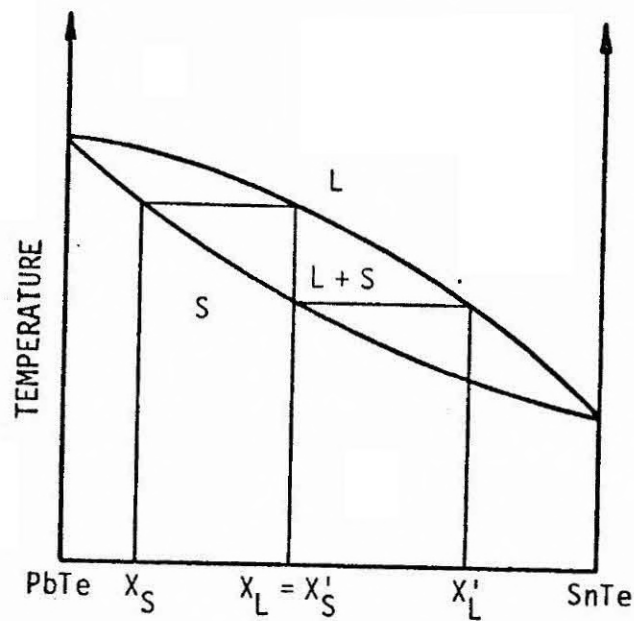


Fig. 2 - Binary constitutional diagram for a solute (SnTe), which lowers the freezing point of the solvent (PbTe).

In the VMS growth, due to the very thin melt layer in front of the crystal, convective flows are very small and solute mixing in the melt is very low. A diffusion-controlled steady-state growth is then possible when the crystallization front proceeds at the same speed as the ampoule.

In a zero g environment the small convective flows inside the melt will be completely suppressed and a pure diffusion-controlled growth will be possible although radial Marangoni convection is still present.

A comparison can then be made with earth grown crystal, which is routinely grown in this Institute. It will also be possible to better determine the diffusion coefficients in $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$, which are not well-known.

The proposed space growth, that can be carried out in, for example, Eureka satellites or Space Shuttle missions, is a variation of the present method in the sense that the top of the liquid reservoir should be almost closed, leaving only a small capillary opening to avoid liquid leakage. The thin melt layer on top of the solid should stay in place by surface tension and the crystal itself by an inevitable sticking to the quartz walls.

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