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Gray Tin Single Crystals*

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A method of growing gray tin single crystals from a liquid amalgam is presented together with a description of the apparatus and specification of the conditions of growth. Photographs of typical crystals ranging in size up to 2 cm and showing well-developed crystallographic planes are included. Residual resistance measurements indicate a total impurity content of the order of 0.001%. The energy gap is the same as for transformed material but the low-temperature mobilities are considerably higher. Evidence that the gray-to-white transformation is of the diffusionless type is presented.

INTRODUCTION

SINCE the discovery in 1950 that gray tin is a semiconductor,[1] the problem of obtaining specimens in other than powder form has received the attention of a number of investigators. As a result considerable progress has been made in producing coherent samples by various techniques including compressing the powder into compact rods[2] and transforming fine wires,[3] thin foils,[4] and tin amalgams.[5] The study of these coherent specimens has made possible more direct and reliable evaluation of the semiconductor parameters which had been determined in the earlier work and also the extension of this to certain measurements which could not be made on powder samples.[6] Yet because all of these techniques involved the transformation from one solid phase to another, the product lacked the high degree of crystalline perfection required for the investigation of many interesting semiconductor properties and our knowledge about gray tin remains quite incomplete. This is especially true of the optical properties but also of all properties to the extent that they may be anisotropic and they may be sensitive to lattice imperfections.

There have been numerous attempts by several investigators to deposite tin atoms directly in the gray tin structure.[2,7] Electrolytic, chemical, and vapor deposition techniques have been tried under a wide range of conditions and using various substances as substrates. These as well as a previous attempt to grow crystals from mercury solution[2] were unsuccessful. Nevertheless a reinvestigation of the latter method was undertaken because of a chance observation made while repeating the experiments of Groen[5] on the transformation of tin amalgams. It was noted that if, after

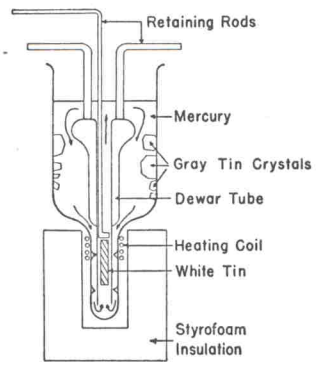

FIG. 1. Crystal growing apparatus

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[2] J. T. Kendall, Phil. Mag. **45**, 141 (1954).
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[7] See, for example, L. J. Groen, Koninkl. Ned. Akad. Wetenschap. Proc. **B57**, 122 (1954) and J. H. Becker, Natl. Bur. Standards Rept. 4576 (1956) (unpublished).

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