

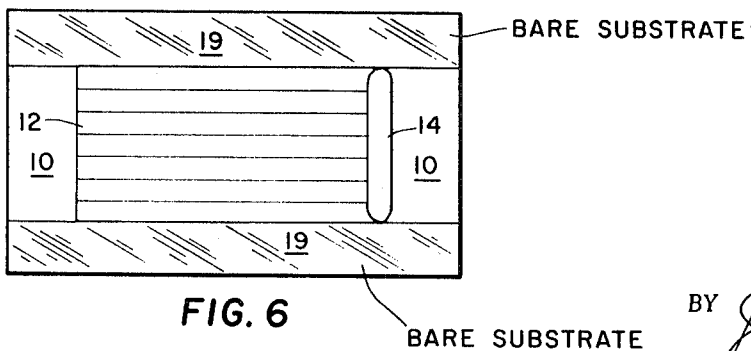
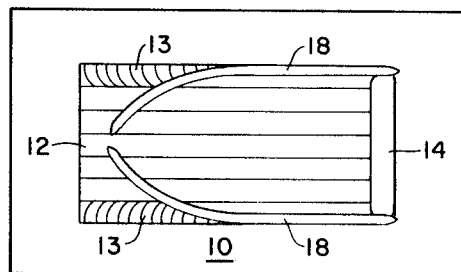
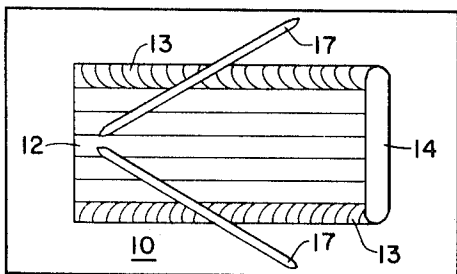
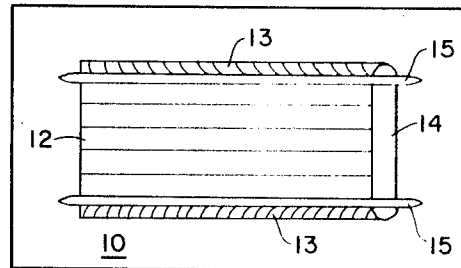
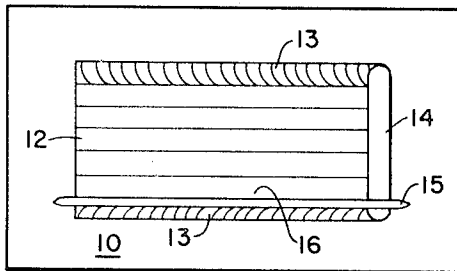
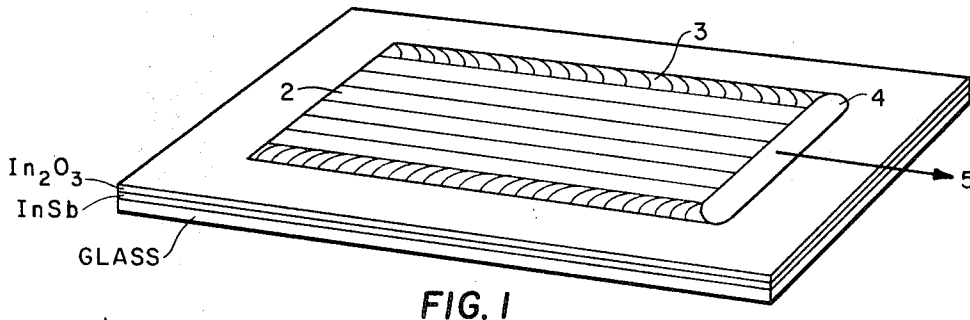
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3,600,237

CONTROLLED NUCLEATION IN ZONE RECRYSTALLIZED InSb FILMS

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CONTROLLED NUCLEATION IN ZONE RECRYSTALLIZED InSb FILMS

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8 Claims

ABSTRACT OF THE DISCLOSURE

Growth of zone recrystallized films without edge nucleation; a technique by which thin semiconducting InSb films and other materials can be crystallized from the melt with selected crystallographic orientation, allowing processing of more homogeneous and higher quality films for a wide variety of transducers based on the Hall effect and magnetoresistance phenomena.

The invention herein described may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The normal or prior form of crystal growth which results from electron beam zone recrystallization of InSb is illustrated in FIG. 1 where an evaporated InSb film has been overcoated with an In_2O_3 layer and zone recrystallization by electron beam bombardment. Electron beam zone recrystallization is discussed by N. M. Davis and H. H. Wieder in Electron Beam Synthesis and Crystallization of InSb Films, 8th Annual Symposium on Electron and Laser Beam Technology at University of Michigan, Ann Arbor, Apr. 8, 1966 and by N. M. Davis in Differentially Pumped Electron Beam System for Microzone Processing of Thin Layers, IEEE 9th Annual Symposium on Electron, Ion and Laser Beam Technology, Berkeley, Calif., May 10, 1967. The recrystallized areas 2, 3, and 4 result from the motion of zone 4 along direction 5. Area 2, the central position of the recrystallized area, consists of long parallel crystals which are oriented generally along the direction of zone motion 5. On the edge of the recrystallized area are small curved crystals which nucleate at the unmelted edge of the zone and grow into the recrystallized area in curved paths.

To increase the usable area of parallel crystals in the film the elimination of the curved crystals is desired. In addition these curved crystals occasionally are the source of large crystals which grow obliquely across the film crowding out the crystals growing parallel to the direction of zone motion. It is desirable to eliminate this oblique growth. U.S. Pat. No. 3,160,521 discloses the use of slits or cuts in the substrate to limit crystal growth to specific boundaries; however, the purpose of the cuts is not related to the prevention of nucleation at the edges as in the present invention. U.S. Pats. 3,036,898 and 3,160,521 discuss specific techniques for zone refining; however, these techniques are not applicable to the technique used with InSb films as in the present invention.

The present invention provides a technique by which thin semiconducting InSb films and other materials can be crystallized from the melt with selected crystallographic orientation. Films of InSb are vacuum evaporated onto glass or other suitable amorphous substrates. An oxide overcoating is used to prevent agglomeration of the molten InSb. The geometry of the InSb is restricted to a long strip. A narrow zone of the InSb film is melted, extending across the width of the vacuum deposited strip. One edge of the zone contacts an InSb crystal of suitable orientation

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for seeding the crystal growth. The zone is slowly scanned to dissolve InSb ahead of the zone and crystallize InSb on the seed behind the zone. Spurious nucleation of undesired crystals is prevented by allowing the crystallizing edge of the molten zone to contact only the solid InSb of the seed. This permits the growth of zone recrystallized films without edge nucleation. This invention confines the nucleation sites of crystallization of films by zone techniques to initial nucleation sites.

Other objects and many of the attendant advantages of this invention will become readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 shows normal form of crystal growth from electron beam zone recrystallization.

FIGS. 2 and 3 show the elimination of nucleation from boundaries of recrystallized areas by the present invention.

FIGS. 4 and 5 show alternate techniques for eliminating nucleation from boundaries of recrystallized areas and for growing a single large crystal.

FIG. 6 is another embodiment for eliminating nucleated boundaries from a recrystallized semiconductor film.

Referring to the drawings like references refer to like portions in each of the figures. In preparing a typical film by the techniques used in this invention, for example, an evaporated InSb 5 micron thick film on #2 microscope cover slip glass substrate and overcoated with a 500 Å. thick layer of In_2O_3 was scribed with a sharp object such that the InSb film and In_2O_3 overcoat were removed along a narrow strip 15. This bare strip lay along one edge of the area of the film which would subsequently be recrystallized.

The film was then processed in the same manner as usual. A molten zone was established along one end of the film by electron bombardment in vacuum. The molten zone was then scanned from one end of the film to the other resulting in a recrystallized sample with the appearance as shown in FIG. 2 where 10 is the evaporated and overcoated InSb film, 12 is the electron bombardment recrystallized region with essentially parallel crystal structure, 13 is the edge region with curved crystals nucleated from the unmelted region of the film, 14 is the final appearance of the moving molten zone, 15 is the scribed line through the film, and 16 is the edge region where the crystals have remained parallel and no edge nucleation has occurred to region 12 at the scribed line 15.

This technique has the advantage of eliminating nucleation from unwanted boundaries of a recrystallized area; thus eliminating any crystal growth which could nucleate at the edge and grow into the region 12 crowding out desired crystals. This increases the usable area of recrystallized films and also permits single and large crystal growth by limiting the nucleation of a crystal grown by recrystallization.

Alternate methods of producing the delineating boundary are by using scribed lines 15 on both sides of the area to be processed, as shown in FIG. 3, and also by using non-parallel lines 17 or 18 to limit nucleation to a smaller number of sites as shown in FIGS. 4 and 5. This will permit growth of a single large crystal nucleated from a single point. In addition, completely removing regions 19 of the film outside the desired area, as shown in FIG. 6, eliminates nucleated areas such as area 13 of FIG. 2.

The advantage of using narrow scribed lines over the technique of FIG. 6 is that the semiconductor film contributes appreciably to the conduction of heat away from the molten zone and thus its presence can be advantageous in maintaining needed thermal distribution in the sample during the electron beam recrystallization.

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The present technique of eliminating edge nucleation can be applied to other methods of crystal growth in film form such as zone heating by radiant energy as well as electron beam heating.

The lines or regions which form delineating boundaries can be produced by such techniques as chemically etching using a photo-mask technique, masking the substrate during the deposition of the semiconductor film—thus preventing it from depositing in the lines, cutting the lines by other mechanical means such as abrasive cutters, string saws, etc.

This technique is also applicable to other materials which can be zone recrystallized in film form.

What is claimed is:

1. A method for the growth of thin semiconducting films, recrystallized from a melt with selected crystallographic orientation and without edge nucleation, comprising:

- (a) vacuum depositing a thin film of semiconductor material onto an amorphous substrate,
- (b) providing an oxide overcoating on the semiconductor film to prevent agglomeration of the semiconductor material when melted,
- (c) completely removing a narrow strip of the oxide coated semiconductor film from said substrate along the edges of a selected area of the film to be subsequently recrystallized,
- (d) establishing a molten zone along one end of said film by zone heating means, said molten zone extending beyond said narrow strip along the edges of said selected area of film to be recrystallized,
- (e) scanning with said heating means to traverse said molten zone from one end of said film to the other to melt and recrystallize said film without edge nucleation.

2. A method as in claim 1 wherein said strip of oxide coated semiconductor film is removed from the substrate by scribing.

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3. A method as in claim 1 wherein said strip of oxide coated semiconductor film is removed by etching.

4. A method as in claim 1 wherein said zone heating means to melt the film for recrystallization is provided by radiant energy.

5. A method as in claim 1 wherein said zone heating means to melt the film for recrystallization is provided by electron beam bombardment.

6. A method as in claim 1 wherein a narrow strip of the oxide coated semiconductor film is removed along non-parallel edges of a selected area of the film to be recrystallized to permit growth of a single large crystal nucleated from a single point.

7. A method as in claim 1 wherein said semiconductor material is InSb and said oxide coating is In_2O_3 .

8. A method as in claim 1 wherein one edge of said molten zone contacts an InSb crystal of suitable orientation for seeding the crystal growth and scanning with said heating means to melt InSb in said zone and crystallize InSb on the seed, spurious nucleation of undesired crystals being prevented by allowing the crystallizing edges of the molten zone to contact only the solid InSb of the seed, thus confining the nucleation sites of crystallization of films to initial nucleation sites.

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