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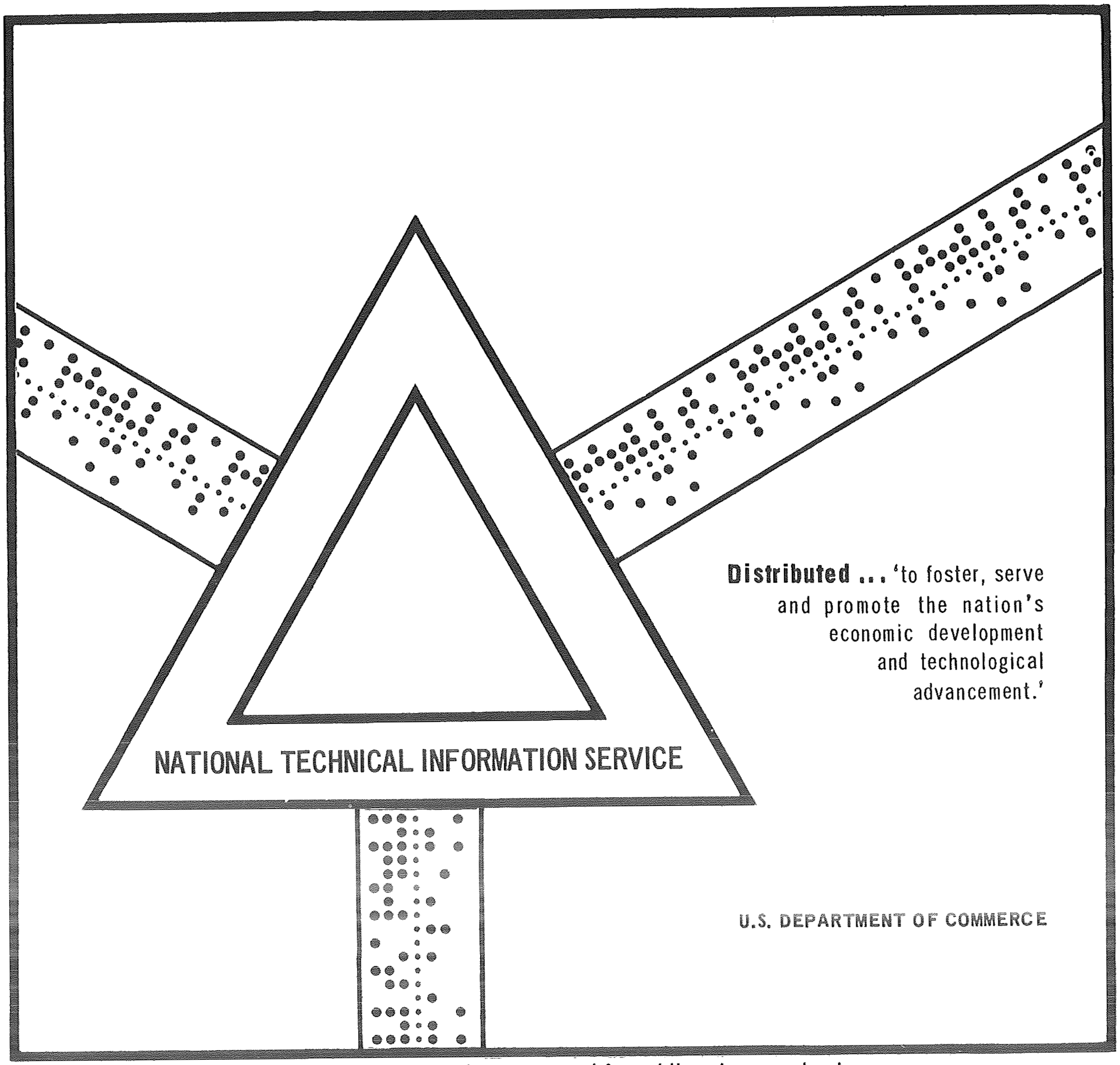
ANNOUNCEMENT OF NASA-OWNED U.S. PATENTS IN STAR

Gayle Parker

15 October 1970



N71-18064

Sept. 6, 1966 JAMES E. WEBB 3,271,637

ADMINISTRATOR OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

GaAs SOLAR DETECTOR USING MANGANESE AS A DOPING AGENT

Filed July 22, 1963

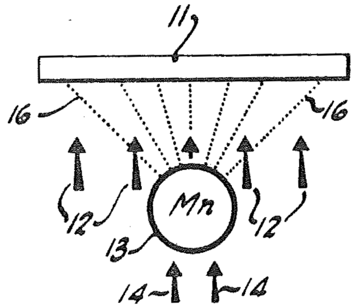


FIG-1

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50%

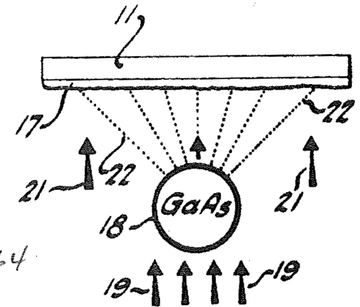

FIG-2

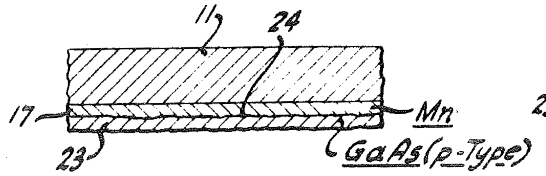

FIG-3

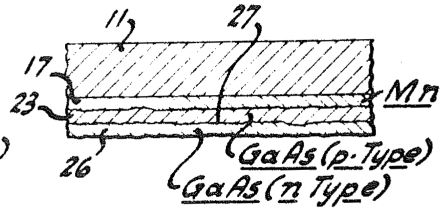

FIG-4

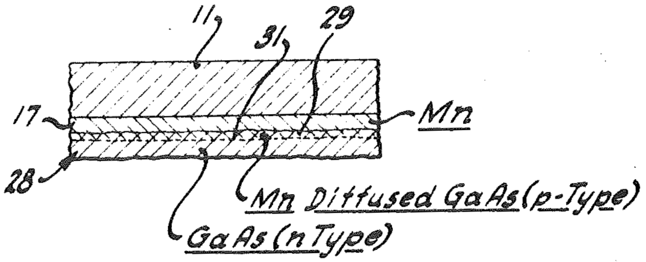

FIG-5

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1069

United States Patent Office

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Patented Sept. 6, 1966

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GaAs SOLAR DETECTOR USING MANGANESE AS A DOPING AGENT

James E. Webb, Administrator of the National Aeronautics and Space Administration with respect to an invention of Edward F. Pasierb

Filed July 22, 1963, Ser. No. 296,879
1 Claim. (Cl. 317—234)

This invention relates to the vapor deposition of gallium arsenide films to manganese substrates to provide semiconductor devices having a relatively small substrate resistance.

Various semiconductor devices have existed heretofore wherein gallium arsenide films are deposited upon substrates of germanium to provide p-n junctions, and the like. However, for certain applications, such as solar energy converters, it is desirable that a substantially lower substrate resistance be provided than that obtainable with germanium.

The present invention provides semiconductor devices of the general type noted above, but which have a low resistance substrate and are, accordingly, particularly advantageous in solar energy converter applications. More particularly, the present invention provides for the vapor deposition of thin polycrystalline films of gallium arsenide upon polycrystalline substrates of manganese to thereby provide semiconductor devices or portions thereof, which by virtue of the metallic properties of manganese, have a low substrate resistance. In one form of device in accordance with the invention, a p-type semiconductor to conductor junction is provided at the interface defined between the gallium arsenide film and manganese substrate. In another device embodiment which may be produced, the film of n-type gallium arsenide is deposited upon a film of p-type gallium arsenide which has been previously deposited upon the manganese substrate. A p-n junction is thereby provided between the respective films of p and n type gallium arsenide. In a further, and particularly salient device embodiment in accordance with the invention, a film of n-type gallium arsenide is vapor-deposited directly upon the manganese substrate and a slight amount of manganese diffusion into the gallium arsenide is effected at the gallium arsenide-manganese interface. Inasmuch as manganese is a p-type determining material in gallium arsenide, a p-n junction is thereby directly provided within the deposited gallium arsenide film.

A better understanding of the invention may be had from the following illustrative description and the accompanying drawing, wherein:

FIGURE 1 is a schematic illustration of an initial step of the method of producing semiconductor devices in accordance with the invention;

FIGURE 2 is a schematic illustration similar to FIGURE 1, showing a further step of the method;

FIGURE 3 is a cross-sectional view of a semiconductor device produced by the method;

FIGURE 4 is a cross-sectional view of another semiconductor device embodiment which may be produced in accordance with the method; and

FIGURE 5 is a cross-sectional view of a further semiconductor device embodiment which may be produced in accordance with the method.

Broadly stated, the present invention comprises the provision of semiconductor devices which include a low electrical resistance substrate region of manganese and a deposited film region of gallium arsenide contiguous with the manganese to thereby provide an electrical junction at, or adjacent the interface defined by the substrate and film regions. The term "electrical junction" is used herein to mean a low resistance ohmic contact. More particularly, the invention provides a method of forming semiconductor devices of the foregoing variety which, by virtue of the properties of manganese, are particularly suited to solar energy converter applications and equivalent applications wherein a low resistance substrate is required. With reference to FIGURE 1, there is initially provided a backing member **11**, which is preferably of a material such as molybdenum, and which may be heated, as indicated by the arrows **12**, to a relatively high temperature. Manganese is then evaporated upon a face of the backing member **11**, as by disposing a manganese source **13** subjacent the heated backing member and applying heat to such source, as indicated by the arrows **14**, to convert the manganese into the vapor state. The manganese vapor rises, as indicated by the dashed lines **16**, to be, in turn, deposited as a thin layer upon the subface of the backing member. This evaporated layer of manganese serves as a substrate **17** suitable for the deposition of gallium arsenide thereon in a manner subsequently described. It should be noted that the thickness of the evaporated manganese substrate **17** is very thin, preferably less than 1.0 micron, for purposes of reducing the potential problems of thermal stress and cracking from heating due to thermal expansion differences which may arise in subsequent stages of the process or in use of the resultant device.

The unit comprising the backing member **11** and manganese substrate **17** evaporated thereon is next subjected to the vapor deposition of gallium arsenide, as by means of vapor transport techniques indicated in FIGURE 2. In this regard, the backing member **11** may be disposed with the manganese substrate **17** in close opposed relation to a gallium arsenide source wafer **18** and a suitable vapor transporting agent provided therebetween. The transport agent may be advantageously a stagnant reducing atmosphere, for example a substantially stagnant dry hydrogen atmosphere, which encompasses the backing member and source wafer **18**. The source wafer and substrate are next heated, as respectively indicated by arrows **19** and **21**, in such a manner that the source wafer is vaporized and is maintained at a slightly higher temperature than the substrate. By virtue of the temperature gradient and the transporting medium, gallium arsenide vapor is transported to the substrate, as indicated by the dashed lines **22**, and is deposited as a thin film thereon. Through appropriate control of the temperature gradient between the source wafer **18** and substrate **17**, and of the time during which the substrate is subjected to the vapor depositing process, the thickness of the gallium arsenide film may be readily controlled as desired. It has been found that gallium arsenide films vapor-deposited upon thin manganese substrates in the foregoing manner are substantailly uniform and continuous. In the instance of simple vapor deposition of the gallium arsenide on the manganese substrate, the manganese substrate and gallium arsenide film are both polycrystalline.

Where p-type gallium arsenide is employed as the wafer **18** in the conduct of the method described above, the manganese substrate **17** is, hence, coated with a thin film **23** of p-type gallium arsenide, as indicated in FIGURE 3. Inasmuch as manganese is a p-type determining material to gallium arsenide, the resulting semiconductor device of FIGURE 3 provides a p-type semiconductor to conductor ohmic contact at the interface **24** defined by the substrate **17** and film **23**. This device is characterized by a low substrate resistance by virtue of the metallic properties of manganese.

P-n junction semiconductor devices having a low substrate resistance are also provided in accordance with the invention through a simple extension of the method described hereinbefore. More particularly, the basic structure of FIGURE 3, just described, is subjected to a further vapor deposition step of the type depicted by

FIGURE 2. In this case the gallium arsenide source wafer **18** is of an opposite conductivity type from the first deposited layer. In the foregoing example, there is employed n-type gallium arsenide whereby the p-type gallium arsenide film **23** is coated with an n-type gallium arsenide film **26**, and a modified semiconductor device of the type depicited in FIGURE 4 is obtained. Such device includes a p-n junction **27** which is defined between the p and n type gallium arsenide films **23** and **26**, respectively.

As a further particularly important alternative in the conduct of the method of the invention, n-type gallium arsenide may be employed as the source wafer **18** in the initial vapor deposition step of the method. As a result, a semiconductor device of the type depicited in FIGURE 5 is produced, wherein a thin film **28** of polycrystalline n-type gallium arsenide is vapor-deposited directly upon the manganese substrate **17**. It is particularly important to note that during the deposition of the film **28** a slight amount of manganese diffusion into the n-type gallium arsenide film **28** is permitted. Such diffusion is accomplished by techniques well known in the art and is regulated, for example, by suitable control of the temperature of the substrate and deposited film. As a result, there is produced a manganese diffused gallium arsenide boundary layer **29** within the gallium arsenide film **28** adjacent the interface defined between the film and substrate. By virtue of the manganese being a p-type determining material, the diffusion layer **29** is converted to p-type gallium arsenide. A diffused p-n junction, as generally indicated at **31**, is thus defined between the p and n type regions of the gallium arsenide film **28**.

Although the present invention has been described hereinbefore and illustrated in the accompanying drawing with respect to specific steps of the method and several specific embodiments of articles producible by the method, it will be appreciated that various modifications and variations may be made therein without departing from the spirit and scope of the invention. For example, the backing member **11** of the various semiconductor device embodiments may be advantageously provided as a transparent material such as quartz to thereby provide back wall solar cells in which the light passes through the backing member to energize the electrical junction of the device. Thus, it is not intended to limit the invention except by the terms of the following claim.

What is claimed is:

A semiconductor device comprising: a molybdenum backing member; a manganese substrate dopant on said member, the dopant having a thickness of less than one micron; and a film of gallium arsenide on said substrate, the film and substrate providing an electrical p-type junction at the interface thereof.

References Cited by the Examiner

UNITED STATES PATENTS

2,937,324	5/1960	Kroko	317—234
3,005,107	10/1961	Weinstein	250—211
3,110,849	11/1963	Soltys	317—237
3,117,229	1/1964	Friedland	250—83.3
3,150,999	9/1964	Rudenberg	316—89
3,160,800	12/1964	Smart	317—235
3,179,541	4/1965	Hull et al.	148—175
3,179,542	4/1965	Quinn et al.	148—177
3,196,329	7/1965	Cook et al.	317—234
3,200,259	8/1965	Braunstein	307—88.5

FOREIGN PATENTS

887,208	1/1962	Great Britain.

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