United States Patent

Stark

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[54] **TRITIUM AND DEUTERIUM IMPREGNATED TARGETS FOR NEUTRON GENERATORS**

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[58] **Field of Search**...........250/84.5; 313/61; 117/71

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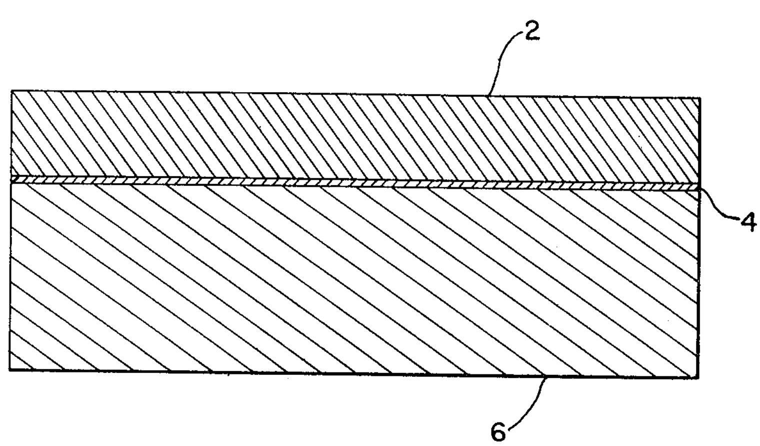
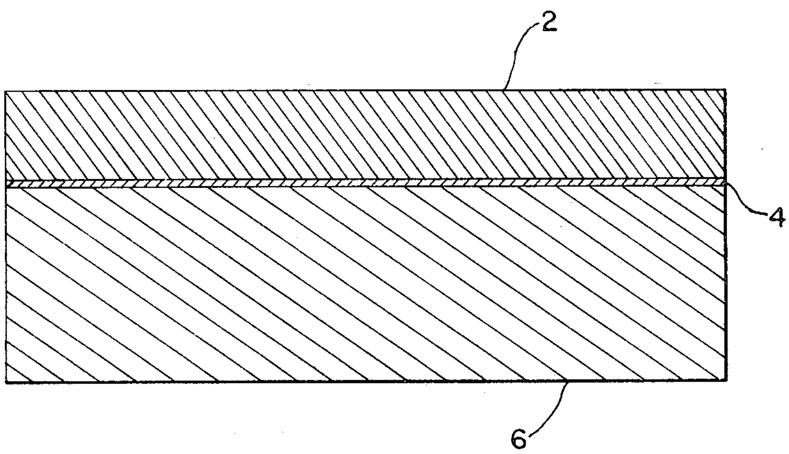
[57] **ABSTRACT**

In rare-earth neutron targets, there is a tendency for the hydrided rare-earth film to flake off the metal substrate because of the formation of the brittle trihydrides. The present invention provides targets which alleviate this difficulty. In these novel targets there is located between the substrate and the hydrided rare-earth film an intermediate film of a further metal, the further metal being selected to diffuse readily into the metal of the first-mentioned film under solid-state conditions and form a solid solution or compound therewith, and to adhere well to the substrate, and being sufficiently thin not to reduce substantially the absorption of hydrogen by the first-mentioned film by dilution of the first-mentioned film. Suitable intermediate films include nickel and gold.

6 Claims, No Drawings





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TRITIUM AND DEUTERIUM IMPREGNATED TARGETS FOR NEUTRON GENERATORS

BACKGROUND OF THE INVENTION

This invention relates to neutron generator targets in which a hydrogen isotope, deuterium and/or tritium, is absorbed in a film of a lanthanon, scandium or yttrium.

Such targets are described, for example, in United Kingdom British specification No. 974,622, in which the lanthanon elements are defined. In the aforesaid specification, the film is deposited on a substrate metal with which it does not readily alloy. The substrate is so much thicker than the film that alloying would partially or completely inhibit the absorption of hydrogen. The choice of substrate metal is thus limited; molybdenum, tungsten, tantalum and chromium are the most suitable.

For a sealed neutron generator, e.g. as described in United Kingdom British specification No. 1,088,088, having a high neutron output and long life, a comparatively thick film must be used to compensate for sputtering by incident deuterium or tritium ions accelerated on to the target. It is difficult in practice to obtain an incident ion beam of uniform power density. This leads to a variation of temperature over the target area, and in preventing an excessive target temperature in the high-temperature regions of the target, it is difficult to prevent the cooler regions falling below about 200° C. At these lower temperatures the absorption of ions from the beam can lead to the formation of the trihydride of the film metal, e.g., erbium trihydride; at higher temperatures only the dihydrides are formed. The trihydrides are extremely brittle compared with the dihydrides, and it is found that although comparatively thin films of 0.0002–0.0005 cm can be made which remain adherent, long-life films of 0.0025 cm and thicker disintegrate upon partial trihydriding, leaving clean bare areas of substrate.

It is an object of the present invention to provide a form of neutron target which reduces this tendency to disintegration.

SUMMARY OF THE INVENTION

According to the present invention a neutron generator target comprises a metal film impregnated with hydrogen isotope, said metal being chosen from the group consisting of yttrium, scandium and the lanthanons, the metal film being supported on a metal substrate, preferably a substrate which does not alloy readily with the metal of the film, wherein there is located between the substrate and the film an intermediate film of a further metal, said further metal being selected to diffuse readily into the metal of the first-mentioned film under solid-state conditions and form a solid solution or compound therewith, and to adhere well to the substrate, and being sufficiently thin not to reduce substantially the absorption of hydrogen by the first-mentioned film by dilution of the first-mentioned film.

The formation of the solid solution or compound by intermetallic diffusion in the solid state is to be distinguished from the formation of the alloy by melting. The further metal is preferably selected so that the alloy formed between it and the metal of the first-mentioned film does not melt at the temperatures used when evaporating the first-mentioned film on to the intermediate film and subsequently loading the former film with hydrogen isotope. For example, available data indicates that erbium forms alloys with the following metals, listed in order of decreasing alloy melting points, and therefore decreasing suitability: beryllium, gold, silver, nickel, cobalt, copper. Beryllium has the disadvantages of high toxicity. Other suitable metals may be used.

The thickness of the intermediate film is made much less than that of the hydrogen-absorbing film in order to limit the dilution of the latter by diffusion when the solid solution or compound is formed, but is sufficient to increase its adhesion to the substrate.

The intermediate film is preferably evaporated on to the substrate using an evaporation geometry similar to that subsequently used for evaporating the film of hydride-forming metal on to the intermediate film, in order to produce a more uniform thickness ratio of the two films over the target surface.

Because of the thinness of the intermediate film it is preferred, despite any "buffer" action which the latter may provide, to use as the substrate a metal which does not alloy readily with the metal of the first-mentioned film, as in the prior art.

The present invention also provides a method of producing targets as aforesaid, and a sealed neutron generator comprising a target as aforesaid.

A drawing is included to further describe the invention. The drawing is a diagrammatic elevation in section of the neutron target of the invention wherein **6** represents the metal substrate; **4** represents the intermediate metal film of a further metal and **2** represents the metal film impregnated with hydrogen isotope.

EXAMPLES OF THE INVENTION

The following are examples of neutron targets and methods of producing them, embodying the present invention.

EXAMPLE 1

A 0.0001 cm thick film of nickel was vacuum evaporated on to a molybdenum substrate and a 0.005 cm thick film of erbium subsequently evaporated on to the nickel. The target was loaded to a hydrogen/erbium atomic ratio of 2.8, with practically no loss of erbium film integrity. At this ratio, an erbium film of such thickness without the intermediate nickel film disintegrates to a powder, leaving the substrate bare. Ultrasonic cleaning in toluene followed by an adhesive-tape "strip-test" (in which Scotch tape is applied to the loaded erbium film and subsequently pulled off) removed only about 8 percent of the erbium film.

The intermediate nickel film can also be applied to the substrate by electroplating, but vacuum evaporation is preferred since the use of similar processes for the nickel and erbium films produce a more uniform nickel/erbium thickness ratio. If this ratio is too high over any part of the target area, the excess of nickel appears to encourage the formation of a low melting-point nickel/erbium alloy; where such melting is observed to occur, there is a greater tendency for the erbium layer to flake off when loaded with hydrogen. For this reason, and because the quantity of nickel to be evaporated is so much smaller than the quantity of erbium, the evaporation boat may be plated uniformly with the nickel, e.g., by electroplating, instead of loaded with wire or particles in the usual manner (and as in Example 1), in order to obtain a better defined geometry similar to that for the erbium. This plated-boat technique may be used for intermediate films of metals other than nickel. The film of erbium, or other hydride-forming metal, is preferably evaporated (as in Example 1) by the two-stage evaporation technique described in copending application Ser. No. 3129/68.

EXAMPLE 2

A 0.0001 cm thick gold film was vacuum evaporated on to a molybdenum substrate and a 0.005 cm thick erbium film evaporated on to the gold, using the same techniques as in Example 1. The erbium film was loaded to a hydrogen/erbium atomic ratio of 2.8. There was no visible flaking or crumbling of the erbium film, as would have been the case without the intermediate gold film. The erbium film withstood ultrasonic cleaning in toluene with the loss of only about 10 very small pinholes (about 0.25 mm in diameter).

Although the above examples relate only to the use of erbium with a molybdenum substrate, the remaining lanthanons, yttrium or scandium can be used, and other substrates such as tungsten, tantalum or chromium, a suitable metal being selected for the intermediate film in each case, e.g., one of the six (beryllium, gold, silver, nickel, cobalt, copper) mentioned above.

I claim:

1. A neutron generator target comprising a metal film impregnated with hydrogen isotope, said metal being chosen from the group consisting of yttrium, scandium and the lanthanons, the metal film being supported on a metal substrate which does not alloy readily with the metal of the film, wherein there is located between the substrate and the film an intermediate film of a further metal, said further metal having a thickness much less than that of said metal film impregnated with hydrogen isotope and being selected to diffuse readily into the metal of the first-mentioned film under solid-state conditions and form a solid solution or compound therewith, and to adhere well to the substrate, and being sufficiently thin not to reduce substantially the absorption of hydrogen by the first-mentioned film by dilution of the first-mentioned film.

2. A target as claimed in claim 1 wherein the further metal is selected from the group consisting of beryllium, gold, silver, nickel, cobalt and copper.

3. A target as claimed in claim 2 wherein the first-mentioned film is of erbium and the further metal is selected from the group consisting of nickel and gold.

4. A target as claimed in claim 1 wherein the intermediate film is approximately one-fiftieth of the thickness of the first-mentioned film.

5. A target as claimed in claim 1 wherein the substrate is selected from the group consisting of tungsten, tantalum, chromium and molybdenum.

6. A target as claimed in claim 1 wherein said impregnated metal film is more than 0.0025 cm thick.

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