

[54] **TUNGSTEN ALLOY X-RAY TARGET**

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[57] **ABSTRACT**

This invention relates to alloys useful in X-ray targets comprising tungsten and one or more of technetium, rhodium, ruthenium and palladium.

16 Claims, No Drawings

TUNGSTEN ALLOY X-RAY TARGET

X-ray equipment is in wide use for a variety of purposes. Various means are employed to bombard electrons onto a positively charged surface which is conveniently referred to either as an anode or as an X-ray target. There are various types of targets available on the market. These include stationary targets and rotating targets. In general, the X-rays are produced when the electrons hit the surface of the anode or target under appropriate X-ray generating conditions.

The portion of the surface of the target that is bombarded by electrons can be referred to as the focal track.

The material of which the target surface area of focal track is produced is quite important. The material must be of the proper type to both withstand the temperatures of operation and to be an X-ray emitter of sufficient intensity. In addition, the material must have sufficient ductility to withstand conditions of repeated operation. One of the problems frequently encountered with X-ray targets is the roughening of the surface thereby diminishing the efficiency of X-ray emission and rendering emission erratic.

Tungsten is a material commonly used in X-ray targets because of its high melting point, high density and large atomic number. The performance of tungsten can be improved by using alloying additions of other transition metals with high melting point and atomic number such as rhenium, osmium, iridium and platinum. Such alloying additives have been found to reduce roughening and permit longer use as well as higher loads without excess dose losses.

The present invention involves the discovery that an even greater improvement in the performance of X-ray targets can be achieved by the alloying with tungsten of a small quantity of one or more of technetium, rhodium, ruthenium and palladium. The resultant alloy yields significant and unexpected advantages to tungsten X-ray targets despite the fact that their atomic numbers are lower than tungsten and lower than those of the previously used alloying additives. Even very small quantities of the alloying additives of this invention, on the order of one-tenth of one per cent by weight, when alloyed with tungsten, produce X-ray targets that are characterized by a noticeably improved service life. The primary improvement is that much less roughening of the surface occurs with the tungsten alloys of this invention upon exposure to service as compared to tungsten alone. X-ray targets made of a tungsten-rhenium alloy are particularly satisfactory for use and they, too, are improved in the same fashion by the addition of a small quantity of one or more of the alloying additives of this invention. Also improved by the addition of a small quantity of the alloying additive of this invention are X-ray targets made of tungsten and one or more of osmium, iridium and platinum with or without rhenium.

As is the case in known X-ray targets, for example, in rotating targets, the entire target need not be made of the tungsten alloys of this invention but, instead, the target can be a composite of a base having applied thereon a thin focal track, i.e., a surface of bombardment of electrons, made of the tungsten alloys of this invention. Molybdenum is a suitable material for a base of this type. Other bases including tungsten itself or tungsten-molybdenum alloys may also be employed as

is conventional in the art. For example, the base may be made of graphite. However, where a graphite base is employed, there should be an intermediate layer between the graphite and the tungsten alloy for the purpose of preventing the formation of the brittle tungsten carbide. A suitable intermediate layer can be made of such materials as, for example, rhenium or osmium. Such an intermediate layer should have a thickness on the order of 2 to 10 microns.

Where a composite X-ray target is employed made of a base and a focal track of the tungsten alloy of this invention, the total thickness of the tungsten alloy layer in the focal track should be between about 0.1 mm and 2 mm.

A typical rotating X-ray target of the type that could be used in commercial X-ray tubes will have a molybdenum base of approximately 6 mm thickness and a focal track of the tungsten alloy of this invention of approximately 1.2 mm thickness.

The amount of alloying additive employed in the tungsten alloys of this invention need not be very great. The content of technetium, rhodium, ruthenium and palladium in the tungsten alloy may be as low as about 0.01 percent by weight. The upper limit is determined by the solubility of the alloying additives in tungsten, e.g., 20 percent for technetium, 5 percent for rhodium, 15 percent for ruthenium and 4 percent for palladium, all by weight. The best results are generally achieved when the tungsten alloy contains from about 0.1 to about 5 percent weight of ruthenium or technetium or from about 0.1 to about 2 percent by weight of rhodium or palladium. Preferably, where mixtures of alloying additives of this invention are employed, the total quantity should not exceed 5 percent by weight of the alloy.

The tungsten alloys of the invention can also contain up to about 10 percent rhenium for the purpose of improving physical properties such as, for example, the cold ductility of the alloy. Where rhenium is employed, the minimum amount of rhenium to have an appreciable effect should be at least about 0.5 percent by weight of the alloy. Similarly, where desired, amounts of up to 5 percent osmium, up to 5 percent platinum and up to 2 percent iridium by weight can be present in the alloy of this invention for the purpose of improving target performance. Where osmium is employed, a minimum of about 0.1 percent by weight can be used, and where platinum or iridium is employed, a minimum of about 0.05 percent by weight can be used.

The method of producing the alloy of the invention is conveniently carried out by powder metallurgical techniques. For example, powders of the various alloy components can be mixed together, compressed and sintered under vacuum or inert atmosphere at an appropriate sintering temperature to cause alloy formation. The sintering temperature will generally be in the range of from about 1600° to 2400° C., preferably on the order of about 2000° C. Alternatively, the tungsten alloys can be first formed by any conventional technique and applied to the base of the target by flame spraying, by vapor deposition and subsequent diffusion annealing or by any other method that is convenient.

Where tungsten powder is desired for use in a powder metallurgical system, it can be obtained conveniently by reducing a mixture of a powdered tungsten

compound such as tungsten trioxide or ammonium tungstate. The other alloying components can be obtained by conventional means. In general, powders employed can have particle sizes in the range of 1 to 50 microns.

A convenient rotating target for use in an X-ray tube can be made, for example, by preparing a die and filling it to the predetermined level with molybdenum powder of particle size range 2 to 10 microns, i.e., where a molybdenum base is desired for the target. On top of this, a homogeneous mixture of 2 to 10 microns tungsten powder and 1.5 percent by weight of 1 to 6 microns rhodium powder is placed in the die. Thereupon a pressure of about 4 tons per square centimeter is employed to compact the powder in the die. The green compacts thus formed are then sintered under a high degree of vacuum or in an inert atmosphere such as hydrogen, helium or argon, at a temperature of about 2000° C. for 2 hours, and thereupon cooled under the protective atmosphere. The anode is then given its final shape by forging and grinding.

What is claimed is:

1. X-ray tube target comprising a base and a focal track positioned thereon for electron impact, said focal track having enhanced resistance to roughening under electron bombardment as a result of fabrication from an alloy comprising tungsten with at least one alloying additive from the group consisting of technetium, rhodium and ruthenium.

2. An X-ray target as in claim 1 wherein the amount of alloying additive is within the range from about 0.01 percent by weight of the tungsten alloy to the maximum solubility of the additive in tungsten.

3. An X-ray target as in claim 1 wherein the alloying additive is rhodium.

4. An X-ray target as in claim 3 wherein the rhodium is present in an amount of up to 5 percent by weight of

the tungsten alloy.

5. An alloying additive as in claim 3 wherein the rhodium is present in an amount from 0.1 percent to 2 percent by weight of the tungsten alloy.

6. An X-ray target as in claim 1 wherein the alloying additive is technetium.

7. An X-ray target as in claim 6 wherein the technetium is present in an amount of up to 20 percent by weight of the tungsten alloy.

8. An alloying additive as in claim 6 wherein the technetium is present in an amount of 0.1 to 5 percent by weight of the tungsten alloy.

9. An X-ray target as in claim 1 wherein the alloying additive is ruthenium.

10. An X-ray target as in claim 9 wherein the ruthenium is present in an amount of up to 15 percent by weight of the tungsten alloy.

11. An alloying additive as in claim 9 wherein the ruthenium is present in an amount from 0.1 to 5 percent by weight of the tungsten alloy.

12. An X-ray target as in claim 1 also having alloyed with tungsten an amount of rhenium of up to 10 percent by weight of the tungsten alloy.

13. An X-ray tube target as in claim 1 wherein the said alloy also contains minor amounts of at least one metal from the group consisting of rhenium, platinum, iridium and osmium.

14. An X-ray tube target as in claim 13 wherein the base comprises molybdenum.

15. An X-ray tube target as in claim 13 wherein the base comprises graphite.

16. An X-ray tube target as in claim 15 wherein there is an intermediate layer interposed between the graphite and the focal track, said intermediate layer being of a material capable of preventing reaction between tungsten and graphite.

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