US 20090183598A1

(54) **COMPOSITE MATERIAL , METHOD FOR MANUFACTURING THE SAME, AND EDGED TOOL BY USING THE SAME**

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(57) **ABSTRACT**

It is an object to provide a composite material having a satisfactory sintering density and exhibiting excellent abrasion resistance and a method for manufacturing the same. The composite material contains a Ti alloy matrix containing Ti as a primary component and TiB and NiB dispersed in the Ti alloy matrix. The method for manufacturing the composite material includes the step of conducting sintering by using a mixed powder containing a Ti powder and/or a Ti alloy powder containing Ti as a primary component and a Ni—B alloy powder.

2(Ti ALLOY)
4(TiNi)
3(TiB)
1(NiB)

FIG. 1

2(Ti ALLOY)

1(NiB)

FIG. 2

2(Ti ALLOY)

4(TiNi)

3(TiB)

1(NiB)

FIG. 3

2(Ti ALLOY)

1(NiB)

FIG. 4

2(Ti ALLOY)

4(TiNi)

1(NiB)

3(TiB)
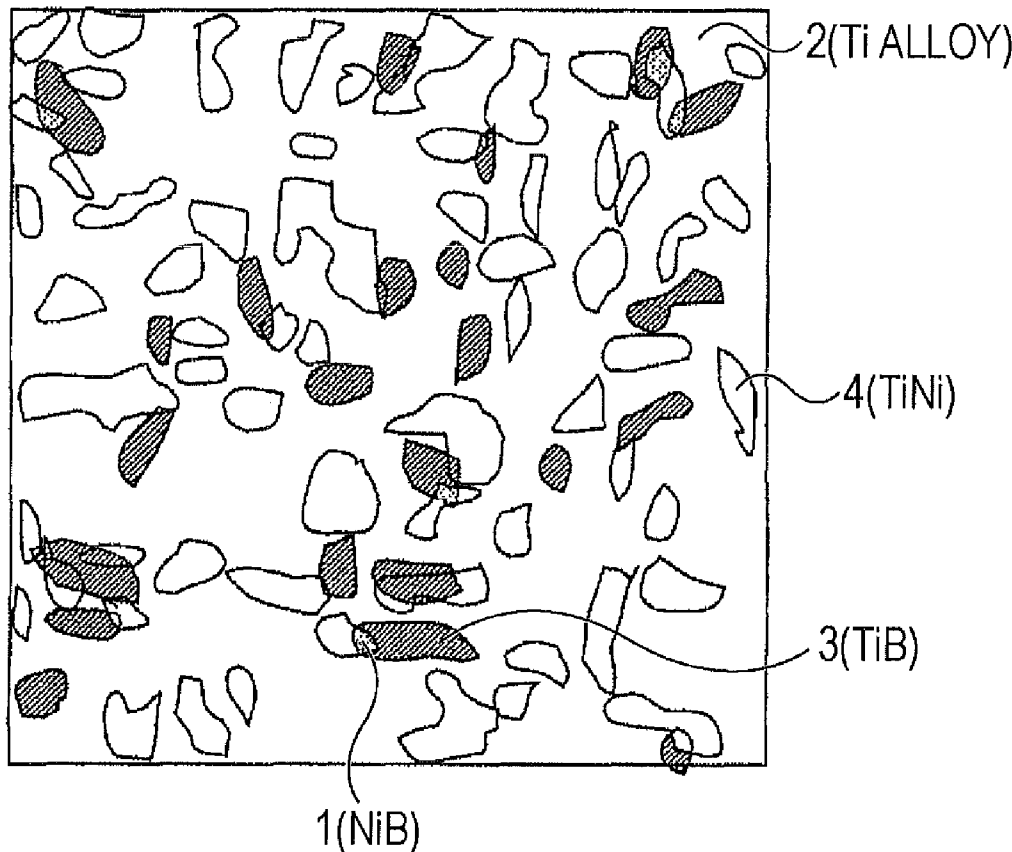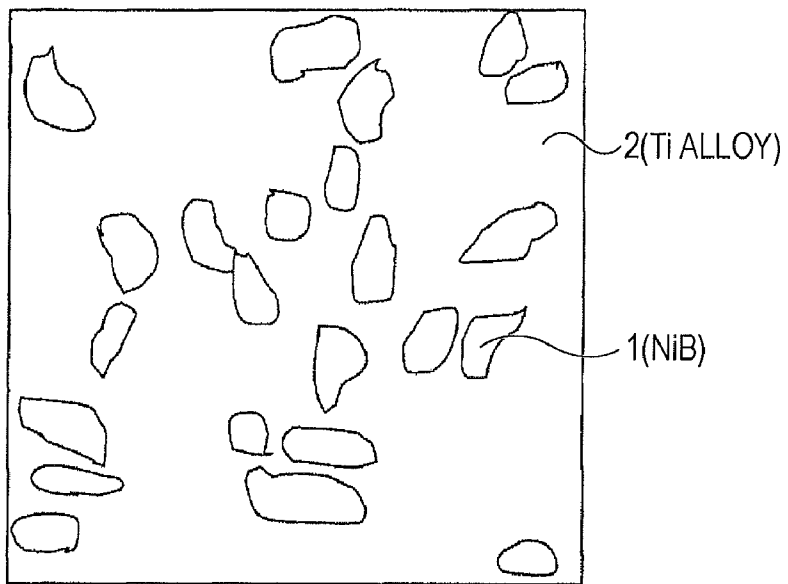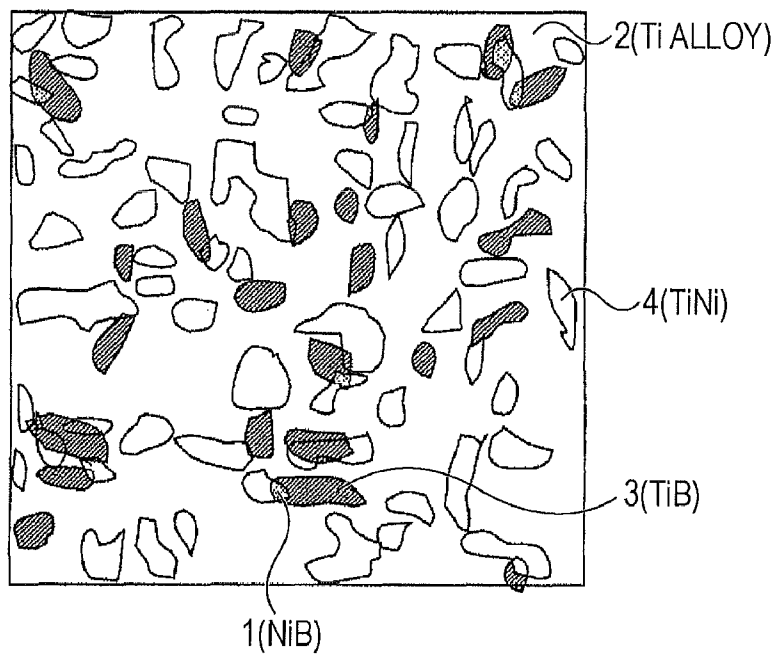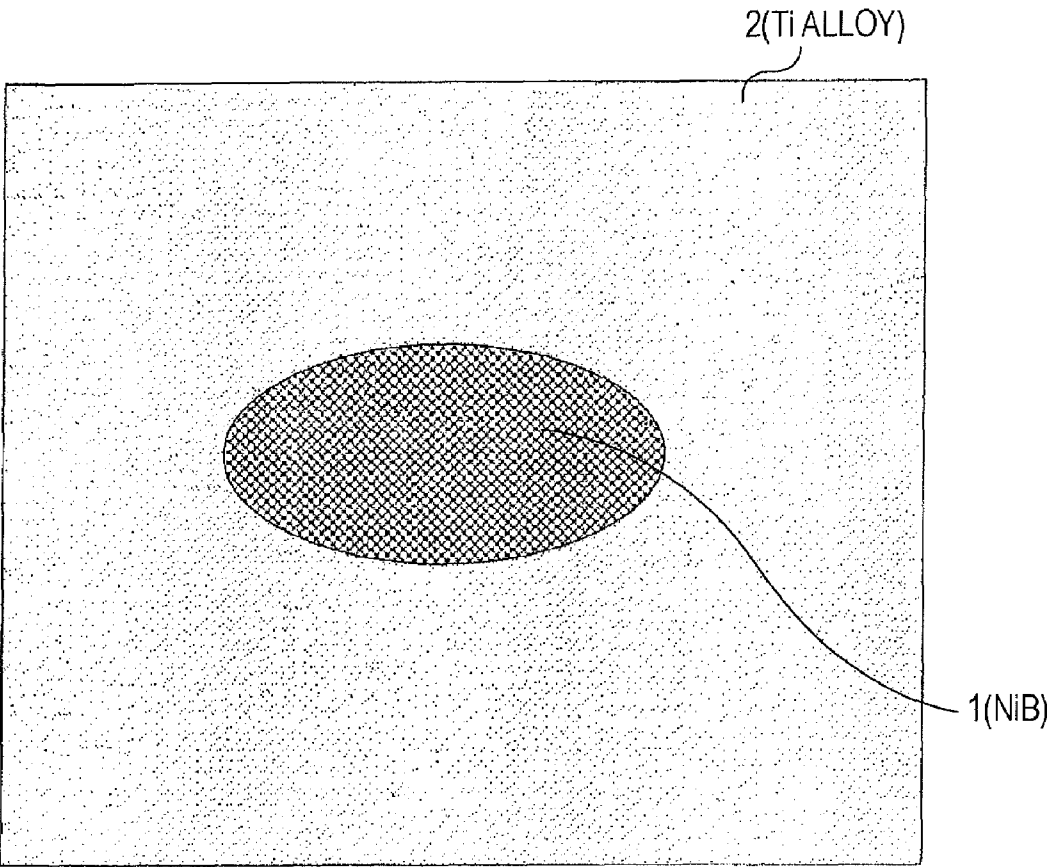
FIG. 5

FIG. 6

FIG. 7

COMPOSITE MATERIAL , METHOD FOR MANUFACTURING THE SAME, AND EDGED TOOL BY USING THE SAME

TECHNICAL FIELD

[0001] The present invention relates to a titanium based sintering composition in which NiB hard particles are dispersed in a titanium alloy matrix and a sintered composite material prepared using the same. In particular, the present invention relates to an abrasion-resistant titanium based composite material having excellent sinterability. Furthermore, the present invention relates to an edged tool made using the abrasion-resistant titanium based composite material.

BACKGROUND ART

[0002] Titanium alloys have relative strength and relative toughness higher than those of super strength steels, high tensile aluminum alloys, and the like and, therefore, are used for strength components and the like of aircraft and racing cars, for example.
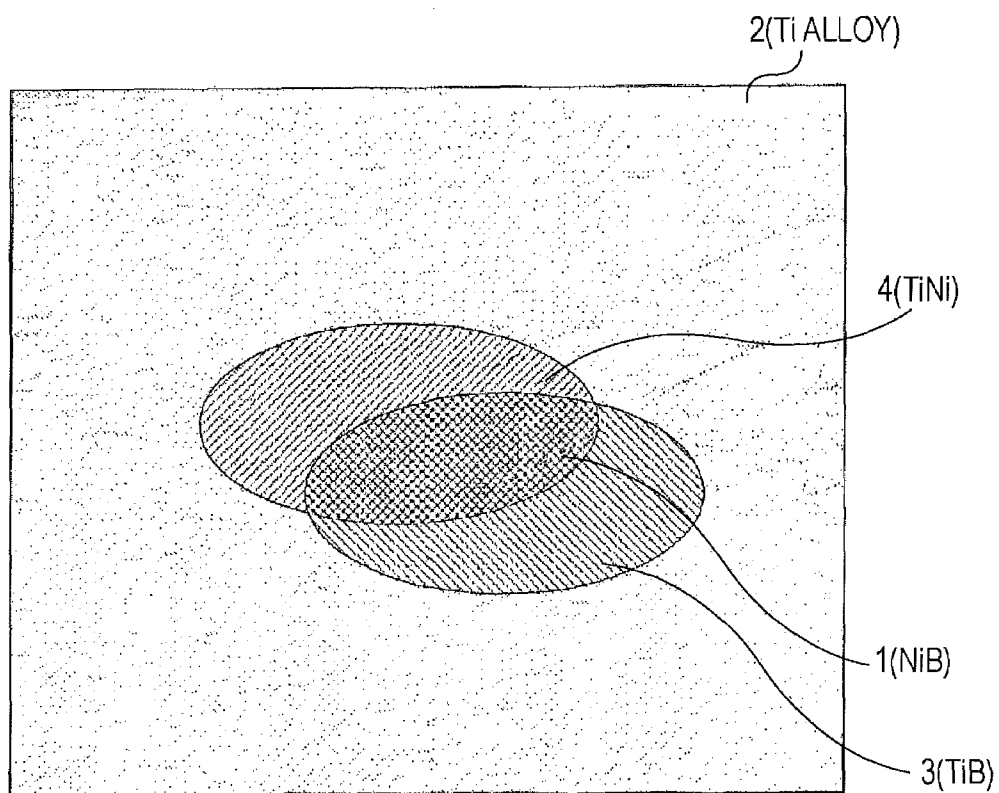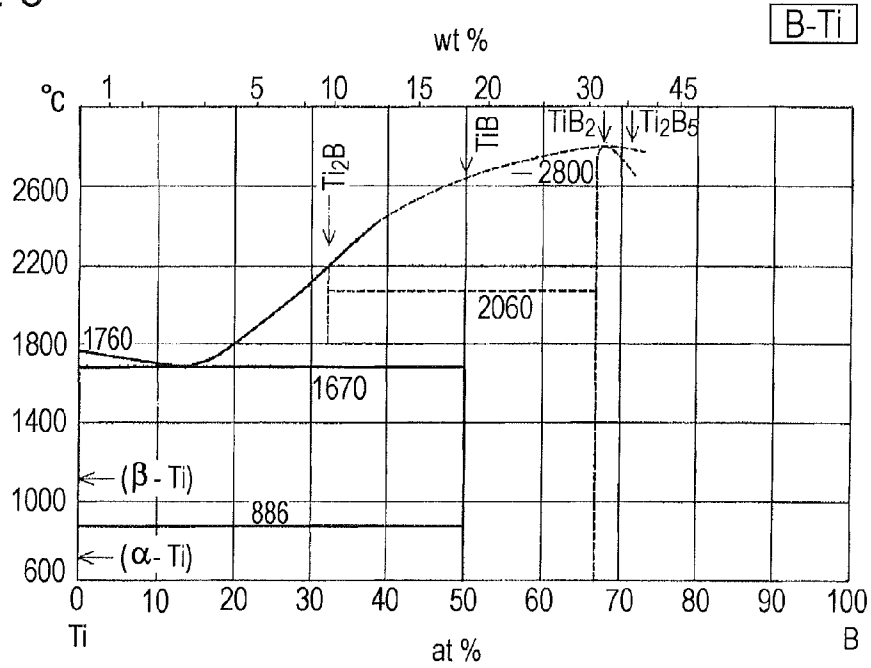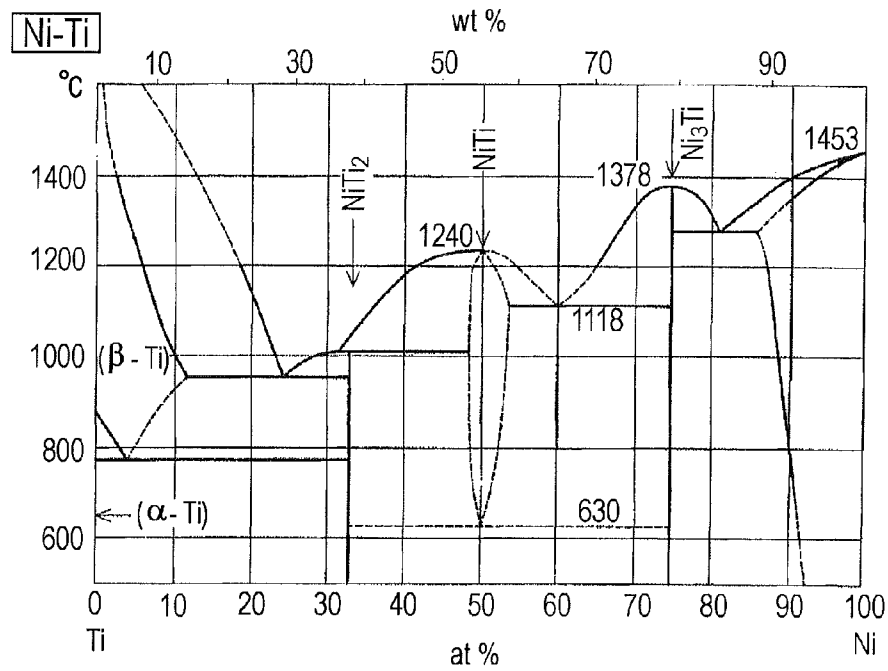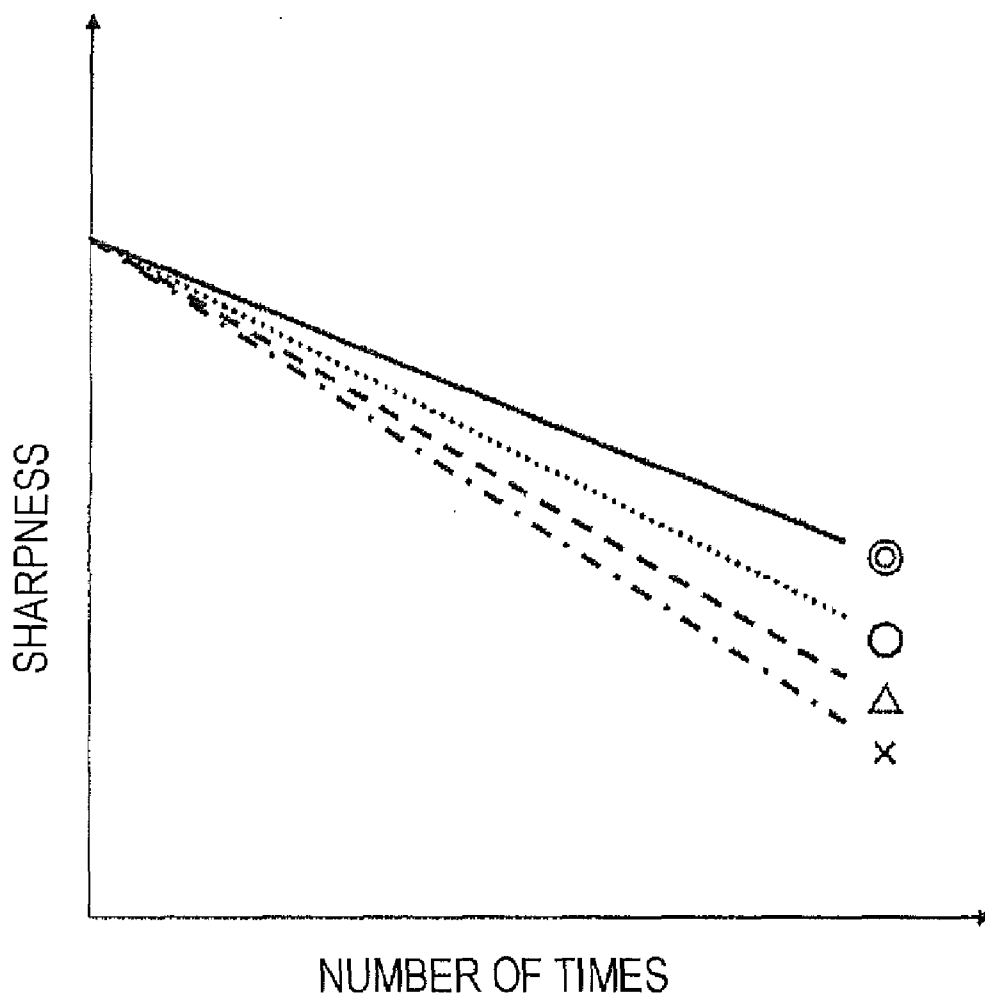
[0003] Recently, in order to further improve the characteristics, e.g., the heat resistance, the stiffness, and the abrasion resistance, of the titanium alloy, a composite material in which hard particles are dispersed in the titanium alloy has been developed. Particles of TiC, TiN, SiC, TiB, and the like are used as the dispersion particles.

[0004] Regarding this Ti based composite material, a Ti based composite material in which TiB particles are dispersed in a Ti alloy by using a powder metallurgy process and a method for manufacturing a powder alloy laminated material "Titanium Diboride/Titanium Alloy Metal Matrix Microcomposite and Process for Powder Metal Cladding" (Patent Document 1) has been proposed. It is described that the resulting alloy composition has excellent strength, stiffness, and abrasion resistance. However, with respect to the TiB particle dispersion type composite material, TiB and a Ti alloy do not achieve thermodynamic equilibrium at high temperatures. Therefore, production of this composite material is predicated on that sintering is conducted at low temperatures, at which the reaction does not proceed easily, and furthermore under high pressure. Consequently, there is a problem in that production cost becomes significantly high.

[0005] Then, as for a method for increasing density inexpensively with high productivity, a Ti alloy for sintering a high density powder has been proposed, in which the amounts of Fe, Mo, Al, V, and O are specified, and the remainder is composed of Ti and incidental impurities (Patent Document 2). In this method, in order to conduct sintering densely at low temperatures in a short time, Fe having a high diffusion rate in the Ti alloy and Mo having a low diffusion rate are combined. However, this method has not yet improved the low stiffness, which is a disadvantage of the Ti alloy.

[0006] Consequently, in recent years, a technology of using a temporary liquid phase primarily containing Ti—Mo—B, which is generated at a temperature slightly lower than the sintering temperature, as a sintering-promotion phase has been proposed, wherein the sintering-promotion phase contains B as a constituent element that can become TiB, which effective as reinforcing particles in the Ti alloy, after the sintering, so as to improve the strength, the stiffness, and the abrasion resistance of the resulting sintered Ti alloy material (Patent Document 3).

[0007] [Patent Document 1] U.S. Pat. No. 4,968,348

[0008] [Patent Document 2] Japanese Unexamined Patent Application Publication No. 5-171321

[0009] [Patent Document 3] Japanese Unexamined Patent Application Publication No. 11-92843

DISCLOSURE OF INVENTION

Problems to be Solved by the Invention

[0010] However, if a liquid phase primarily containing Ti—Mo—B is used as the sintering-promotion phase, sintering does not proceed satisfactorily (relatively slow). This may be because a difference in specific gravity between Ti and Mo hinders formation of the liquid phase during sintering. Therefore, there are disadvantages that not only an unsatisfactory sintering density is obtained, but also the cost of the Ti based composite material increases because of addition of Mo.

Means for Solving the Problems

[0011] In consideration of the problems described above, the present invention is a composite material characterized by including a Ti alloy matrix containing Ti as a primary component and TiB and NiB dispersed in the Ti alloy matrix.

[0012] Furthermore, the present invention is an edged tool including the composite material as an edge portion.

[0013] Furthermore, the present invention is a method for manufacturing a composite material, characterized by including the step of conducting sintering by using a mixed powder containing a Ti powder and/or a Ti alloy powder containing Ti as a primary component and a NiB powder.

[0014] Moreover, the present invention provides a sintering composition usable as a sintering-promotion phase instead of MoB, and the gist thereof is characterized by being a mixed powder including a Ti powder and/or a Ti alloy powder containing Ti as a primary component and a NiB powder.

ADVANTAGES

[0015] According to the present invention, the sintering density can be improved as compared with that in the case where MoB serves as a sintering-promotion phase, and an abrasion-resistant titanium based composite material can be obtained, in which TiB and NiB are dispersed in a Ti alloy including a base material (matrix) composed of at least one of an α phase and a β phase containing Ti as a primary component.

BRIEF DESCRIPTION OF DRAWINGS

[0016] FIG. 1 is a structural diagram of a composite material according to the present invention before sintering.

[0017] FIG. 2 is a structural diagram of a composite material according to the present invention after sintering.

[0018] FIG. 3 is a magnified diagram of NiB shown in FIG. 1.

[0019] FIG. 4 is a magnified diagram of TiNi, NiB, and TiB shown in FIG. 2.

[0020] FIG. 5 is a phase diagram of Ti and B.

[0021] FIG. 6 is a phase diagram of Ti and Ni.

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[0022] FIG. 7 is a diagram showing abrasion resistance of a composite material according to the present invention.

REFERENCE NUMERALS

[0023] 1 NiB, 2 Ti alloy, 3 TiB, 4 TiNi

BEST MODES FOR CARRYING OUT THE
INVENTION

[0024] FIG. 1 is a structural diagram of a composite material according to the present invention before sintering, and FIG. 2 is a structural diagram after sintering. In the composite material after sintering, a part of dispersed Ni is present as a β phase (reference numeral 4 in the drawing) of an intermetallic compound TiNi independent of TiB (reference numeral 3 in the drawing) and an α phase or a β phase (reference numeral 2 in the drawing) of Ti. The remainder Ni is present in the state of a NiB phase (reference numeral 1 in the drawing). FIG. 3 is a magnified diagram of NiB, TiB, and TiNi (NiTi) present in a Ti alloy matrix before sintering. At least a part of the compound NiB decomposes into Ni atoms and B atoms during heating (for example, 1200° C. or higher) in the sintering. The Ni atoms and the B atoms diffuse in the Ti alloy matrix individually. Subsequently, in a region in which Ni atoms are present, the Ni atoms are bonded to Ti atoms in the Ti alloy matrix so as to form an intermetallic compound TiNi during heating in the sintering and/or cooling. On the other hand, in a region in which B atoms are present, the B atoms are bonded to Ti atoms in the Ti alloy matrix so as to form a compound TiB. Furthermore, in a region in which both Ni atoms and B atoms are present, NiB is formed. Therefore, a composite material containing TiB, NiB, and TiNi, as shown in FIG. 2 and FIG. 4, can be obtained by sintering. In the distribution of B and Ni in FIG. 2, a portion where B and Ni are overlapped becomes the NiB phase, and a portion where merely B is present becomes the TiB phase. As a result, the above-described presence of TiB and NiB is supported. Consequently, the TiNi phase, the TiB phase, the Ti phase, and the NiB phase are present.

[0025] A difference in specific gravity between Ti, which is a primary component, and Ni is smaller than that between Ti and Mo. Therefore, homogeneous dispersion occurs and an improvement of sintering density can be facilitated. It is believed that presence of the NiB phase in the region where the TiNi phase and the TiB phase are overlapped strengthens the coupling of the TiNi phase and the TiB phase and reduces elimination of particles of the TiB phase. Consequently, the presence of the NiB phase is important.

[0026] Addition of 0.1 to 5 percent by weight of Ag to the above-described composite material results in an abrasion-resistant titanium based composite material having an excellent antimicrobial property and, therefore, being useful as an edged tool composite material used for edge portions of edged tools, e.g., knives, kitchen knives, and cutting drills.

[0027] Furthermore, halides contained in the above-described composite material are less than or equal to the detection limit (5 ppm) of X-ray fluorescence analysis and, therefore, a titanium based composite material exhibiting excellent abrasion resistance is produced.

[0028] The sintered Ti alloy material of the present invention is a sintered Ti alloy material including a matrix containing a Ti alloy as a primary component and TiB and NiB dispersed and held in the matrix, and the TiNi phase, the TiB phase, the Ti phase, and the NiB phase are present.

[0029] The sintered Ti alloy material of the present invention exhibits excellent strength, stiffness, abrasion resistance, and fatigue characteristic. This is, the TiB and NiB solid solutions can coexist so as to enhance the strength, the stiffness, the abrasion resistance, and the heat resistance of the sintered Ti alloy of the present invention and, thereby, high-density sintered Ti alloy material can be obtained.

[0030] The mechanism of densification for obtaining a high-density sintered Ti alloy is not quite certain now. However, it is believed to be based on that a part of the added NiB is decomposed into Ni and B, a part of the dispersed Ni forms a solid solution with Ti so as to present as a β phase of TiNi independently of the α phase of TiB and Ti, and the other Ni is present in the state of the NiB phase.

[0031] Initially, interaction energy between individual constituent elements in the Ti alloy in the vicinity of the sintering temperature is considered. That is, Ti—B and Ni—B have high affinity for βTi alloy, and Ti—B has the highest attraction force. On the other hand, Ti—Ni exhibits repulsion. This indicates that in the case where Ni coexists with B in Ti, it is difficult to form a solid solution with Ti.

[0032] Next, the solid solubility of each element into Ti and the temperature dependence of the diffusion coefficient in Ti are considered. In this consideration, the phase diagram of Ti and B shown in FIG. 5 and the phase diagram of Ni and Ti shown in FIG. 6 are used. Regarding the solid solubility of B and Ni into Ti (for example, the solid solubility at a sintering temperature of 1,200° C. or higher), B (ppm)<<Ni holds as is clear from phase diagrams shown in FIG. 5 and FIG. 6. The diffusion coefficient of B is not certain because detailed data are not available. However, in consideration of the very small solid solubility thereof, it is concluded that long-range diffusion in a βTi phase is difficult. The diffusion coefficient of Ni is much smaller than the self diffusion coefficient of Ti and is one-tenth that of Ti.

[0033] The distribution of each element in the vicinity of grain boundaries at a temperature slightly lower than the sintering temperature is considered on the basis of the above-described behavior of each element in the vicinity of the sintering temperature. In the βTi phase, B can hardly move and, therefore, begins to react with Ti on the surface of the Ti powder to form TiB. Ni is allowed to cohere at grain boundaries on the basis of the interaction with Ti. This means that in a system including B, a local liquid phase of Ti—Ni—B appears at grain boundaries at a temperature slightly lower than the sintering temperature in B rich portions, while B coheres at grain boundaries.

[0034] This locally generated liquid phase disappears gradually as Ni diffuses along with sintering, and a brittle phase or a melt-off pore, which is concerned in usual liquid phase sintering, is not generated. That is, as for the Ti—Ni—B based Ti alloy material, this temporary liquid phase has a function of facilitating densification. The present invention has been made on the basis of the above-described findings and takes advantage of the interactions between Ti and Ni and between Ti and B. That is, the present invention relates to a sintered Ti alloy material characterized in that densification is conducted while the temporary liquid phase of Ti—Ni—B, which is generated at a temperature slightly lower than the sintering temperature on the basis of the interaction between Ti, Ni, and B, serves as a sintering-promotion phase.

[0035] The content of NiB constituting the sintered Ti alloy material of the present invention is 0.6 to 4.8 percent by

weight (hereafter % refers to percent by weight unless otherwise specified) in the state before sintering (compact). If the NiB content is less than 0.6%, the liquid phase necessary and sufficient for densification is not supplied in the vicinity of grain boundaries. If the NiB content exceeds 4.8%, large amounts of TiB grains deposit, so that densification becomes unsatisfactory and the toughness is reduced. Furthermore, as described above, a part of this NiB is decomposed during sintering so as to form TiB and, therefore, the NiB content of the composite material (in the state after sintering) is preferably 0.3% to 2.4%.

[0036] In order to conduct these reactions smoothly, Cl is required to be controlled at a low level, and preferably, the Cl content in the composite material is 0.03% or less. Regarding a method for reducing the Cl content, chlorine is removed (dehalogenation) from a chlorine compound through the use of a strong reduction reaction due to metal sodium, so that the compound can be made harmless. Examples thereof include a method in which an object substance is dried to nearly absolute dry and, thereafter, is mixed with a trace amount of sodium while grinding is conducted in a reducing gas (nitrogen gas) atmosphere by using a ball mill or the like so as to produce stable sodium chloride, and the resulting sodium chloride is removed, if necessary.

[0037] Although Mo does not become an inhibition factor, it is preferable that Mo is not used because the cost increases.

[0038] Furthermore, Al can be contained in the sintered Ti alloy material of the present invention. An Al element strengthens the αTi phase by forming a solid solution and has high effects of improving strength and, in addition, improving Young's modulus. Moreover, addition of Al has a function of suppressing generation of an ω phase which causes embrittlement of the βTi alloy. The sintered Ti alloy material containing Al has both of excellent strength and excellent toughness. Preferably, the Al content is 0.1% to 6.0% relative to 100 percent by weight of sintered Ti alloy material. If the Al content is less than 0.1%, an effect of improving the strength is not obtained. If the Al content exceeds 6.0%, TiAl deposits and the toughness deteriorates. Therefore, it is preferable that the composition range of Al is 0.1% to 6.0%. The Ti alloy matrix of the sintered Ti alloy material (composite material) according to the present invention is either the αTi alloy or the βTi alloy and, as described above, addition of Al is useful for both the αTi alloy or the βTi alloy.

[0039] It is preferable that the sintered Ti alloy material containing Al contains Fe, Co, or Cu. Specific examples thereof can include an alloy material containing 0.6% to 4.8% of NiB and at least one of 1.0% to 7.0% of Fe, 1.0% to 8.5% of Co, and 1.0% to 8.0% of Cu, further containing 0.1% to 6.0% of Al and, in addition, containing 50% or more of Ti and the remainder composed of incidental impurities relative to 100 percent by weight of sintered Ti alloy material.

[0040] Moreover, V, Sn, Zr, Nb, and Mn can be contained in the sintered Ti alloy material of the present invention. The Sn element is a neutral type element (neutral element) which strengthens the αTi phase by forming a solid solution and which has high effects of improving tensile and fatigue strength and, in addition, improving Young's modulus. The Zr element is a complete solid solution type and neutral type element which increases strength by forming a solid solution and which improves Young's modulus besides the improvement of strength, similarly to Sn. The V, Nb, and Mn elements stabilize the βTi phase. In particular, since a function of suppressing generation of TiAl which causes deterioration in

toughness is performed, an effect of increasing the Al content is exerted. In addition, an effect of improving hot and warm workability is also exerted besides an effect of improving heat treatment characteristics.

[0041] Preferably, the V content is 0.1% to 4.0% relative to 100 percent by weight of sintered Ti alloy material. If the V content is less than 0.1%, a strengthening function and a β stabilization function are unsatisfactory. If the content exceeds 4.0%, the β stabilization function is too strong so as to cause deterioration in toughness. Preferably, the Nb content is 1.0% to 4.0% relative to 100 percent by weight of sintered Ti alloy material.

[0042] The Nb element has a function of improving the strength characteristic at high temperatures due to coexistence with Ni. If the Nb content is less than 1%, the effect thereof is unsatisfactory. If the content exceeds 4.0%, the β stabilization function is too strong so as to cause deterioration in toughness.

[0043] Preferably, the Sn content is 1.0% to 5.0% relative to 100 percent by weight of sintered Ti alloy material. If the Sn content is less than 1%, a strengthening function and a β stabilization function are unsatisfactory. If the content exceeds 5.0%, the density increases and TiAl deposits so that the toughness deteriorates. Preferably, the Zr content is 1.5% to 6.0% relative to 100 percent by weight of sintered Ti alloy material. If the Zr content is less than 1.5%, the effect thereof is unsatisfactory. If the content exceeds 6.0%, large amounts of fine intermetallic compounds with Ti and Si deposit so as to cause deterioration in toughness.

[0044] Preferably, the Mn content is 1.0% to 6.0% relative to percent by weight of sintered Ti alloy material. If the Mn content is less than 1%, a strengthening function and a stabilization function are unsatisfactory. If the content exceeds 6.0%, the β stabilization function is too strong so as to cause deterioration in toughness.

[0045] Preferable examples of sintered Ti alloy material containing V, Sn, Zr, Nb, and Mn can include an alloy material containing 0.6% to 4.8% of NiB (in the state before sintering), at least one of 1.0% to 7.0% of Fe, 1.0% to 8.5% of Co, and 1.0% to 8.0% of Cu, and 0.1% to 6.0% of Al, further containing at least one of 0.1% to 4.0% of V, 1.0% to 5.0% of Sn, 1.5% to 6.0% of Zr, 1.0% to 4.0% of Nb, and 1.0% to 6.0% of Mn, and in addition, containing 50 percent by weight or more of Ti and the remainder composed of incidental impurities relative to 100 percent by weight of sintered Ti alloy material.

[0046] This sintered Ti alloy material is a sintered Ti alloy material exhibiting, in particular, excellent, well-balanced strength-toughness, wherein a liquid phase of Ti-at least one of Fe, Co, and Cu—Ni—B generated during sintering is used as a sintering-promotion phase. A method for manufacturing a high-density sintered Ti alloy material according to the present invention is characterized by conducting a sintering powder preparation step in which a sintering powder at least containing 50% or more of Ti powder and 0.6% to 4.8% of B and Ni constituent powders (in such a way that the total of B and Ni becomes 0.6% to 4.8% and an atomic value ratio becomes B:Ni=1:1) or an alloy powder (for example, a NiB compound powder), where the whole is assumed to be 100%, is prepared, a molding step in which the resulting sintering powder is molded into a predetermined shape so as to produce a compact, and a sintering step in which the resulting compact is heated to a sintering temperature and, thereby, a liquid phase composed of Ti—Ni—B is formed and then allowed to disappear so as to produce a sintered compact of the sintered

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Ti alloy material having a matrix containing the Ti alloy as a primary component and TiB dispersed and held in the matrix. Here, in order to exert the effects, e.g., abrasion resistance, of the present invention satisfactorily, presence of NiB after the sintering is necessary. Therefore, it is preferable that B and Ni are added at the same time in the form of a NiB powder or a Ni—B alloy powder rather than B and Ni are added independently. It is particularly preferable that the NiB powder is used.

[0047] The sintering powder preparation step is a step in which a Ti powder, a constituent powder or a mother alloy powder containing at least one of Fe, Co, and Cu, B, and Ni, and furthermore, NiB, if necessary, are prepared individually at first, and then these raw material powders are mixed so as to produce a mixed powder (sintering powder) serving as a molding raw material. In the present step, a known powder mixing method can be adopted. Therefore, a homogeneous mixed powder of individual raw material powders can be obtained without executing any specific means.

[0048] The following molding step is a step in which the prepared sintering powder is molded into a predetermined shape in a molding die or the like so as to produce a compact. The molding of the sintering powder is conducted by using a known metal powder molding technique at a commonly-used pressure and, thereby, a compact (green compact) taking a predetermined shape and having strength sufficient for handling can be obtained easily. The following sintering step is a step in which the resulting compact is heated so as to sinter. The sintering of the compact can be conducted in a vacuum or protective atmosphere (for example, an inert atmosphere or a reducing atmosphere) in a furnace at a commonly-used temperature for a commonly-used time. At this time, a temporary liquid phase of Ti—Ni—B, which serves effectively as a sintering-promotion phase, is formed at a temperature slightly lower than the sintering temperature. Therefore, a sintered compact having a desired density is obtained by the present step, so that a bulk material in a desired shape can be produced. Furthermore, the present manufacturing method is a manufacturing method following a common powder metallurgy technology. Since easily available raw material powders and already-existing facilities can be used, a high-density sintered Ti alloy material can be produced inexpensively.

[0049] In the above-described sintering powder preparation step, a sintering powder further containing at least one of Fe, Ni, Co, Cu, Al, V, Sn, Zr, Nb, and Mn can be produced. In particular, in preparation of the sintering powder containing Fe and Ni, it is possible to add Fe and Ni as an alloy of Fe and Ni, or add individual constituent alloy elements as borides.

[0050] In the method for manufacturing a sintered Ti alloy material according to the present invention, in either case where the constituent powder or the alloy powder serves as the raw material for the sintering powder, the mechanism of formation of the temporary liquid phase is not influenced. Therefore, the type of the raw material is not limited.

[0051] The Fe—Ni alloy is a commonly-used material as a melting raw material and has excellent grindability and, therefore, any specific melting method or grinding method is not required. Likewise, various boride powders are commercially available in general and, therefore, any specific melting method is not required. Consequently, a desired sintered Ti alloy material can be obtained at a low cost without using any specific means.

[0052] A sintered Ti alloy material, in which the sintered Ti alloy material composed of Ti, B, Ni according to the present invention contains at least one of Fe, Ni, Co, and Cu, has a high density and, in addition, has excellent characteristics, e.g., high stiffness, high strength, and abrasion resistance. That is, even in the case where large amounts of TiB particles are made into a composite, while only TiB is thermodynamically stable in the Ti alloy, a dense sintered composite can be obtained by forming a temporary liquid phase of Ti-at least one of Fe, Co, and Cu—Ni—B, which serves effectively as a sintering-promotion phase, at a temperature slightly lower than the sintering temperature. Therefore, excellent characteristics, e.g., high stiffness, high strength, and abrasion resistance, can be exhibited. In particular, since Fe, Co, and Cu are contained, a (β+TiB+Liquid) phase becomes stable at lower temperatures and, thereby, a high-density sintered Ti alloy material can be obtained in a short time.

[0053] Ti alloys are materials frequently used as lightweight, high-strength materials in aviation, space, and military fields. However, since the production cost is significantly high, there is no example in which the Ti alloy has been applied to mass-production components, in particular mass-production specific components in which steels have been frequently used. Furthermore, not only in cost, but also in characteristics, needs of automobile component designers are not satisfied, for example, the stiffness is low (about half) and the abrasion resistance is poor as compared with those of steels.

[0054] The sintered Ti alloy material of the present invention can satisfy these needs. Therefore, the sintered Ti alloy material of the present invention can be applied to components and the like burdened with the above-described requirements and can be applied to, for example, automobile engine components, various sporting goods components, and tools. Specific examples of application to automobile engine components include valve retainers, valve lifters, and connecting rods. Furthermore, typical examples of sporting goods components include golf driver heads, irons, and putters.

[0055] Valve retainers, valve lifters, and connecting rods are required to have the mass productivity, as a matter of course, and excellent cold, warm, and hot workability from the viewpoint of a production process of automobile components. Furthermore, in order to satisfy the function thereof, high strength, in particular, high fatigue strength is required. Therefore, a sintered Ti alloy material containing 0.6% to 4.8% of NiB (0.3% to 2.4% after sintering), at least one of 1.0% to 7.0% of Fe, 1.0% to 8.5% of Co, and 1.0% to 8.0% of Cu, and 0.1% to 6.0% of Al, further containing 0.1% to 4.0% of V, and in addition, containing 50% or more of Ti and the remainder composed of incidental impurities, where the whole is assumed to be 100%, is favorable.

[0056] Edged tool composite materials are required to have not only excellent abrasion resistance, but also an antimicrobial property from the viewpoint of some uses. Therefore, the sintered Ti alloy material of the present invention containing at least 0.6% to 4.8% of NiB (before sintering, 0.3% to 2.4% after sintering), at least one of 1.0% to 7.0% of Fe, 1.0% to 8.5% of Co, and 1.0% to 8.0% of Cu, and 0.1% to 6.0% of Al, further containing 0.1% to 4.0% of V, and in addition, containing 0.1 to 5 percent by weight of Ag, 50% or more of Ti, and the remainder composed of incidental impurities, where the whole is assumed to be 100%, is favorable.

[0057] In the present invention, a liquid phase of Ti—B serving as a sintering-promotion phase is generated during the sintering process by containing at least NiB. No example has been reported previously, in which a temporary liquid

phase is generated through the use of physical phenomena (characteristics), e.g., interaction energy, diffusion, and solid solubility, and thereby, densification is conducted. Regarding the sintered Ti alloy material of the present invention, as for an alloy composition to obtain a dense sintered Ti alloy material at low temperatures in a short time for the purposes of cost reduction and improvement of productivity, a sintered Ti alloy material containing at least one of Fe, Ni, Co, and Cu besides B and Ni is preferable. Furthermore, it is more preferable that a constituent powder or a mother alloy powder containing at least one of V, Sn, Zr, Nb, and Mn is added to the above-described sintered Ti alloy material containing at least one of Fe, Ni, Co, and Cu besides B and Ni because a high-density sintered Ti alloy material having excellent strength-toughness balance can be obtained.

[0058] A method for manufacturing the sintered Ti alloy material will be described below. Regarding the method for manufacturing a sintered Ti alloy material, initially, a Ti powder, a constituent powder or a mother alloy powder (or compound powder) including B and Ni, furthermore a constituent powder or a mother alloy powder containing at least one of Fe, Ni, Co, and Cu in the case where the productivity is considered, and moreover a constituent powder or a mother alloy powder containing at least one of V, Sn, Nb, and Mn for obtaining excellent strength-toughness balance are mixed so as to produce a sintering powder (sintering powder preparation step). Next, the resulting sintering powder is molded into a predetermined shape so as to produce a compact (molding step). The resulting compact is heated to form a liquid phase and, thereafter, the liquid phase is allowed to disappear so as to produce a sintered compact of a sintered Ti alloy material having a matrix containing the Ti alloy as a primary component and TiB dispersed and held in the matrix (sintering step). This sintering powder can be used for producing a high-density sintered Ti alloy material inexpensively by using a temporary liquid phase of Ti—Ni—B, which serves effectively as a sintering-promotion phase at a temperature slightly lower than the sintering temperature, as the sintering-promotion phase.

[0059] The Ti powder used in the sintering powder preparation step may be any commercially available Ti powder. For example, a powder, e.g., a sponge titanium powder, a hydrogenation-dehydrogenation powder, a titanium hydride powder, or an atomized titanium powder, can be used on an acquisition basis. Here, the particle diameters of many commercially available powders are adjusted at about 150 μm (−#100) or less. It is more preferable that the particle diameter of the Ti powder is 45 μm or less because the sintered compact is easily densified.

[0060] It is preferable that B and Ni are added at the same time in the form of a compound NiB powder or a mixed powder of B and Ni rather than B and Ni are added independently by using constituent powders of individual elements. It is particularly preferable that the NiB powder is used. This is because Ni atoms are present in the vicinity of B atoms and, thereby, NiB is formed easily during sintering and the characteristics, e.g., the abrasion resistance, can be improved reliably.

[0061] As for the constituent powder or the mother alloy powder containing at least one of Fe, Ni, Co, and Cu, at least one of V, Sn, Zr, Nb, and Mn, B, and Ni, any product which is commercially available, produced by a known method, or the like may be used. In particular, in the case where the sintered Ti alloy material is produced inexpensively by using a liquid phase of Ti—Fe—Ni—B as a sintering-promotion phase, it is practical and desirable that Fe and Ni are added as an alloy of Fe and Ni or individual constituent elements are added as borides. It is preferable that the alloy powder or boride powder of a few micrometers is used. If a powder larger than that is acquired, preferably, the powder is used after grinding and adjustment are conducted to obtain a desired particle size with various grinders, e.g., ball mills, vibration mills, and attritors.

[0062] In this regard, the mixing method used in the sintering powder preparation step is not specifically limited. A V-type mixer, a ball mill, a vibration mill, or the like can be used. However, in the case where the boride particles of the powder are secondary particles or the like resulting from significant aggregation, an agitation mixing treatment with a high-energy ball mill, e.g., an attritor, in an inert gas atmosphere is effective at activating densification.

[0063] Any molding method is employed insofar as a desired shape can be obtained by the method. Any method of die molding, CIP molding, RIP molding, SPS molding, and the like may be used. In this regard, the molding pressure is not specifically limited insofar as compact strength sufficient for handling is obtained. In the sintering step, it is desirable that the atmosphere is in a vacuum or an inert gas atmosphere. Furthermore, it is preferable that the sintering is conducted at a temperature range of 1,200° C. to 1,300° C. for about 1 to 16 hours. If the sintering is conducted at lower than 1,200° C. and for less than 1 hour, the liquid phase required for densification is not sufficiently supplied to the vicinity of grain boundaries. If the sintering is conducted at a temperature higher than 1,300° C. and for 16 hours or more, there is no economy from the viewpoint of energy.

[0064] It is more preferable that hot working is conducted after the sintering step. As for the hot working method, a HIP treatment, hot forging, extrusion, swaging, and the like are used. Regarding the working temperature, it is desirable that the working is conducted within the range of 700° C. to 1,200° C. In the working at lower than 700° C., the deformation resistance is significant. In the case where the temperature is higher than 1,200° C., oxidation is significant, and unfavorably, material characteristics may be adversely affected thereafter or fine cracks may be formed in the surface during hot working.

EXAMPLES

First Example

[0065] As for raw material powders, a Ti powder (average particle diameter: 75 μm), a Ni—B powder (NiB compound powder) (average particle diameter: 75 μm), and a Ag powder (average particle diameter: 50 μm) were prepared. Next, the Ti powder, the Ni—B powder, and the Ag powder were blended at a ratio shown in Table 1 so as to produce a sintering powder. The resulting sintering powder was molded at a pressure of 3 ton/cm^2 into a shape of 20 mm in diameter×10 mm. Then, the resulting compact was sintered in a vacuum of 1.3×10^3 Pa at 1,300° C. for 1 hr. (Sample Number: 1)

TABLE 1

		NiB Powder		Ti Alloy Powder						
	Sample Number	Composite or Simple Substance	NiB (wt %)	Composite or Simple Substance	Ti (wt %)	Al (wt %)	V (wt %)	Ag (wt %)	Relative Density (%)	Abrasion Resistance
1st Example	1	Composite	2.7		Remainder	0	0	1	98.5	Δ
2nd Example	2	Composite	2.7	Simple Substance	Remainder	3	2	1	98.3	⊙
3rd Example	3	Composite	2.7	Composite	Remainder	3	2	1	97.6	⊙
3rd Example	4	Composite	2.7	Composite	Remainder	0.1	2	1	98.3	Δ
3rd Example	5	Composite	2.7	Composite	Remainder	6	2	1	98.1	○
3rd Example	6	Composite	2.7	Composite	Remainder	3	0.1	1	98.5	Δ
3rd Example	7	Composite	2.7	Composite	Remainder	3	4	1	98.2	○
3rd Example	8	Composite	0.6	Composite	Remainder	3	2	1	99	Δ
3rd Example	9	Composite	2.4	Composite	Remainder	3	2	1	98.5	⊙
3rd Example	10	Composite	4.8	Composite	Remainder	3	2	1	97.3	⊙
3rd Example	11	Composite	2.7	Composite	Remainder	0.05	2	1	96.7	Δ
3rd Example	12	Composite	2.7	Composite	Remainder	6.5	2	1	95.5	Δ
3rd Example	13	Composite	2.7	Composite	Remainder	3	0.05	1	96.1	Δ
3rd Example	14	Composite	2.7	Composite	Remainder	3	4.5	1	96	Δ
3rd Example	15	Composite	0.5	Composite	Remainder	3	2	1	97.4	Δ
3rd Example	16	Composite	4.9	Composite	Remainder	3	2	1	96	Δ
1st Comparative Example	C1	Simple Substance	2.7	Simple Substance	Remainder	3	2	0	93.5	x
2nd Comparative Example	C2	Simple Substance	2.7	Composite	Remainder	3	2	0	93.1	x

Second Example

[0066] As for raw material powders, a Ti powder (average particle diameter: 75 μm), an Al powder (average particle diameter: 75 μm), a V powder (average particle diameter: 75 μm), a Ni—B powder (NiB powder) (average particle diameter: 75 μm), and a Ag powder (average particle diameter: 50 μm) were prepared. Next, the Ti powder, the Al powder, the V powder, the Ni—B powder, and the Ag powder were blended at a ratio shown in Table 1 so as to produce a sintering powder. The resulting sintering powder was molded at a pressure of 3 ton/cm^2 into a shape of 20 mm in diameter×10 mm. Then, the resulting compact was sintered in a vacuum of 1.3×10^3 Pa at 1,300° C. for 1 hr. (Sample Number: 2).

Third Example

[0067] As for raw material powders, an alloy powder composed of Ti—Al—V (average particle diameter: 75 μm), a Ni—B powder (NiB powder) (average particle diameter: 75 μm), and a Ag powder (average particle diameter: 50 μm) were prepared. Next, the Ti—Al—V alloy powder, the Ni—B powder, and the Ag powder were blended at a ratio shown in Table 1 so as to produce a sintering powder. The resulting sintering powder was molded at a pressure of 3 ton/cm^2 into a shape of 20 mm in diameter×10 mm. Then, the resulting compact was sintered in a vacuum of 1.3×10^3 Pa at 1,300° C. for 1 hr. (Sample Numbers: 3 to 16).

First Comparative Example

[0068] As for raw material powders, a Ti powder (average particle diameter: 75 μm), a Ni powder (average particle diameter: 75 μm), and a B powder (average particle diameter: 75 μm) were prepared. Next, the Ti powder, the Ni powder, and the B powder were blended at a ratio shown in Table 1 so as to produce a sintering powder. The resulting sintering powder was molded at a pressure of 3 ton/cm^2 into a shape of 20 mm in diameter×10 mm. Then, the resulting compact was sintered in a vacuum of 1.3×10^3 Pa at 1,300° C. for 1 hr. (Sample Number: C1).

Second Comparative Example

[0069] As for raw material powders, an alloy powder composed of Ti—Al—V (average particle diameter: 75 μm), a Ni powder (average particle diameter: 75 μm), and a B powder (average particle diameter: 50 μm) were prepared. Next, the Ti—Al—V alloy powder, the Ni powder, the B powder, and a Ag powder were blended at a ratio shown in Table 1 so as to produce a sintering powder. The resulting sintering powder was molded at a pressure of 3 ton/cm^2 into a shape of 20 mm in diameter×10 mm. Then, the resulting compact was sintered in a vacuum of 1.3×10^3 Pa at 1,300° C. for 1 hr. (Sample Number: C2).

[0070] The relative densities after sintering of First example to Third example, First comparative example, and Second comparative example prepared as described above were measured by an Archimedes method. The densities thereof are collectively shown in Table 1. Furthermore, the abrasion resistance was measured thereafter. The resulting mechanical characteristics thereof are shown in Table 1 for purposes of comparison.

[0071] Regarding evaluation of the abrasion resistance, an evaluation method in which a sample is provided with an edge so as to prepare an edge portion, the edge of the edge portion is touched to test paper under a constant load, cyclic reciprocating motion with each way of 30 mm was performed 128 times at a constant speed, and the number of cut sheets of the test paper was recorded on a cycle basis was adopted. The evaluation can be conducted on the basis of whether stable results are obtained up to the 128th cycle. Regarding the method for measuring the abrasion resistance, the horizontal axis is graduated logarithmically, and the evaluation is con-

ducted on the basis of the slope of the sharpness straight line up to 128 times. The sample exhibiting excellent abrasion resistance is indicated by a mark ⊙, where the slope of graph based on the above-described evaluation method is small. The sample exhibiting good abrasion resistance is indicated by a mark ○. The sample exhibiting abrasion resistance is indicated by a mark Δ. The sample exhibiting no abrasion resistance is indicated by a mark x. FIG. 7 is a diagram showing graphed abrasion resistance.

[0072] As is clear from the results shown in Table 1, the Ti alloy materials of examples according to the present invention have high relative densities of 97% or more and exhibit excellent abrasion resistance. That is, the relative density is high and, in addition, the hardness increases through alloying, so that the abrasion resistance is obtained as compared with comparative examples.

[0073] Regarding C1 and C2, it is clear that since the Ni powder and the B powder are added as simple substances individually, the relative density does not increase, and the abrasion resistance is not exhibited. Furthermore, the antimicrobial property due to a silver ion was recognized sufficiently by adding about 1% of Ag.

[0074] Incidentally, in the present invention, addition of 4.8 percent by weight of NiB to the Ti alloy before sintering results in about 6.3 percent by weight of Ti—Ni, about 0.6 percent by weight of NiB, and about 3.7 percent by weight of TiB relative to the Ti alloy after sintering. Here, NiB powder composite described in Table 1 refers to an alloy powder (NiB compound powder) produced by reacting Ni and B in advance, and simple substance refers to addition of Ni and B as respective simple substance powders. Likewise, Ti alloy powder composite described in Table 1 refers to an alloy powder produced by reacting Ti, Al, and V in advance, and simple substance refers to addition of Ti, Al, and V as respective simple substance powders.

Fourth Example

[0075] As for raw material powders, a Ti powder (average particle diameter: 75 μm), an Al powder (average particle diameter: 75 μm), a V powder (average particle diameter: 75 μm), a NiB powder (NiB compound powder) (average particle diameter: 75 μm), and a Ag powder (average particle diameter: 50 μm) were blended in such a way as to satisfy a composition shown in Table 2 to prepare a sintering powder (composition for composite material). At this time, regarding "addition of B, N in Table 2, the description related to Comparative example 4-2 is "simple substance", wherein a Ni powder and a B powder were used instead of the NiB powder (that is, "composite" refers to use of a BN powder).

[0076] The resulting sintering powder was molded at a pressure of 3 ton/cm² into a shape of 20 mm in diameter×10 mm. Then, the resulting compact was sintered in a vacuum of 1.3×10³ Pa at 1,300° C. for 1 hr.

[0077] In this regard, in Comparative example 4-1, sintering was conducted in a vacuum of 1.3×10³ Pa at 1,200° C. for 1 hr in order to prevent decomposition of NiB. Furthermore, in Example 4-2, sintering was conducted in a vacuum of 1.3×10³ Pa at 1,350° C. for 1 hr. In Example 4-3, sintering was conducted in a vacuum of 1.3×10³ Pa at 1,400° C. for 1 hr.

TABLE 2

Sample	Addition of B, Ni	Composition (wt %)						
		NiB	Al	V	Ag	Cl	Mo	Ti
Example 4-1	Composite	2.4	3	2	3	0	0	Remainder
Comparative Example 4-1	Composite	2.4	3	2	3	0	0	Remainder
Comparative Example 4-2	Simple Substance	2.4 (Atomic value ratio is Ni:B = 1:1)	3	2	3	0	0	Remainder
Example 4-2	Composite	2.4	3	2	3	0	0	Remainder
Example 4-3	Composite	2.4	3	2	3	0	0	Remainder
Example 4-4	Composite	0.4	3	2	3	0	0	Remainder
Example 4-5	Composite	0.6	3	2	3	0	0	Remainder
Example 4-6	Composite	4.8	3	2	3	0	0	Remainder
Example 4-7	Composite	5	3	2	3	0	0	Remainder
Example 4-8	Composite	2.4	0.1	2	3	0	0	Remainder
Example 4-9	Composite	2.4	0.1	2	3	0	0	Remainder
Example 4-10	Composite	2.4	6	2	3	0	0	Remainder
Example 4-11	Composite	2.4	6.1	2	3	0	0	Remainder
Example 4-12	Composite	2.4	3	0.1	3	0	0	Remainder
Example 4-13	Composite	2.4	3	0.1	3	0	0	Remainder
Example 4-14	Composite	2.4	3	4	3	0	0	Remainder
Example 4-15	Composite	2.4	3	4.1	3	0	0	Remainder
Example 4-16	Composite	2.4	3	2	0.1	0	0	Remainder
Example 4-17	Composite	2.4	3	2	0.1	0	0	Remainder
Example 4-18	Composite	2.4	3	2	5	0	0	Remainder
Example 4-19	Composite	2.4	3	2	5.1	0	0	Remainder
Example 4-20	Composite	2.4	3	2	3	0	0	Remainder
Example 4-21	Composite	2.4	3	2	3	0	0	Remainder
Example 4-22	Composite	2.4	3	2	3	0	0	Remainder
Example 4-23	Composite	2.4	3	2	3	0	0	Remainder

[0078] Regarding each sample, presence or absence of a Ti alloy matrix, TiB, NiB, and TiNi (intermetallic compound), the weight ratio of the TiB content to the NiB content (TiB/NiB ratio), and the composition (contents of NiB, Al, V, Ag, Cl, and Mo), and abrasion resistance test results are shown in Table 3.

[0079] Regarding presence or absence of a Ti alloy matrix, TiB, NiB, and TiNi (intermetallic compound), each sample was subjected to structure observation with a transmission electron microscope (TEM) provided with EELS (electron energy loss spectroscopy) and, in addition, check was conducted on the basis of element mapping by using the EELS. A phase in which Ti and B are primarily present was assumed to be the TiB phase, a phase in which Ni and B are primarily present was assumed to be the NiB phase, and a phase in which Ti and Ni are primarily present was assumed to be the TiNi phase.

TABLE 3

| Sample | Result of TEM Observation | | | | | Composition (wt %) | | | | | | | Abrasion |
	Ti Alloy Matrix	TiB	NiB	TiNi	TiB/NiB	NiB	Al	V	Ag	Cl	Mo	Ti	Resistance
Example 4-1	Present	Present	Present	Present	0.9	1.2	3	2	3	0.02	0.02	Remainder	⊙
Comparative Example 4-1	Present	Absent	Present	Present		1.2	3	2	3	0.02	0.02	Remainder	x
Comparative Example 4-2	Present	Present	Absent	Present			3	2	3	0.02	0.02	Remainder	x
Example 4-2	Present	Present	Present	Present	1	1.14	3	2	3	0.02	0.02	Remainder	○
Example 4-3	Present	Present	Present	Present	1.1	1.09	3	2	3	0.02	0.02	Remainder	Δ
Example 4-4	Present	Present	Present	Present	0.9	0.2	3	2	3	0.02	0.02	Remainder	Δ
Example 4-5	Present	Present	Present	Present	0.9	0.3	3	2	3	0.02	0.02	Remainder	○
Example 4-6	Present	Present	Present	Present	0.9	2.4	3	2	3	0.02	0.02	Remainder	○
Example 4-7	Present	Present	Present	Present	0.9	2.5	3	2	3	0.02	0.02	Remainder	Δ
Example 4-8	Present	Present	Present	Present	0.9	1.2	0.05	2	3	0.02	0.02	Remainder	Δ
Example 4-9	Present	Present	Present	Present	0.9	1.2	0.1	2	3	0.02	0.02	Remainder	○
Example 4-10	Present	Present	Present	Present	0.9	1.2	6	2	3	0.02	0.02	Remainder	○
Example 4-11	Present	Present	Present	Present	0.9	1.2	6.1	2	3	0.02	0.02	Remainder	Δ
Example 4-12	Present	Present	Present	Present	0.9	1.2	3	0.05	3	0.02	0.02	Remainder	Δ
Example 4-13	Present	Present	Present	Present	0.9	1.2	3	0.1	3	0.02	0.02	Remainder	○
Example 4-14	Present	Present	Present	Present	0.9	1.2	3	4	3	0.02	0.02	Remainder	○
Example 4-15	Present	Present	Present	Present	0.9	1.2	3	4.1	3	0.02	0.02	Remainder	Δ
Example 4-16	Present	Present	Present	Present	0.9	1.2	3	2	0.05	0.02	0.02	Remainder	○
Example 4-17	Present	Present	Present	Present	0.9	1.2	3	2	0.1	0.02	0.02	Remainder	○
Example 4-18	Present	Present	Present	Present	0.9	1.2	3	2	5	0.02	0.02	Remainder	○
Example 4-19	Present	Present	Present	Present	0.9	1.2	3	2	5.1	0.02	0.02	Remainder	○
Example 4-20	Present	Present	Present	Present	0.9	1.2	3	2	3	0.04	0.02	Remainder	Δ
Example 4-21	Present	Present	Present	Present	0.9	1.2	3	2	3	0.03	0.02	Remainder	○
Example 4-22	Present	Present	Present	Present	0.9	1.2	3	2	3	0.02	0.04	Remainder	○
Example 4-23	Present	Present	Present	Present	0.9	1.2	3	2	3	0.02	0.03	Remainder	○

[0080] The phases determined to be the TiB phase, the NiB phase, and the TiNi phase were analyzed with AES (Auger electron spectroscopy). The atomic value ratios of individual phases of TiB phase, the NiB phase, and the TiNi phase were Ti:B=1:1, Ni:B1:1, and Ti:Ni=1:1, respectively. Therefore, it was able to be ascertained that the phases were compounds in which individual elements were present at stoichiometric composition ratios.

[0081] Regarding the TiB/NiB ratio, a predetermined visual field area, specifically a square region 500 μm long and 500 μm wide (area 250,000 μm²) was subjected to TEM observation, the area ratio of TiB to NiB observed in this region was determined, and a weight ratio was calculated therefrom.

[0082] The method for determining the composition will be described. The B content of each sample was determined by atomic absorption analysis. On the other hand, The Al, Ag, Cl, and Mo contents of each sample were determined by X-ray fluorescence analysis. Subsequently, since B is present in the form of TiN or NiB in the sample, the NiB content of the sample was determined from the B content and the TiB/NiB ratio.

[0083] The abrasion resistance shown in Table 3 was evaluated by the above-described method. An excellent sample was indicated by a mark ⊙, a good sample was indicated by a mark ○, a sample exhibiting the abrasion resistance was indicated by a mark Δ, and a sample exhibiting no abrasion resistance was indicated by a mark x.

[0084] Comparative example 4-1 not containing TiB and 4-2 not containing NiB did not exhibit abrasion resistance. On the other hand, all of Examples 4-1 to 4-23 containing both TiB and NiB exhibited the abrasion resistance. Regarding the composition of Example 4-1, not only Al, V, Ag, Cl, and Mo are within the above-described preferable range, but the composition is the optimum condition of the present invention. As a result, TiB, TiNi, and NiB in the Ti alloy matrix are present while being bonded to each other in a balanced manner, and particularly excellent abrasion resistance was exhibited.

[0085] Regarding the samples of Examples 4-16 to 4-19, the antimicrobial property was also evaluated. As for the antimicrobial property with respect to fungus and legionella, the incidence of microbe was measured and evaluated. Regarding the method for evaluating the incidence of

microbe, the evaluation including a method for analyzing and measuring microbe and a method for cleaning assembly parts, was conducted on the basis of Japanese Industrial Standards (JIS).

[0086] Regarding fungus, a mixed spore suspension of five types of fungi was used on the basis of JIS Z 2911 Methods of test for fungus resistance. A sample was taken from a cultivation surface after cultivation in a PSA culture medium for 10 days, and was filtered. Thereafter, the sample was immersed in ethanol for 1 minute and was dried. The resulting sample was stuck on an object, cultivation was conducted at 28° C. and a relative humidity of 95% for 4 weeks, and if the incidence of microbe was 10^{-2} or less, it was determined that the antimicrobial property was exhibited.

[0087] Regarding legionella, the film adhesion test specified in JIS Z 2801 was followed. Legionella was placed on a surface of a film to adhere the film, and was stuck on a surface of an object. After 24 hours at a temperature of 35° C. and a relative humidity of 90% or more, if the number of microbes thereof was 10 or less, it was determined that the antimicrobial property was exhibited.

[0088] Examples 4-17 to 4-19 containing 0.1% or more of Ag exhibited excellent corrosion resistance to both fungus and legionella. However, if the Ag content exceeds 5%, the cost increases significantly. Therefore, it is desirable that Ag is 5% or less.

[0089] Regarding addition of Mo, Examples 4-22 and 4-24 containing 0.03% and 0.04% of Mo exhibited good abrasion resistance. However, since Mo is an expensive element, it is preferable that addition thereof is 0.03% or less.

1. A sintered composite material, comprising:
a titanium alloy matrix comprising titanium as a primary component; and
TiB and NiB phases dispersed in the titanium alloy matrix.

2. The sintered composite material according to claim 1, wherein the content of the NiB in terms of percent by weight is larger than the content of the TiB in terms of percent by weight.

3. The sintered composite material according to claim 1, further comprising TiNi phases.

4. The sintered composite material according to claim 1, wherein the content of the NiB is 0.3 to 2.4 percent by weight of the composite material.

5. The sintered composite material according to claim 1, further comprising aluminum and vanadium, wherein the content of the aluminum is 0.1 to 6 percent by weight of the composite material and the content of the vanadium is 0.1 to 4 percent by weight of the composite material.

6. The sintered composite material according to claim 1, further comprising silver, wherein the content of the silver is 0.1 to 5 percent by weight of the composite material.

7. The sintered composite material according to claim 1, further comprising chlorine, wherein the content of the chlorine is 0.03 percent by weight of the composite material or less.

8. The sintered composite material according to claim 1, further comprising molybdenum, wherein the content of the molybdenum is 0.03 percent by weight of the composite material or less.

9. An edged tool, comprising:
an edge portion comprising a sintered composite material, wherein the sintered composite material comprises a titanium alloy matrix, TiB and NiB,
wherein the titanium alloy matrix comprises titanium as a primary component, and wherein TiB and NiB phases are dispersed in the titanium alloy matrix.

10.-15. (canceled)

16. A powdered sintering composition comprising:
a mixed powder comprising a NiB powder and at least one of a titanium and a titanium alloy powder, wherein the titanium alloy powder comprises titanium as a primary component.

17. (canceled)

18. The powdered sintering composition according to claim 16, wherein the content of NiB is 0.6 to 4.8 percent by weight of the powdered sintering composition.

19. The sintered composite material according to claim 3, wherein a TiNi phase and a TiB phase are connected via a NiB phase.

20. The edged tool according to claim 9, wherein the content of the NiB in terms of percent by weight is larger than the content of the TiB in terms of percent by weight.

21. The edged tool according to claim 9, wherein the composite material further comprises TiNi phases.

22. The edged tool according to claim 21, wherein a TiNi phase and a TiB phase are connected via a NiB phase.

23. The edged tool according to claim 9, wherein the content of the NiB is 0.3 to 2.4 percent by weight of the composite material.

24. The edged tool according to claim 9, wherein the composite material further comprises aluminum and vanadium, wherein the content of the aluminum is 0.1 to 6 percent by weight of the composite material and the content of the vanadium is 0.1 to 4 percent by weight of the sintered composite material.

25. The edged tool according to claim 9, wherein the composite material further comprises silver, wherein the content of the silver is 0.1 to 5 percent by weight of the sintered composite material.

26. The edged tool according to claim 9, wherein the composite material further comprises chlorine, wherein the content of the chlorine is 0.03 percent by weight of the sintered composite material or less.

27. The edged tool according to claim 9, further comprising molybdenum, wherein the content of the molybdenum is 0.03 percent by weight of the sintered composite material or less.

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