

Description

The present invention relates to a permanent magnet, and more particular, to a rare-earth permanent magnet.

Broadly, there are three types of permanent magnets, that is hard ferrite magnets, alnico magnets and rare-earth magnets. With a recent growing demand for smaller-sized and more efficient electrical appliances for office automation (OA) and facsimile automation (FA), specifically the demand for rare-earth magnets has increased.

It is well known that rare-earth magnets may be classified into three classes according to the production methods, that is, (1) sintered magnets, (2) bonded magnets and (3) cast magnets.

Typical rare-earth magnets are further grouped into two groups according to their composition, that is, (1) rare-earth magnets comprising a rare-earth metal (hereinafter referred to as R) and cobalt, and (2) rare-earth magnets comprising a rare-earth metal and ferrite.

By way of example, EP-B-108474 discloses a magnet which comprises a rare-earth metal and iron, obtained by a rapid-quenching method. EP-B-101552 describes a magnet also comprising a rare-earth metal and iron, obtained by a sintering method. In both cases the magnet mainly consists of Nd, Fe and B.

With the rapid-quenching method, a ribbon-like material having a thickness of 20 μm is first made and is an aggregate of crystals having a diameter of 0.1 - 0.5 μm , which is smaller than the critical diameter of uniaxial particles. Therefore, this material is pulverized into a particle diameter of less than 177 μm but not less than 0.1 μm , while maintaining the coercive force, resulting in a material applicable especially for bonded type magnets.

Having regard to the coercive force mechanism, rare-earth magnet materials are classified into two classes. One class is formed by the 1-5 system rare-earth magnetic materials comprising rare-earth transition metal compounds like e.g. SmCo_5 , CeCo_5 , $\text{Sm}_{0.5}\text{Ce}_{0.5}\text{Co}_5$, YCo_5 , PrCo_5 , $\text{Sm}(\text{CoCu})_5$, or the nucleation-type comprising intermetallic compounds of at least one rare-earth metal and at least one transition metal including compounds based on R-Fe-B. The second class is formed by the 2-17 system rare-earth transition metal compound magnetic materials (pinning type of 2-17 system magnets for precipitation hardening type), comprising a rare-earth transition metal intermetallic compound like e.g.

$\text{Sm}(\text{Co}_{0.9}\text{Cu}_{0.05}\text{Fe}_{0.02}\text{Zr}_{0.02})_{7.8}$,

$\text{Sm}(\text{Co}_{0.8}\text{Cu}_{0.06}\text{Fe}_{0.22}\text{Ti}_{0.16})_{7.6}$,

$\text{Sm}_{0.8}\text{Y}_{0.2}(\text{Co}_{0.8}\text{Cu}_{0.06}\text{Fe}_{0.20}\text{Nb}_{0.018})_{7.8}$, $\text{Sm}_{0.7}\text{Ce}_{0.3}(\text{Co}_{0.8}\text{Cu}_{0.06}\text{Fe}_{0.24}\text{Zr}_{0.02})_{7.4}$,

and $\text{Sm}_{0.5}\text{Pr}_{0.5}(\text{Co}_{0.8}\text{Fe}_{0.3}\text{Cu}_{0.07}\text{Zr}_{0.02})_{7.6}$.

The above mentioned rare-earth transition metal intermetallic compounds comprise a rare-earth metal, a transition metal, and a semi-metal or semiconductor element. Such rare-earth transition compound magnets are very active to oxygen, if their surface is exposed to an oxidizing atmosphere. In particular, R-Fe-B magnets comprising a rare-earth metal, iron and boron as the main ingredients, cause many problems. For instance when an R-Fe-B magnet is used in a motor, a relay or the like, oxide is produced and torn off. This oxide may cause troubles to such an extent that those magnets cannot be used in practice.

EP-B-101552 describes R-Fe-B permanent magnets manufactured by a sintering method, however, does not mention any problem with respect to rust.

To prevent rust, it is well known from JP-A-56-81908 to coat a rare-earth magnet with resin such as an epoxy resin. It is also known, however, that in this case, subtle pin holes occur in the plating or coating layer, and there is no way to avoid this. Therefore, there is the disadvantage that despite of the coating, rust may be generated as water enters through the pin holes of the plating or coating layer.

The pin holes occur mainly due to the following reasons:

1) Because the magnets do not have a uniform plain or mirror surface but a subtly uneven surface or spaces between particles, the pin holes are generated in the layer deposited on a magnet.

2) The solvent in the plating solution or the coating solution remains in the coating layer, and is volatilized during the drying process. As a result, portions where such volatilization occurred, become pin holes.

Such pin holes are not a big problem with prior art magnets such as Sm-Co including only a small amount of iron. On the contrary, prior art magnets comprising a rare-earth metal and iron have a large amount of iron and, thus, are apt to rust. Therefore, when such a magnet is used in a rotating machine such as a motor, a VCM (voice coil motor), a speaker or a relay to provide a magnetic circuit, generation of rust lowers its magnetic performance.

The object of the present invention is to eliminate the above mentioned problems and to provide a rare-earth magnet having a superior corrosion and weathering resistance and a high strength. Another object of the invention is to prevent the surface of a rare-earth magnet from losing particles and becoming damaged.

This object is achieved with rare-earth permanent magnets as claimed.

According to the invention a rare-earth permanent magnet is coated with an organic resin having a water-proof property. The organic resin material includes fluoro-plastics and preferably consists of a mixture of fluoroplastics and at least of one of epoxy resin, polyester resin and phenol resin. The coating has a thickness of approximately 1 μm - 50 μm . The proportion of fluoroplastics in the organic resin material is approximately 2 - 70% by weight of the organic resin. It is also possible to coat the magnet with fluoroplastics alone. By the coating water is repelled and prevented from entering into pin holes.

In one embodiment of the present invention, a powder bonded rare-earth permanent magnet comprises particles of a rare-earth magnet material and a thermosetting resin as a bonding material. This magnet is coated with fluoroplastics in a thickness of 1 - 50 μm .

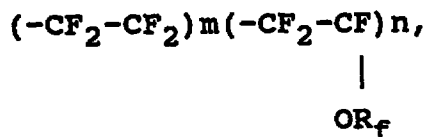
In accordance with the present invention, the above described coating of the magnets with an organic resin material can be performed by a physical or a chemical method.

A rare-earth permanent magnet according to the present invention comprises an intermetallic compound comprising at least one rare-earth metal R, iron Fe and boron B, like $\text{Nd}_{15}\text{Fe}_{77}\text{B}_8$, $\text{Nd}_{15}\text{Fe}_{73}\text{Co}_4\text{B}_8$, $\text{Pr}_{15}\text{Fe}_{77}\text{B}_8$, $\text{Pr}_{15}\text{Fe}_{80}\text{B}_5$. Magnets of this material have a large saturation magnetization ($4\pi\text{Is}$) and a large anisotropic magnetic field (H_a), therefore these magnets have the best performance of all the magnets. The composition includes 8 - 18% by atomic of a rare-earth metal, 73 - 88% by atomic of a transition metal, and 4 - 9% by atomic of submetal or semiconductor element such as As, Sb, Bi, B, C, Si, P, Se. H-OH in water and iron (Fe) of the magnet cause a substitution reaction to form $\text{Fe}(\text{OH})_3$. To prevent this substitution reaction, an organic coating layer having a water-proof property is formed on the magnets. The preferable thickness of the organic coating layer is more than 1 μm .

The fluoroplastics preferably used in the first and second embodiments of the present invention are:
4-fluorinated ethylene resin (PTFE)

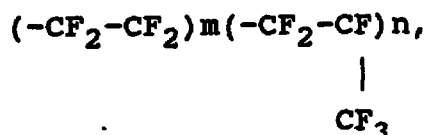
($-\text{CF}_2-\text{CF}_2-$),

a copolymer resin (PFA) of 4-fluorinated ethylene and per-fluoroalkoxyethylene

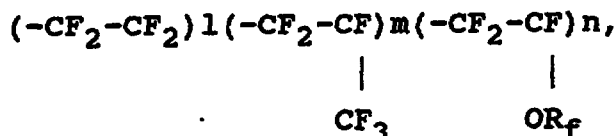


(R_f is an alkyl group)

a copolymer resin (FEP) of 4-fluorinated ethylene and 6-fluorinated propylene



a copolymer resin (EPE) of 4-fluorinated ethylene,
6-fluorinated propylene and per-fluoroalkoxyethylene



a copolymer resin (ETFE) of 4-fluorinated ethylene and ethylene

($-\text{CF}_2-\text{CF}_2-$) $_m$ ($-\text{CH}_2-\text{CH}_2-$) $_n$,

a copolymer resin (PCTFE) of 3-fluorinated ethylene chloride

$(-\text{CF}_2-\text{CFCl})_n$,

or

a copolymer resin (ECTFE) of 3-fluorinated ethylene chloride and ethylene

$(-\text{CF}_2-\text{CFCl})_m(-\text{CH}_2-\text{CH}_2)_n$,

fluorinated vinyliden resin (PVDF)

$(-\text{CF}_2-\text{CH}_2)_n$, and

fluorinated vinyl resin (PVE)

$(-\text{CHF}-\text{CH}_2)_n$.

When the proportion of fluoroplastics (fluorine resin) in the organic resin which further includes at least one of epoxy resin, polyester resin and phenol resin is less than 2% by weight, it is not possible to have a superior weathering resistance. When the proportion is more than 70% by weight, it is impossible to obtain a uniform mixture of the components resulting in an organic resin layer with an uneven surface and a low strength. Therefore, according to the present invention, the preferable proportion of fluorine resin is approximately 2 - 70% by weight of the organic resin.

If the thickness of the coating layer is less than 1 μm , it is difficult to obtain reliability since the layer becomes uneven. However, if the thickness of the coating layer is more than 50 μm , forming of the layer takes a long time and requires high costs. Therefore, the preferable thickness of the coating layer is within the range of 1 μm - 50 μm .

Fluoroplastics are inferior as regards their adherence to metal (where the magnet comprises an intermetallic compound), compared to other resins. In general, when metal is coated with fluoroplastics, it is heat treated at 100°C - 900°C to improve the adherence. However, the heat treatment of the magnet impairs its magnetic property to a great extent.

According to the present invention, by mixing fluoroplastics with another resin and keeping the waterproof property, it is possible to obtain a high-performance magnet and yet to achieve sufficient adherence and durability of the coating.

Some specific effects of the present invention are as follows:

(1) When a rare-earth permanent magnet according to the present invention is used with speakers, motors, meters, or the like, it is possible to obtain a sufficient reliability for a long time and a sufficient stability.

(2) It is possible to provide a magnetic circuit having a high accuracy and high efficiency.

(3) It is possible to use the magnet even in a high temperature or corrosion promoting surrounding, thus, to broaden the field of application.

(4) It is possible to prevent any magnetic particles from separating from the magnet.

(5) It is possible to prevent any cracking of the magnet.

(6) It is possible to enhance the stability and the resistance of the magnet in heat.

(7) It is possible to enhance the strength of a device in which the magnet is used.

The above and other objects, features and advantages of the present invention will become clearer from the following description of preferred examples.

The following examples relate to powder bonded rare-earth permanent magnets, but the invention is also applicable to sintered rare-earth permanent magnets and cast rare-earth permanent magnets.

Example 1

As the basic material for the magnet, the composition $\text{Nd}_{14}\text{Fe}_{80}\text{B}_6$ represented by the compound in terms of percentage was used. A thin film of this material obtained by a rapid-quenching thin film producing process was pulverized in a ball mill to obtain magnetic particles having a diameter of about 177 μm . The magnetic particles were sufficiently milled after 1-3% by weight of epoxy resin had been added thereto and the mixture was then pressed to obtain a predetermined molded body. The molded body was cured at a temperature of approximately 155°C for approximately one hour to become hard. The resulting powder bonded permanent magnet was coated with the respective coating materials indicated in table 1.

Table 1

Sample No.	coating material	ratio (weight)	thickness of the coating layer (μm)
1	epoxy resin : PTFE	= 99:1	10
2	epoxy resin : PTFE	= 98:2	8
3	epoxy resin : PTFE	= 95:5	0.5
4	epoxy resin : PTFE	= 80:20	10
5	epoxy resin : PTFE	= 70:30	20
6	phenol resin : PCTFE	= 60:40	10
7	phenol resin : PFA	= 60:40	12
8	phenol resin : FEP	= 55:45	11
9	phenol resin : ETFE	= 60:40	9
10	phenol resin : PCTFE	= 60:40	10
11	phenol resin : PTFE	= 25:75	15

The magnetic properties were as follows:

$(BH)_{\text{max}} = 7.6 (1/4\pi) \text{ kTA/cm}$, $Br = 5.9 \cdot 10^{-1} \text{ T}$, $iHc = 15.4 (10/4\pi) \cdot \text{kA/cm}$, $bHc = 5.3 (10/4\pi) \cdot \text{kA/cm}$, density = $6.3 \text{ (g/cm}^3\text{)}$.

The samples 1 to 11 were exposed to a constant temperature of 60°C and a constant humidity of 95% for approximately 1500h. The magnetic properties and the appearance of the samples after that treatment are shown in table 2. In addition, as a comparative example, table 2 shows a magnet which had not been coated with a coating layer.

As shown in table 2, since the coating layer of sample 1 has an amount of PTFE of less than 2% by weight, and the sample 11 has an amount of PTFE of more than 70% by weight, both samples exhibit a poor corrosion resistance.

Table 2

Sample No.	Br (10^{-1} T)	Magnetic properties		(BH)max ($(1/4\pi)$ kTA/cm)	corrosion condition
		bHc ($(10/4\pi)$ kA/cm)	iHc ($(10/4\pi)$ kA/cm)		
1	5.4	4.9	14.9	6.6	[III]
2	5.6	5.0	15.0	7.0	[II]
3	5.3	4.8	14.8	6.5	[II]
4	5.7	5.3	15.3	7.5	[I]
5	5.6	5.1	15.2	7.5	[I]
6	5.7	5.2	14.8	7.6	[I]
7	5.7	5.1	15.1	7.4	[I]
8	5.8	5.2	15.2	7.6	[I]
9	5.7	5.2	15.1	7.5	[I]
10	5.7	5.2	15.3	7.5	[I]
11	5.4	4.8	14.8	6.5	[III]
*	5.0	4.6	14.5	5.9	[IV] *comparative example
[I]: no corrosion [II]: minimal corrosion [III]: partial corrosion [IV]: complete corrosion					

Example 2

In the same way as in example 1, powder bonded magnets were produced. These magnets were repeatedly coated with a fluoroplastic to a thickness of 0.5 μ m, 1 μ m, 10 μ m, 30 μ m, 50 μ m and 70 μ m, respectively. In a corrosion resistance test, the coated magnets were exposed to an atmosphere of a temperature of about 60°C and a humidity of about 90%. Table 3 shows the rust condition of the magnets after 10, 100 and 500 h, respectively.

Table 3

Thickness of coating film	Time		
	10 h	100 h	500 h
0.5 μ m	[III]	[IV]	[IV]
1.0 μ m	[II]	[III]	[IV]
10 μ m	[I]	[I]	[II]
30 μ m	[I]	[I]	[II]
50 μ m	[I]	[I]	[I]
70 μ m	[I]	[I]	[I]
(Temperature: 60°C, Humidity: 90%)			

As apparent from Table 3, when the thickness of the coating layer is not more than 1 μ m, it is impossible to obtain a corrosion resistance sufficient for practical use. If the thickness of the coating layer is more than 50 μ m, it is possible to obtain a sufficient corrosion resistance without any corrosion.

Example 3

Two solutions of fluoroplastics with different densities were prepared. A first powder bonded permanent magnet was coated with the solution having a higher density one time to obtain a coating layer having a

higher thickness of about 10 μm . A second powder bonded permanent magnet was coated with the other solution three times to obtain a coating layer structure having a total thickness of about 10 μm . In a corrosion resistance test both magnets were exposed to an atmosphere of approximately 60°C and a humidity of approximately 95%. The rust condition of the magnets after 10, 100 and 500 h, respectively, revealed that by a repeated coating process a more superior corrosion resistance is achieved.

Example 4

As the basic material for the magnet in this case, the composition $\text{Nd}_{13}\text{Fe}_{77}\text{Co}_4\text{B}_8$ represented by the compound in terms of percentage was used. A thin film of this material obtained by a rapid-quenching thin film producing process was pulverized in a ball mill to obtain magnetic particles having a diameter of less than 100 μm . The magnetic particles were sufficiently milled after 1-3% by weight of epoxy resin had been added thereto and the mixture was then pressed to obtain a predetermined molded body. The molded body was cured at a temperature of approximately 125°C for approximately one hour to obtain a powder bonded permanent magnet. The resulting powder bonded permanent magnet was coated with the respective coating materials indicated in Table 4.

Table 4

Sample No.	coating material	ratio (weight)	thickness of the coating layer (μm)
21	epoxy resin : PTFE	= 99:1	10
22	epoxy resin : PTFE	= 98:2	8
23	epoxy resin : PTFE	= 95:5	0,8
24	epoxy resin : PTFE	= 80:20	10
25	epoxy resin : PCTFE	= 70:30	18
26	phenol resin : PTFE	= 60:40	10
27	phenol resin : PFA	= 50:50	12
28	phenol resin : FEP	= 60:40	20
29	phenol resin : ETFE	= 55:45	9
30	phenol resin : PCTFE	= 60:40	11
31	phenol resin : PTFE	= 25:75	15

The magnetic properties were as follows:

$(\text{BH})_{\text{max}} = 11.0 (1/4\pi)\text{kTA/cm}$, $\text{Br} = 7.2 \cdot 10^{-1}\text{T}$ $\text{IHc} = 9.8 (10/4\pi) \cdot \text{kA/cm}$, $\text{bHc} = 5.0 (10/4\pi) \cdot \text{kA/cm}$, density = 6.4 (g/cm^3).

Samples 21 - 32 were exposed for about 1500 h to an atmosphere of a constant temperature of 60°C and a constant humidity of 95%. The magnetic properties and the appearance (corrosion condition) of the exposed samples after that treatment are shown in Table 5. In addition, a magnet which had not been coated is shown in Table 5 as a comparative example.

Table 5

Sample No.	Br (10^{-1} T)	Magnetic properties		(BH)max ($(1/4\pi)$ kTA/cm)	corrosion condition
		bHc ($(10/4\pi)$ kA/cm)	iHc ($(10/4\pi)$ kA/cm)		
21	6.8	4.6	9.4	8.6	[III]
22	6.8	4.8	9.7	8.9	[II]
23	6.9	4.8	9.6	9.2	[II]
24	7.1	5.0	9.8	10.7	[I]
25	7.2	4.9	9.7	10.9	[I]
26	7.1	5.1	9.9	11.0	[I]
27	7.1	4.8	10.0	10.9	[I]
28	7.2	4.9	9.8	10.9	[I]
29	7.2	4.8	9.8	10.8	[I]
30	7.2	5.0	9.8	10.9	[I]
31	6.9	4.8	9.5	8.5	[III]
*	6.5	4.5	9.2	7.9	[IV]
*comparative example (Temperature: 60 °C, Humidity: 95%)					

As shown in Table 4, the coating material of sample 21 has an PTFE content of less than 2% by weight whereas the coating material of sample 31 has an PTFE content of more than 70% by weight. As shown in Table 5, both samples 21 and 31 have a poor corrosion resistance.

Example 5

In the same way as in example 4, powder bonded magnets were produced. These magnets were repeatedly coated with a fluoroplastic layer of a thickness of 0.5 μ m, 1 μ m, 10 μ m, 30 μ m, 50 μ m and 70 μ m, respectively. In a corrosion resistance test, the coated magnets were exposed to an atmosphere of a temperature of about 60 °C and a humidity of about 90%. Table 6 shows the rust condition of the magnets after 10, 100 and 500 h, respectively.

Table 6

Thickness of coating film	Time		
	10 h	100 h	500 h
0.5 μ m	[III]	[IV]	[IV]
1.0 μ m	[II]	[III]	[IV]
10 μ m	[I]	[I]	[II]
30 μ m	[I]	[I]	[II]
50 μ m	[I]	[I]	[I]
70 μ m	[I]	[I]	[I]
(Temperature: 60 °C, Humidity: 90%)			

As apparent from Table 6, when the thickness of the coating layer is not more than 1 μ m, it is impossible to obtain a corrosion resistance sufficient for practical use. If the thickness of the coating layer is more than 50 μ m, it is possible to obtain a sufficient corrosion resistance without any corrosion.

Example 6

As the basic material for the magnet in this case, the composition $\text{Nd}_{13}\text{Fe}_{74}\text{Co}_7\text{B}_6$ represented by the compound in terms of percentage was used. A thin film of this material obtained by a rapid-quenching thin film producing process was pulverized in a ball mill to obtain magnetic particles having a diameter of less

than 120 μm . The magnetic particles were sufficiently milled after 1-3% by weight of epoxy resin had been added thereto and the mixture was then pressed to obtain a predetermined molded body. The molded body was cured at a temperature of approximately 160°C for approximately one hour to obtain a powder bonded permanent magnet. The resulting powder bonded permanent magnet was coated with the respective coating materials indicated in Table 7.

Table 7

Sample No.	coating material	ratio (weight)	thickness of the coating layer (μm)
41	polyester resin	: PTFE = 99:1	12
42	polyester resin	: PTFE = 98:2	7
43	polyester resin	: PTFE = 95:5	0.6
44	polyester resin	: PTFE = 80:20	10
45	polyester resin	: PCTFE= 70:30	15
46	polyester resin	: PTFE = 60:40	11
47	(phenol:epoxy=50:50)	: PFA = 60:40	13
48	(polyester:epoxy=50:50)	: FEP = 60:40	20
49	(polyester:phenol=40:60)	: ETFE = 60:40	8
50	(phenol:polyester:epoxy=20:30:50)	: PCTFE= 60:40	10
51	(phenol:polyester:epoxy=20:30:50)	: PTFE = 25:75	13

The magnetic properties were as follows:

$(BH)_{\text{max}} = 11.5 \text{ (1/4}\pi\text{)kTA/cm}$, $Br = 7.4 \cdot 10^{-1}\text{T}$, $iHc = 9.4 \text{ (10/4}\pi\text{)}\cdot\text{kA/cm}$, $bHc = 4.8 \text{ (10/4}\pi\text{)}\cdot\text{kA/cm}$, density = $6.8(\text{g/cm}^3)$.

Samples 41 - 51 were exposed for about 1500 h to an atmosphere of a constant temperature of 60°C and a constant humidity of 95%. The magnetic properties and the appearance (corrosion condition) of the exposed samples after that treatment are shown in Table 8. In addition, a magnet which had not been coated is shown in Table 8 as a comparative example.

Table 8

Sample No.	Br (10^{-1} T)	Magnetic properties		(BH)max ($(1/4\pi)kTA/cm$)	corrosion condition
		bHc ($(10/4\pi)kA/cm$)	iHc ($(10/4\pi)kA/cm$)		
41	6.9	4.7	8.5	9.6	[III]
42	7.0	4.7	8.9	10.0	[II]
43	6.9	4.7	8.8	10.4	[II]
44	7.4	4.9	9.1	11.4	[I]
45	7.3	4.8	9.0	11.5	[I]
46	7.4	4.8	8.9	11.3	[I]
47	7.4	4.9	9.2	11.3	[I]
48	7.4	4.9	9.1	11.2	[I]
49	7.4	4.8	9.1	11.4	[I]
50	7.4	4.8	9.2	11.4	[I]
51	7.1	4.7	8.9	10.5	[III]
*	6.6	4.7	8.0	8.9	[IV]
*comparative example (Temperature: 60 °C, Humidity: 95%)					

As shown in Table 7, the coating material of sample 41 has an PTFE content of less than 2% by weight whereas the coating material of sample 51 has an PTFE content of more than 70% by weight. As shown in Table 8, both samples 41 and 51 have a poor corrosion resistance.

Claims

1. A rare-earth permanent magnet of the general formula R-Fe-B wherein R represents a rare earth metal, said magnet being coated with a waterproof organic resin coating having a thickness of more than 1 μm ,
characterized in that
the organic resin of the coating includes a fluorine resin the amount of which being 2 to 70% by weight of the total resin composition.
2. The magnet of claim 1, wherein the fluorine resin is selected from the group consisting of 4-fluorinated ethylene resin; a copolymer resin of 4-fluorinated ethylene and perfluoroalkoxyethylene; a copolymer resin of 4-fluorinated ethylene and 6-fluorinated propylene; a copolymer resin of 4-fluorinated ethylene, 6-fluorinated propylene and per-fluoroalkoxyethylene; a copolymer resin of 4-fluorinated ethylene and ethylene; a copolymer resin of 3-fluorinated ethylene chloride; a copolymer resin of 3-fluorinated ethylene chloride and ethylene; fluorinated vinylidene resin; fluorinated vinyl resin and mixtures thereof.
3. The magnet of claim 1 or 2, wherein the organic resin of the coating includes said fluorine resin mixed with a second organic resin selected from the group consisting of epoxy resins, polyester resins, acrylic resins, phenol resins and mixtures thereof.
4. The magnet of any of claims 1 to 3, wherein the coating has a thickness of no more than 50 μm .
5. The magnet of any of claims 1 to 4, wherein the permanent magnet member is a powder bonded magnet.
6. The magnet of any of claims 1 to 4, wherein the permanent magnet member is a sintered magnet.
7. The magnet of any of claims 1 to 4, wherein the permanent magnet member is a cast magnet.
8. The magnet of claim 5, wherein the powder bonded permanent magnet is selected from the group consisting of rare-earth transition metal intermetallic compounds; and intermetallic compounds including

Table 8

Sample No.	Br (10^{-1} T)	Magnetic properties		(BH)max (($1/4\pi$)kTA/cm)	corrosion condition
		bHc (($10/4\pi$)kA/cm)	iHc (($10/4\pi$)kA/cm)		
41	6.9	4.7	8.5	9.6	[III]
42	7.0	4.7	8.9	10.0	[II]
43	6.9	4.7	8.8	10.4	[II]
44	7.4	4.9	9.1	11.4	[I]
45	7.3	4.8	9.0	11.5	[I]
46	7.4	4.8	8.9	11.3	[I]
47	7.4	4.9	9.2	11.3	[I]
48	7.4	4.9	9.1	11.2	[I]
49	7.4	4.8	9.1	11.4	[I]
50	7.4	4.8	9.2	11.4	[I]
51	7.1	4.7	8.9	10.5	[III]
*	6.6	4.7	8.0	8.9	[IV]
*comparative example (Temperature: 60 °C, Humidity: 95%)					

As shown in Table 7, the coating material of sample 41 has an PTFE content of less than 2% by weight whereas the coating material of sample 51 has an PTFE content of more than 70% by weight. As shown in Table 8, both samples 41 and 51 have a poor corrosion resistance.

Claims

1. A rare-earth permanent magnet of the general formula R-Fe-B wherein R represents a rare earth metal, said magnet being coated with a waterproof organic resin coating having a thickness of more than 1 μ m,
characterized in that
the organic resin of the coating includes a fluorine resin the amount of which being 2 to 70% by weight of the total resin composition.
2. The magnet of claim 1, wherein the fluorine resin is selected from the group consisting of 4-fluorinated ethylene resin; a copolymer resin of 4-fluorinated ethylene and perfluoroalkoxyethylene; a copolymer resin of 4-fluorinated ethylene and 6-fluorinated propylene; a copolymer resin of 4-fluorinated ethylene, 6-fluorinated propylene and per-fluoroalkoxyethylene; a copolymer resin of 4-fluorinated ethylene and ethylene; a copolymer resin of 3-fluorinated ethylene chloride; a copolymer resin of 3-fluorinated ethylene chloride and ethylene; fluorinated vinylidene resin; fluorinated vinyl resin and mixtures thereof.
3. The magnet of claim 1 or 2, wherein the organic resin of the coating includes said fluorine resin mixed with a second organic resin selected from the group consisting of epoxy resins, polyester resins, acrylic resins, phenol resins and mixtures thereof.
4. The magnet of any of claims 1 to 3, wherein the coating has a thickness of no more than 50 μ m.
5. The magnet of any of claims 1 to 4, wherein the permanent magnet member is a powder bonded magnet.
6. The magnet of any of claims 1 to 4, wherein the permanent magnet member is a sintered magnet.
7. The magnet of any of claims 1 to 4, wherein the permanent magnet member is a cast magnet.
8. The magnet of claim 5, wherein the powder bonded permanent magnet is selected from the group consisting of rare-earth transition metal intermetallic compounds; and intermetallic compounds including



at least one rare-earth metal in an amount between about 8 and 18 atomic percent, iron or other transition metal in an amount between about 73 and 88 atomic percent and boron or other sub-metal or semiconductor element in an amount between about 4 and 9 atomic percent.

9. The magnet of claim 5, wherein the powder bonded permanent magnet member is obtainable by:
pulverizing a magnetic alloy composition to obtain magnetic particles;
mixing the magnetic particles with a thermosetting resin to obtain a mixture;
press molding the mixture to obtain a bonded magnet; and
hardening the powder bonded magnet.

10. The magnet of claim 9, wherein the thermosetting resin is an epoxy resin.

Patentansprüche

1. Seltenerden-Permanentmagnet der allgemeinen Formel R-Fe-B, in der R ein Seltenerdenmetall darstellt, wobei der Magnet mit einer wasserfesten Beschichtung aus einem organischen Harz mit einer Dicke von mehr als 1 μm beschichtet ist, dadurch gekennzeichnet, daß das organische Harz der Beschichtung ein Fluorharz in einer Menge von 2 bis 70 Gew.-% der gesamten Harzzusammensetzung umfaßt.
2. Magnet nach Anspruch 1, wobei das Fluorharz unter einem Tetrafluorethylenharz; einem Copolymerharz aus Tetrafluorethylen und Perfluoralkoxyethylen; einem Copolymerharz aus Tetrafluorethylen und Hexafluorpropylen; einem Copolymerharz aus Tetrafluorethylen, Hexafluorpropylen und Perfluoralkoxyethylen; einem Copolymerharz aus Tetrafluorethylen und Ethylen; einem Copolymerharz aus Trifluorchlorethylen; einem Copolymerharz aus Trifluorchlorethylen und Ethylen; einem fluorierten Vinylidenharz; einem fluorierten Vinylharz und Gemischen davon ausgewählt ist.
3. Magnet nach Anspruch 1 oder 2, wobei das organische Harz in der Beschichtung das Fluorharz im Gemisch mit einem zweiten organischen Harz, das unter Epoxyharzen, Polyesterharzen, Acrylharzen, Phenolharzen und Gemischen davon ausgewählt ist, umfaßt.
4. Magnet nach einem der Ansprüche 1 bis 3, wobei die Beschichtung eine Dicke von nicht mehr als 50 μm aufweist.
5. Magnet nach einem der Ansprüche 1 bis 4, wobei das Permanentmagnet-Element ein pulvergebundener Magnet ist.
6. Magnet nach einem der Ansprüche 1 bis 4, wobei das Permanentmagnet-Element ein gesinterter Magnet ist.
7. Magnet nach einem der Ansprüche 1 bis 4, wobei das Permanentmagnet-Element ein gegossener Magnet ist.
8. Magnet nach Anspruch 5, wobei der pulvergebundene Permanentmagnet ausgewählt ist unter intermetallischen Seltenerden-Übergangsmetall-Verbindungen; und intermetallischen Verbindungen unter Einschluß mindestens eines Seltenerdenmetalls in einer Menge zwischen 8 und 18 Atom-%, Eisen oder anderer Übergangsmetalle in einer Menge zwischen etwa 73 und 88 Atom-% und Bor oder eines anderen Halbmetalls oder Halbleiterelements in einer Menge zwischen etwa 4 und 9 Atom-%.
9. Magnet nach Anspruch 5, wobei das pulvergebundene Permanentmagnet-Element durch folgende Stufen erhältlich ist:
Pulverisierung einer magnetischen Legierungszusammensetzung, um magnetische Teilchen zu erhalten;
Mischen der magnetischen Teilchen mit einem wärmehärtbaren Harz, um ein Gemisch zu erhalten;
Verpressen des Gemisches, um einen gebundenen Magneten zu erhalten; und
Härten des pulvergebundenen Magneten.
10. Magnet nach Anspruch 9, wobei es sich bei dem wärmehärtbaren Harz um ein Epoxyharz handelt.



Revendications

1. Un aimant permanent à terres rares ayant la formule générale R-Fe-B dans laquelle R représente un métal de la famille des terres rares, cet aimant étant revêtu par un revêtement de résine organique étanche ayant une épaisseur supérieure à 1 μm ,
 caractérisé en ce que
 la résine organique du revêtement contient une résine fluorée dans une proportion comprise entre 2 et 70% en masse de la composition de résine totale.
2. L'aimant de la revendication 1, dans lequel la résine fluorée est sélectionnée dans le groupe comprenant : une résine d'éthylène tétrafluoré; une résine consistant en un copolymère d'éthylène tétrafluoré et de perfluoroalcoxyéthylène; une résine consistant en un copolymère d'éthylène tétrafluoré et de propylène hexafluoré; une résine consistant en un copolymère d'éthylène tétrafluoré, de propylène hexafluoré et de perfluoroalcoxyéthylène; une résine consistant en un polymère d'éthylène tétrafluoré et d'éthylène; une résine consistant en copolymère de chlorure d'éthylène trifluoré; une résine consistant en un copolymère de chlorure d'éthylène trifluoré et d'éthylène; une résine de vinylidène fluoré; une résine de vinyle fluoré et des mélanges de celles-ci.
3. L'aimant de la revendication 1 ou 2, dans lequel la résine organique du revêtement contient la résine fluorée mélangée avec une seconde résine organique qui est sélectionnée dans le groupe comprenant des résines époxy, des résines de polyester, des résines acryliques, des résines phénoliques et des mélanges de celles-ci.
4. L'aimant de l'une quelconque des revendications 1 à 3, dans lequel le revêtement a une épaisseur qui n'est pas supérieure à 50 μm .
5. L'aimant de l'une quelconque des revendications 1 à 4, dans lequel la structure d'aimant permanent consiste en un aimant à poudre agglomérée.
6. L'aimant de l'une quelconque des revendications 1 à 4, dans lequel la structure d'aimant permanent consiste en un aimant fritté.
7. L'aimant de l'une quelconque des revendications 1 à 4, dans lequel la structure d'aimant permanent consiste en un aimant coulé.
8. L'aimant de la revendication 5, dans lequel l'aimant permanent à poudre agglomérée est sélectionné dans le groupe qui comprend des composés intermétalliques de terres rares et de métaux de transition; et des composés intermétalliques comprenant au moins un métal de la famille des terres rares en un pourcentage atomique compris entre environ 8 et 18%, du fer ou un autre métal de transition en un pourcentage atomique compris entre environ 73 et 88%, et du bore ou un autre semi-métal ou élément semiconducteur en un pourcentage atomique compris entre 4 et 9%.
9. L'aimant de la revendication 5, dans lequel la structure d'aimant permanent à poudre agglomérée peut être obtenue par les opérations suivantes :
 on pulvérise une composition d'alliage magnétique pour obtenir des particules magnétiques;
 on mélange les particules magnétiques avec une résine thermodurcissable pour obtenir un mélange;
 on moule le mélange par compression, pour obtenir un aimant à structure agglomérée; et
 on durcit l'aimant à poudre agglomérée.
10. L'aimant de la revendication 9, dans lequel la résine thermodurcissable est une résine époxy.

