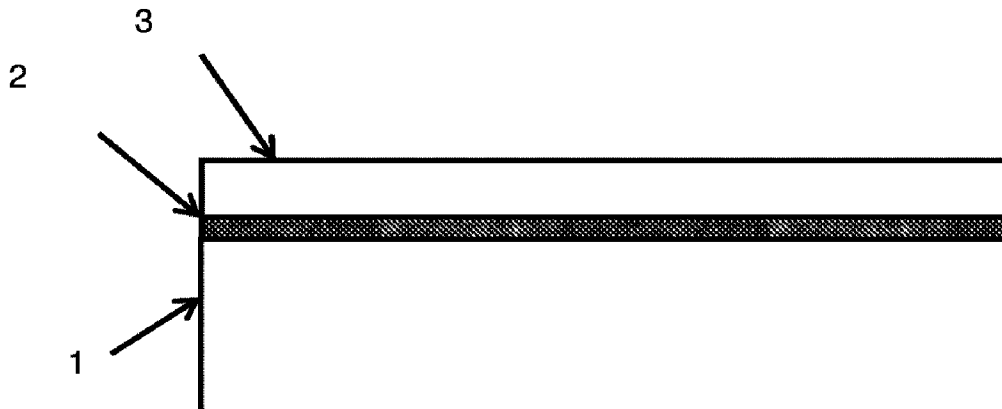




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(54) **Title: A METHOD FOR MANUFACTURING AN ASSEMBLY**



(57) **Abrégé/Abstract:**

The present invention relates to a pre-coated steel substrate coated with: - a first pre-coating comprising titanium, said first coating having a thickness of 40 nm to 1200 nm, - optionally, an intermediate pre-coating layer comprising at least 8% by weight nickel and at least 10% by weight chromium, the rest being iron or an intermediate pre-coating layer comprising Fe, Ni, Cr and Ti wherein the amount of Ti is above or equal to 5 wt.% and wherein the following equation is satisfied: $8 \text{ wt.}\% < \text{Cr} + \text{Ti} < 40 \text{ wt.}\%$, the balance being Fe and Ni, the intermediate pre-coating layer having a thickness between 2 and 30nm - a second pre-coating being a zinc-based coating and - said steel substrate comprising above 0.05wt.% of Si.



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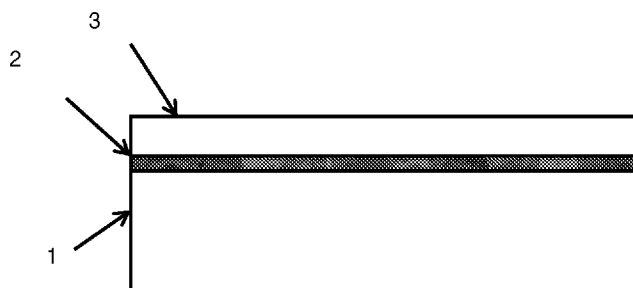
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Figure 1



(57) **Abstract:** The present invention relates to a pre-coated steel substrate coated with: - a first pre-coating comprising titanium, said first coating having a thickness of 40 nm to 1200 nm, - optionally, an intermediate pre-coating layer comprising at least 8% by weight nickel and at least 10% by weight chromium, the rest being iron or an intermediate pre-coating layer comprising Fe, Ni, Cr and Ti wherein the amount of Ti is above or equal to 5 wt.% and wherein the following equation is satisfied: $8 \text{ wt.\%} < \text{Cr} + \text{Ti} < 40 \text{ wt.\%}$, the balance being Fe and Ni, the intermediate pre-coating layer having a thickness between 2 and 30 nm - a second pre-coating being a zinc-based coating and - said steel substrate comprising above 0.05 wt.% of Si.



WO 2020/245773 A1

A method for manufacturing an assembly

The present invention relates to a pre-coated steel substrate, a method for the manufacture of the coated steel substrate; a method for the manufacture of an assembly and an assembly. It is particularly well suited for construction and automotive industries.

Zinc based coatings are generally used because they allow a protection against corrosion, thanks to barrier protection and cathodic protection. The barrier effect is obtained by the application of a metallic or non-metallic coating on steel surface. Thus, the coating prevents the contact between steel and corrosive atmosphere. The barrier effect is independent from the nature of the coating and the substrate. On the contrary, sacrificial cathodic protection is based on the fact that zinc which is active metal as compared to steel as per EMF series. Thus, if corrosion occurs, zinc is consumed preferentially as compared to steel. Cathodic protection is essential in areas where steel is directly exposed to corrosive atmosphere, like cut edges where surrounding zinc consumes before the steel.

However, when heating steps are performed on such zinc coated steel sheets, for example during hot press hardening or resistance spot welding, cracks are observed in the steel which initiates from the steel/coating interface. Indeed, occasionally, there is a reduction of mechanical properties due to the presence of cracks in the coated steel sheet after the above operation. These cracks appear with the following conditions: high temperature above the melting point of coating materials; contact between the liquid metal having a low melting point (such as zinc) and the substrate in combination with the presence of critical stresses; diffusion and wetting of molten metal in the grain and grain boundaries of the steel substrate. The designation for such phenomenon is known as liquid metal embrittlement (LME), and also called liquid metal assisted cracking (LMAC).

Thus, the objective of the invention is to provide an assembly comprising at least a steel substrate which does not have LME issues. It aims to make available, in particular, an easy to implement method in order to obtain this assembly which does not have LME issues after the hot press forming and/or the welding.

To this end, according to a first aspect, the invention may relate to a coated steel sheet comprising a substrate, the substrate comprising above 0.05 wt% of Si, said substrate being successively coated with:

- a first coating consisting of titanium, said first coating being in direct contact with the substrate and having a thickness ranging from 40 nm to 1200 nm; and
- a second coating being a zinc-based coating.

The coated steel sheet may also comprise one or more of the following features:

- an intermediate coating layer deposited between the first coating and the second coating, the intermediate coating layer having a thickness between 2 and 30nm, the intermediate coating layer comprising:
 - at least 8% by weight nickel and at least 10% by weight chromium, the rest being iron or
 - an intermediate coating layer comprising Fe, Ni, Cr and Ti wherein the amount of Ti is above or equal to 5 wt.% and wherein the following equation is satisfied: $8 \text{ wt.\%} < \text{Cr} + \text{Ti} < 40 \text{ wt.\%}$, the balance being Fe and Ni.

According to another aspect, the invention may relate to a method for the manufacture of a coated steel sheet, the method comprising the following successive steps:

- A. provision of a steel substrate comprising above 0.05 wt% of Si,
- B. deposition of a first coating layer consisting of titanium, said first coating being in direct contact with the steel substrate and having a thickness ranging from 40 nm to 1200 nm; and,
- C. deposition of a second coating layer, said second coating being a zinc-based coating.

According to another aspect the invention may also relate to a method for the manufacture of an assembly of at least two metallic sheets comprising the following successive steps:

- I. provision of the at least two metallic sheets wherein at least one metallic sheet is a coated steel sheet of the type described herein or obtained from a method of the type described herein.
- II. welding of the at least two metallic sheets.

5

According to another aspect the invention may also relate to an assembly obtained from the method described herein, wherein the at least two metallic sheets are welded together through a welded joint and wherein the at least two metallic sheets include a first metallic sheet and a second metallic sheet, wherein the first metallic sheet is

10 a steel sheet topped by a coating comprising iron, Fe_2TiSi_z compounds, z being from 0.01 to 0.8 and being expressed in atomic ratio, the balance being zinc, such coating being covered by a layer comprising titanium oxides.

According to another aspect, the invention may also relate to the use of the assembly

15 obtained from the method described herein for the manufacture of parts of a vehicle.

The invention will now be illustrated by means of indicative examples given for information purposes only, and without limitation, with reference made to the accompanying figures in which:

- 20
- Figure 1 schematically represents a pre-coated steel substrate according to the invention and
 - Figure 2 represents an assembly according to the present invention.

The designation “steel” or “steel sheet” means a steel sheet, a coil, a plate having a composition allowing the part to achieve a tensile strength up to 2500 MPa

25 and more preferably up to 2000MPa. For example, the tensile strength is above or equal to 500 MPa, preferably above or equal to 980 MPa, advantageously above or equal to 1180 MPa and even above or equal 1470 MPa.

The invention relates to a pre-coated steel substrate coated with:

- a first pre-coating comprising titanium, said first coating having a thickness of 40 nm
- 30 to 1200nm,
- optionally, an intermediate pre-coating layer comprising at least 8% by weight nickel and at least 10% by weight chromium, the rest being iron or an intermediate pre-

2b

coating comprising Fe, Ni, Cr and Ti wherein the amount of Ti is above or equal to 5 wt.% and wherein the following equation is satisfied: $8 \text{ wt.\%} < \text{Cr} + \text{Ti} < 40 \text{ wt.\%}$, the balance being Fe and Ni, the intermediate layer layer having a thickness of 2 nm to 30nm,

- 5
- a second pre-coating layer being a zinc-based coating and
 - said steel substrate comprising above 0.05wt.% of Si.

Indeed, without willing to be bound by any theory, it is believed that during the welding, the molten Zn in the second pre-coating dissolves the steel until the coating becomes saturated in iron. In standard Zn-coated steel without the first pre-coating comprises Ti, it is observed that the critical embrittling phenomenon occurs after this first rapid dissolution, because of the preferential Zn diffusion in the steel grain boundaries, especially if steel contains Si, leading to a significant decrease of their cohesive strength. When a first pre-coating comprising titanium is present, precipitates enriched with Fe, Ti and Si are formed in the molten Zn, so that the saturation of the coating in iron is strongly retarded and dissolution can longer and deeper proceed, thus protecting the substrate from LME.

If the thickness of the first pre-coating comprising titanium is below 40nm, there is a risk that the amount of titanium is not enough to form the precipitates in the molten coating during the whole duration of the critical welding operation so as to prevent LME. Adding more than 1200 nm does not bring additional benefits.

Preferably, the first pre-coating consists of titanium, i.e. the amount of titanium is above or equal to 99% by weight.

In a preferred embodiment, the first pre-coating has a thickness between 40 and 80nm. In another preferred embodiment, the first pre-coating has a thickness between 80 and 150nm. In another preferred embodiment, the first pre-coating has a thickness between 150 and 250nm. In another preferred embodiment, the first pre-coating has a thickness between 250 and 450nm. In another preferred embodiment, the first pre-coating has a thickness between 450 and 600nm. In another preferred embodiment, the first pre-coating has a thickness between 600 and 850nm. In another preferred embodiment, the first pre-coating has a thickness between 850 and 1200nm. Indeed, without willing to be bound by any theory, it is believed that these thicknesses further improve the resistance to LME.

Preferably, an intermediate pre-coating is present between the steel substrate and the first pre-coating, such intermediate layer comprising iron, nickel, chromium and optionally titanium. Without willing to be bound by any theory, it

seems that the intermediate coating layer further improves the adhesion of the second pre-coating on the first pre-coating.

In a preferred embodiment, the intermediate layer comprises at least 8% by weight nickel and at least 10% by weight chromium, the rest being iron. For example, the layer of metal coating is 316L stainless steel including 16-18% by weight Cr and 10-14% by weight Ni, the balance being Fe.

In another preferred embodiment, the intermediate layer comprises Fe, Ni, Cr and Ti wherein the amount of Ti is above or equal to 5 wt.% and wherein the following equation is satisfied: $8 \text{ wt.\%} < \text{Cr} + \text{Ti} < 40 \text{ wt.\%}$, the balance being Fe and Ni, such intermediate coating layer being directly topped by a coating layer being an anticorrosion metallic coating.

The thickness of the intermediate pre-coating, when present, is of 2 to 30nm. Indeed, without willing to be bound by any theory, it is believed that this range of thickness allows for an improvement of the adhesion of the second pre-coating.

In another preferred embodiment, the zinc-based coating comprises 0.01-8.0% Al, optionally 0.2-8.0% Mg, the remainder being Zn. For example, the zinc based coating comprises 1.2wt.% of Al and 1.2wt.% of Mg or 3.7wt.% of Al and 3wt.% of Mg. More preferably, the zinc-based coating comprises between 0.10 and 0.40% by weight of Al, the balance being Zn.

Preferably, the steel substrate has the following chemical composition in weight percent:

$$0.05 \leq \text{C} \leq 0.4\%,$$

$$0.5 \leq \text{Mn} \leq 30.0\%,$$

$$0.05 \leq \text{Si} \leq 3.0\%,$$

and on a purely optional basis, one or more elements such as

$$\text{Al} \leq 2.0\%,$$

$$\text{P} < 0.1\%,$$

$$\text{Nb} \leq 0.5 \%,$$

$$\text{B} \leq 0.005\%,$$

$$\text{Cr} \leq 2.0\%,$$

$$\text{Mo} \leq 0.50\%,$$

$$\text{Ni} \leq 1.0\%,$$

5

 $V \leq 0.50\%$, $Ti \leq 0.5\%$,

the remainder of the composition making up of iron and inevitable impurities resulting from the elaboration. More preferably, the amount of Mn is the steel substrate is below or equal to 10wt.%, advantageously below or equal 6wt% or even better below 3.5wt%.

Figure 1 illustrates a pre-coated steel substrate according to the present invention. In this Example, a steel sheet 1, containing above 0.05wt.% of Si, the steel surface being topped by a first pre-coating of titanium 2 having a thickness of 40nm to 1200 nm and a second pre-coating of zinc 3.

The invention also relates to a method for the manufacture of the coated steel substrate according to the present invention, comprising the successive following steps:

- A. The provision of a steel substrate,
- B. Optionally, the surface preparation of the steel substrate,
- C. The deposition of the first pre-coating,
- D. Optionally, the deposition of the intermediate pre-coating,
- E. The deposition of the second pre-coating.

Preferably, in step B), the surface preparation is performed by etching, or pickling. It seems that this step allows for the cleaning of the steel substrate leading to the improvement of the adhesion of the first pre-coating.

Preferably, in steps C) and D), the deposition of first and intermediate pre-coating independently from each other is performed by physical vacuum deposition. More preferably, the deposition of first and intermediate pre-coatings independently from each other is performed by magnetron cathode pulverization process or jet vapor deposition process.

Advantageously, in step E), the deposition of the second pre-coating is performed by a hot-dip coating, by electro-deposition process or by vacuum deposition.

The invention further relates to a method for the manufacture of an assembly comprising the following successive steps:

- I. The provision of at least two metallic substrates wherein at least one metallic substrate is the pre-coated steel substrate according to the present invention and
- II. The welding of the at least two metallic substrates.

5 Preferably, in step II), the welding is performed by spot welding, arc welding or laser welding.

With the method according to the present invention, it is possible to obtain an assembly of at least two metallic substrates welded together through a welded joint wherein the at least one metallic substrate is such that the steel substrate is topped
10 by a coating comprising iron, Fe_2TiSi compounds, the balance being zinc, said coating being covered by a layer comprising titanium oxides. The at least one metallic substrate originates from the pre-coated steel substrate according to the present invention.

Without willing to be bound by any theory, it is believed that Fe_2TiSi
15 compounds precipitates in the liquid Zn of the coating during welding, promoting an intense steel dissolution that prevents the zinc from penetrating into the steel grain boundaries. Moreover, it seems that a part of the first pre-coating layer comprising titanium migrates on the top of the zinc-based coating and oxidizes during the welding. The assembly according to the present invention has thus a high resistance
20 to LME.

Figure 2 illustrates a welded joint of an assembly of two metallic substrates wherein one metallic substrate is a steel sheet 11, topped by a first coating comprising iron, Fe_2TiSi_z compounds 12, z being from 0.01 to 0.8 and being expressed in atomic ratio, the balance being zinc 13 and a second coating
25 comprising titanium oxides 14. In this Example, the second metallic substrate 15 is a bare steel sheet.

In one embodiment, the steel substrate does not comprise internal oxides of alloying elements of the steel.

In another preferred embodiment, the steel substrate comprises internal
30 oxides of alloying elements of the steel. Preferably, the steel substrate comprises internal oxides of alloying elements comprise silicon oxides, manganese oxides, chromium oxides, aluminum oxides or a mixture thereof.

Preferably, the second metallic substrate is a steel substrate or an aluminum substrate. Preferably, the second metallic substrate is a pre-coated steel substrate according to the present invention.

5 Advantageously, the assembly comprises a third metallic substrate. Preferably, the third metallic substrate is a steel substrate or an aluminum substrate. Preferably, the third metallic substrate is a pre-coated steel substrate according to the present invention.

10 Finally, the use of an assembly obtainable from the method according to the present invention for the manufacture of parts of vehicle.

With a view to highlight the enhanced performance obtained through using the assemblies according to the invention, some concrete examples of embodiments will be detailed in comparison with assemblies based on the prior art.

15 Examples

For the Trials, two steel sheets having the chemical composition in weight percent disclosed in Table 1 were used:

Steel Sheets	C	Mn	Si	Al	S	P	Cr	Nb	Cu	Ni	Ti	B	Fe
1	0.21	1.65	1.65	0.042	0.001	0.013	0.026	0.001	0.008	0.011	0.008	0.006	Balance
2	<0.002	0.11	0.007	0.050	0.008	0.010	0.020	<0.002	0.018	0.021	0.054	<0.0003	Balance
3	0.19	2.50	1.70	0.048	0.002	0.011	0.024	0.001	0.009	0.012	0.009	0.005	Balance

Example 1: Critical LME Elongation

20 For Trial 1, a first pre-coating of Titanium having a thickness of 900nm was deposited by magnetron sputtering on a steel sheet having the composition 1. Then, an intermediate pre-coating layer being a stainless steel 316L was deposited on titanium. The thickness of the intermediate layer was of 10nm. Finally, a second pre-coating layer being a zinc coating was deposited by jet vapor deposition.

25 The second pre-coating layer thickness was of 7µm. Trial 4 was made according to the same procedure on a steel sheet having the composition 3.

For Trial 2, a zinc coating having a thickness of 7µm was deposited on steel sheet 1 by electrodeposition. Trial 5 was made according to the same procedure a steel sheet having the composition 3.

Trial 3 is a bare steel sheet 1.

Trials	Steel	1 st coating	Intermediate coating	2 nd coating
1*	1	Ti	FeNiCr (Stainless steel 316L)	Zn
2	1	Zn	-	-
3	1	-	-	-
4*	3	Ti	FeNiCr (Stainless steel 316L)	Zn
5	3	Zn	-	-

5 *: according to the present invention

Then, Trials 1 to 3 were heated from ambient temperature to 800°C, 850°C and 900°C at a heating rate of 1000°C per second using a Gleeble device. A tensile displacement was applied on each tensile specimen until fracture. The strain rate was of 3mm per second. Tensile forces and displacement were recorded and the elongation at fracture could be determined from these stress-strain curves. This elongation at fracture represents the so-called Critical LME Elongation. The higher the critical LME strain, the more the Trial is resistant to LME. The methodology is also explained in the publication called « *Critical LME Elongation : Un essai Gleeble pour évaluer la sensibilité au LME d'un acier revêtu soudé par points* », Journées Annuelles SF2M 2017, 23-25 october 2017, JA0104, ArcelorMittal Research Maizières-lès-Metz.

Results are gathered in the following Table 1.

Trials	Temperature (°C)	Critical LME Elongation (%)
1*	800	46
	850	38
	900	38
2	800	<u>7</u>
	850	<u>13</u>
	900	<u>5</u>

Trials	Temperature (°C)	Critical LME Elongation (%)
3	800	48
	850	49
	900	40

*: according to the present invention

Results shown that Trial 1 has an improved resistance to LME compared to Trial 2. Trial 1 and Trial 3 have the same resistance to LME.

5

Example 2: Three sheets stack up

The sensitivity to LME of different assemblies was evaluated by resistance spot welding method. To this purpose, for each Trial, three steel sheets were welded together by resistance spot welding.

10 Trial 6 was an assembly of Trial 1 with two galvanized steel sheets having the composition 2.

Trial 7 was an assembly of Trial 2 with two galvanized steel sheets having the composition 2.

15 Trial 8 was an assembly of Trial 4 with two galvanized steel sheets having the composition 2.

Trial 9 was an assembly of Trial 5 with two galvanized steel sheets having the composition 2.

The type of the welding electrode was F1 with a face diameter of 6mm; the clamping force of the electrode was of 450daN. The welding cycle was reported in

20 Table 2:

Weld time	Current (Hz)	Welding time (ms)	Cool time (ms)
Cycle	50	380	260

Each trial was reproduced 10 times in order to produce 10 spot welds at a current level defined as the upper welding limit of the current range: I_{max} , I_{max} comprised between 0.9 and $1.1 \cdot I_{exp}$, I_{exp} being the intensity beyond which expulsion appears during welding, I_{exp} was determined according to ISO standard 18278-2.

25

The highest crack length in the spot-welded joint was then evaluated after cross-sectioning through the surface crack and using an optical microscope as reported in the following Table 3. The LME crack resistance behavior was evaluated with respect to the 10 spot welds (representing 100% in total).

Trials	No cracks	0 < Crack < 100µm	100µm < Crack < 200µm	Crack > 0.5*assembly thickness (assembly thickness=1.0mm)
Trial 6*	70%	20%	10%	-
Trial 7	30%	10%	<u>30%</u>	<u>30%</u>
Trial 8*	20%	50%	20%	10%
Trial 9	-	30%	<u>30%</u>	<u>40%</u>

5 *: according to the present invention.

Trials 6 and 8 according to the present invention show an excellent resistance to LME as compared to Trials 7 and 9.

CLAIMS

1. A coated steel sheet comprising a substrate, the substrate comprising above 0.05 wt% of Si, said substrate being successively coated with:
 - 5 – a first coating consisting of titanium, said first coating being in direct contact with the substrate and having a thickness ranging from 40 nm to 1200 nm; and
 - a second coating being a zinc-based coating.
- 10 2. The coated steel sheet according to claim 1, wherein the thickness of the first coating is between 40 and 80nm.
3. The coated steel sheet according to claim 1, wherein the thickness of the first coating is between 80 and 150nm.
- 15 4. The coated steel sheet according to claim 1, wherein the thickness of the first coating is between 150 and 250nm.
5. The coated steel sheet according to claim 1, wherein the thickness of the first coating is between 250 and 450nm.
- 20 6. The coated steel sheet according to claim 1, wherein the thickness of the first coating is between 450 and 600nm.
7. The coated steel sheet according to claim 1, wherein the thickness of the first coating is between 600 and 850nm.
- 25 8. The coated steel sheet according to claim 1, wherein the thickness of the first coating is between 850 and 1200nm.

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9. The coated steel sheet according to any one of claims 1 to 8, wherein the substrate is further coated with an intermediate coating layer deposited between the first coating and the second coating, the intermediate coating layer comprising at least 8% by weight nickel and at least 10% by weight chromium, the rest being iron, the intermediate coating layer having a thickness between 2 and 30nm.
10. The coated steel sheet according to any one of claims 1 to 8, wherein the substrate is further coated with an intermediate coating layer deposited between the first coating and the second coating, the intermediate coating layer comprising Fe, Ni, Cr and Ti, wherein the amount of Ti is above or equal to 5 wt.% and wherein the following equation is satisfied: $8 \text{ wt.\%} < \text{Cr} + \text{Ti} < 40 \text{ wt.\%}$, the balance being Fe and Ni, the intermediate coating layer having a thickness between 2 and 30nm.
11. The coated steel sheet according to claim 9, wherein the intermediate coating layer includes stainless steel containing between 10 and 13% by weight nickel, between 16 and 18% by weight chromium, the remainder being iron.
12. The coated steel sheet according to any one of claims 1 to 11, wherein the second coating is a zinc-based coating consisting of from 0.01 to 8.0% Al, optionally 0.2-8.0% Mg, the remainder being Zn.
13. The coated steel sheet according to any one of claims 1 to 11, wherein the second coating is a zinc-based coating consisting of between 0.10 and 0.40 wt.% of Al, the balance being zinc.

14. The coated steel sheet according to any one of claims 1 to 13, wherein the substrate of the steel sheet has the following chemical composition in weight percent:

5

$$0.05 \leq C \leq 0.4\%$$

0.5 ≤ Mn ≤ 30.0%,

0.05 < Si ≤ 3.0%

and

Al ≤ 2.0%,

10

P < 0.1%.

$$\text{Nb} \leq 0.5 \%$$
$$B \leq 0.005\%$$

Cr ≤ 2.0%

Mo ≤ 0.50%.

15

Ni ≤ 1.0%.

 $V \leq 0.50\%$

Ti ≤ 0.5%,

the remainder of the composition including iron and inevitable impurities resulting from elaboration.

20

15. A method for the manufacture of a coated steel sheet comprising the following successive steps:

A) provision of a steel substrate comprising above 0.05 wt% of Si,

25

B) deposition of a first coating layer consisting of titanium, said first coating being in direct contact with the steel substrate and having a thickness ranging from 40 nm to 1200 nm; and,

C) deposition of a second coating layer, said second coating being a zinc-based coating.

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16. The method according to claim 15, further comprising a surface preparation step of the steel substrate prior to the deposition of the first coating layer.

17. The method according to claim 15 or claim 16, wherein the thickness of the first coating layer is between 40 and 80nm.
- 5 18. The method according to claim 15, wherein the thickness of the first coating layer is between 80 and 150nm.
19. The method according to claim 15, wherein the thickness of the first coating layer is between 150 and 250nm.
- 10 20. The method according to claim 15, wherein the thickness of the first coating layer is between 250 and 450nm.
21. The method according to claim 15, wherein the thickness of the first coating layer is between 450 and 600nm.
- 15 22. The method according to claim 15, wherein the thickness of the first coating layer is between 600 and 850nm.
23. The method according to claim 15, wherein the thickness of the first coating is between 850 and 1200nm.
- 20 24. The method according to any one of claims 15 to 23, further comprising, between the deposition of the first coating layer and the deposition of the second coating layer, a step of deposition of an intermediate coating layer comprising at least 8% by weight nickel and at least 10% by weight chromium, the rest being iron, the intermediate coating layer having a thickness between 2 and 30nm.
- 25 25. The method according to any one of claims 15 to 23, further comprising, between the deposition of the first coating layer and the deposition of the
- 30

second coating layer, a step of deposition of an intermediate coating layer comprising Fe, Ni, Cr and Ti, wherein the amount of Ti is above or equal to 5 wt.% and wherein the following equation is satisfied: $8 \text{ wt.\%} < \text{Cr} + \text{Ti} < 40 \text{ wt.\%}$, the balance being Fe and Ni, the intermediate coating layer having a thickness between 2 and 30nm.

26. The method according to claim 24, wherein the intermediate coating layer includes stainless steel containing between 10 and 13% by weight nickel, between 16 and 18% by weight chromium, the remainder being iron.

27. The method according to any one of claims 24 to 26, wherein the deposition of the first coating layer and the deposition of the intermediate coating layer are performed independently from each other by physical vacuum deposition.

28. The method according to any one of claims 24 to 26, wherein the deposition of the first coating layer and the deposition of the intermediate coating layer are performed independently from each other by a magnetron cathode pulverization process or by a jet vapor deposition process.

29. The method according to any one of claims 15 to 28, wherein the second coating layer is a zinc-based coating consisting of:

- a) from 0.01 to 8.0% Al;
- b) optionally 0.2-8.0% Mg;
- c) the remainder being Zn.

30. The method according to any one of claims 15 to 28, wherein the second coating layer is a zinc-based coating consisting of:

- a) between 0.10 and 0.40 wt.% of Al;
- b) the balance being zinc.

31. The method according to any one of claims 15 to 30, wherein the steel substrate provided at step A) has the following chemical composition in weight percent:

5 $0.05 \leq C \leq 0.4\%$,
 $0.5 \leq Mn \leq 30.0\%$,
 $0.05 < Si \leq 3.0\%$,
and:
 $Al \leq 2.0\%$,
10 $P < 0.1\%$,
 $Nb \leq 0.5 \%$,
 $B \leq 0.005\%$,
 $Cr \leq 2.0\%$,
 $Mo \leq 0.50\%$,
15 $Ni \leq 1.0\%$,
 $V \leq 0.50\%$,
 $Ti \leq 0.5\%$,

the remainder of the composition including iron and inevitable impurities resulting from elaboration.

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32. A method for the manufacture of an assembly of at least two metallic sheets comprising the following successive steps:

25 I. provision of the at least two metallic sheets wherein at least one metallic sheet is the coated steel sheet according to any one of claims 1 to 14 or obtained from the method according to any one of claims 15 to 31 and

II. welding of the at least two metallic sheets.

33. The method according to claim 32, wherein in step II), the welding is performed by spot welding or arc welding.

34. An assembly obtained from the method according to claim 32 or claim 33, wherein the at least two metallic sheets are welded together through a welded joint and wherein the at least two metallic sheets include a first metallic sheet and a second metallic sheet, wherein the first metallic sheet is a steel sheet topped by a coating comprising iron, Fe_2TiSi_z compounds, z being from 0.01 to 0.8 and being expressed in atomic ratio, the balance being zinc, such coating being covered by a layer comprising titanium oxides.
35. The assembly according to claim 34, wherein the first metallic sheet comprises internal oxides of alloying elements of the steel.
36. The assembly according to claim 35, wherein the internal oxides of alloying elements of the steel comprise silicon oxides, manganese oxides, chromium oxides, aluminum oxides or a mixture thereof.
37. The assembly according to any one of claims 34 to 36, wherein the second metallic sheet is a steel sheet or an aluminum sheet.
38. The assembly according to any one of claims 34 to 36, wherein the second metallic sheet is a coated steel sheet according to any one of claims 1 to 14 or obtained from the method according to any one of claims 15 to 31.
39. Use of the assembly obtained from the method according to any one of claims 32 to 33 or according to any one of claims 34 to 38 for the manufacture of parts of a vehicle.

1/1

Figure 1

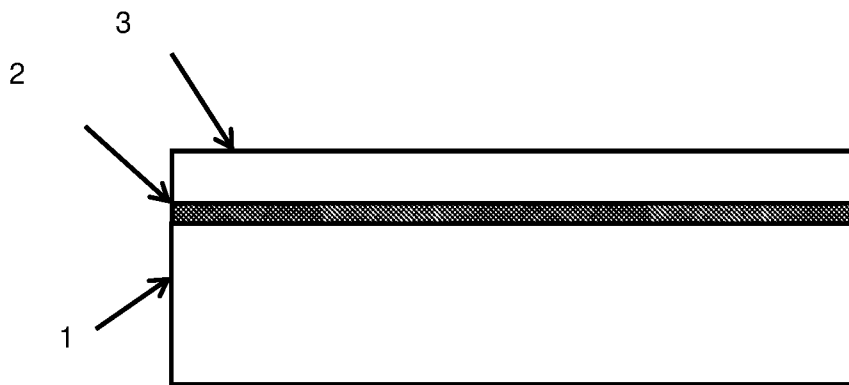


Figure 2

