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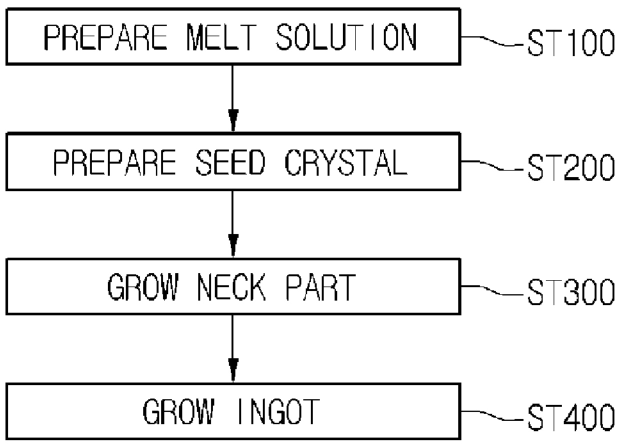
(54) Title: METHOD OF GROWING INGOT AND INGOT

[Fig. 1]



(57) Abstract: Provided is a method of growing an ingot. The method of growing the ingot includes melting a silicon to prepare a silicon melt solution, preparing a seed crystal having a crystal orientation [110], growing a neck part from the seed crystal, and growing an ingot having the crystal orientation [110] from the neck part. The neck part has a diameter of about 4 mm to about 8 mm.

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Description

Title of Invention: METHOD OF GROWING INGOT AND INGOT

Technical Field

[1] The present disclosure relates to a method of growing an ingot and an ingot.

Background Art

[2] Generally, a process of manufacturing a wafer for manufacturing a semiconductor device may include a slicing process for slicing a silicon monocrystalline ingot, an edge grinding process for rounding an edge of the sliced wafer, a lapping process for planarizing a rough surface of the wafer due to the slicing process, a cleaning process for removing particles and all sorts of contaminants which are attached to a surface of the wafer during the edge grinding or lapping process, a surface polishing process for securing a shape and surface suitable for post processes, and an edge polishing process with respect to the edge of the wafer.

[3] Silicon monocrystalline ingots may be grown through a czochralski (CZ) method or a floating zone (FZ) method. The CZ method is commonly used for growing silicon monocrystalline ingots because large-diameter single monocrystalline ingots are capable of being manufactured through the CZ method, and also the CZ method is relatively inexpensive method.

[4] The CZ method may be performed by immersing a seed crystal in silicon melt solution and then lifting the seed crystal at a low speed.

[5] However, products having new crystal orientations are required to overcome limitation of existing semiconductor devices. For example, a product having a crystal orientation [110] is expected as a next generation product. However, when compared to an ingot having crystal orientation [100], an ingot having the crystal orientation [110] have low crystalline because a dislocation is propagated in a crystal growth direction, and also, it is difficult to control the dislocation.

Disclosure of Invention

Technical Problem

[6] Embodiments provide a high-quality wafer having a crystal orientation [100].

Solution to Problem

[7] In one embodiment, a method of growing an ingot includes: melting a silicon to prepare a silicon melt solution; preparing a seed crystal having a crystal orientation [110]; growing a neck part from the seed crystal; and growing an ingot having the crystal orientation [110] from the neck part, wherein the neck part has a diameter of about 4 mm to about 8 mm.

[8] The details of one or more embodiments are set forth in the accompanying drawings

and the description below. Other features will be apparent from the description and drawings, and from the claims.

Advantageous Effects of Invention

[9] According to the method of growing the ingot, the high-quality ingot having the crystal orientation [110] may be grown. That is, the wafer having the new crystal orientation which is capable of overcoming the limitations of the semiconductor device according to the related art may be manufactured. That is, the wafer having the improved device efficiency may be manufactured using the ingot having the crystal orientation [110].

[10] Particularly, the boron concentration of the seed crystal may correspond to the doping concentration of the silicon melt solution. Therefore, an occurrence of the misfit due to a concentration difference between the silicon melt solution and the seed crystal may be controlled. The misfit dislocation represents a dislocation occurring within the seed crystal when the seed crystal contacts the silicon melt solution due to a constant different therebetween in a case where the doping concentration of the silicon melt solution is different from that of the seed crystal. In the embodiment, the misfit dislocation may be controlled to grow the monocrystalline having high quality.

[11] Also, since the neck part grown by the method of growing the ingot according to the embodiment has a diameter greater than that of the neck part according to the related art, the neck part may support the large-size high-weight ingot. That is, the process failure may be prevented, and the process yield may be improved.

Brief Description of Drawings

[12] Fig. 1 is a flowchart illustrating a method of growing an ingot according to an embodiment.

[13] Fig. 2 is a perspective view of an ingot manufactured through the method of growing the ingot according to an embodiment.

[14] Fig. 3 is a cross-sectional view of an apparatus for manufacturing an ingot which is used for a method of growing an ingot according to an embodiment.

[15] Fig. 4 is a graph illustrating experimentation data with respect to a dislocation length to a neck part diameter in a method of growing an ingot according to an embodiment.

Mode for the Invention

[16] In the drawings, the thickness or size of each layer (film), each region, each pattern, or each structure is modified for convenience in description and clarity. Thus, the size of each element does not entirely reflect an actual size.

[17] Example embodiments will now be described more fully hereinafter with reference to the accompanying drawings.

[18] Referring to Figs. 1 and 2, a method of growing an ingot according to an em-

bodiment and an ingot manufactured by the method will be described below in detail. Fig. 1 is a flowchart illustrating a method of growing an ingot according to an embodiment. Fig. 2 is a perspective view of an ingot manufactured through the method of growing the ingot according to an embodiment.

[19] A method of growing an ingot according to an embodiment includes preparing a melt solution (ST100), preparing a seed crystal (ST200), growing a neck part (ST300), and growing an ingot (ST400).

[20] In the preparing of the melt solution (ST100), a silicon melt solution may be prepared in a quartz crucible installed within a chamber. That is, in the preparing of the melt solution (S100), silicon may be melted to prepare a silicon melt solution. The silicon melt solution may have a doping concentration of about 8.5×10^{18} atoms/cm^3 to about 1.7×10^{19} atoms/cm^3. Particularly, the silicon melt solution may be doped with boron. Here, the boron may have a concentration of about 8.5×10^{18} atoms/cm^3 to about 1.7×10^{19} atoms/cm^3. In the boron doping concentration, boron may be heavily doped for determining an EPI-substrate, but not a general specific resistance band.

[21] Particularly, in the preparing of the melt solution (ST100), a magnetic field may be applied. Particularly, the magnetic field may be applied into a lower side from a surface of the silicon melt solution. More particularly, if a level of the surface of the silicon melt solution is zero, the maximum magnetic field may be applied into a position corresponding to a level of about -100 mm from the zero. The magnetic field may have intensity of about 1,500 G to about 3,500 G. As a result, a temperature deviation of the silicon melt solution may be reduced. Thus, the dislocation may be controlled.

[22] In the preparing of the seed crystal (ST200), a seed crystal having a crystal orientation [110] may be prepared. Thus, an ingot having the crystal orientation [110] may be grown from the seed crystal.

[23] The seed crystal may have a boron concentration of about 8.5×10^{18} atoms/cm^3 to about 1.7×10^{19} atoms/cm^3. That is, the boron concentration of the seed crystal may correspond to the doping concentration of the silicon melt solution. Therefore, an occurrence of a misfit due to a concentration difference between the silicon melt solution and the seed crystal may be controlled. The misfit dislocation represents a dislocation occurring within the seed crystal when the seed crystal contacts the silicon melt solution due to a constant different therebetween in a case where the doping concentration of the silicon melt solution is different from that of the seed crystal. In the current embodiment, the misfit dislocation may be controlled to grow a monocrystalline having high quality.

[24] Next, in the growing of the neck part (ST300), the neck part may be grown from the seed crystal. That is, the neck part N having a thin and long shape may be grown from

the seed crystal.

[25] In the growing of the neck part (ST300), the neck part may have a growth rate of about 3.0 mm/min to about 3.2 mm/min. Thus, the neck part may be quickly grown than a dislocation velocity to control the dislocation.

[26] If the neck part has a growth rate of about 2 mm/min or less, the neck part may be increased in diameter. Thus, it may be more difficult to control the dislocation of the neck part in a [110] crystal. On the other hand, if the neck part has a growth rate of about 4 mm/min or more, the neck part may be decreased in diameter. Thus, the neck part may be vulnerable to a weight. Thus, the neck part may have a growth rate of about 3 mm/min to about 3.2 mm/min.

[27] Referring to Fig. 2, the neck part N may have a length ℓ of about 400 mm or more. Also, the neck part N may have a diameter d of about 4 mm to about 8 mm. Since the neck part N has a diameter greater than that of a neck part according to a related art, the neck part N may support a large-size high-weight ingot. That is, process failure may be prevented, and process yield may be improved.

[28] In detail, if the neck part has a diameter less than about 4 mm, the neck part may not endure a weight of a large scale ingot having a diameter of about 300 mm or more during the growth of the ingot. Thus, the neck part may be broken to cause loss. Also, if the neck part has a diameter greater than about 8 mm, it may be difficult to control the dislocation of the neck part.

[29] A reason in which the neck part has a diameter of about 4 mm to about 8 mm and a length of about 400 mm or more will be described with reference to following experimentation results.

[30] Table below illustrates results obtained by arranging a dislocation length according to a diameter of the neck part. Fig. 4 illustrates the experimentation data of Table of Fig. 4 as a graph.

[31] Table 1

[Table 1]

Orientation	Neck Diameter	Dislocation length
[110]	2.9	175
	2.9	165
	3.0	220
	3.0	230
	3.0	230
	5.92	270
	6.81	350
	6.24	280
	5.98	300
	6.48	390
	6.82	400
	5.1	320
	5.98	300
	5.92	270

[32] Referring to Table 1 and Fig. 4, when the neck part has a length less than about 400 mm, the dislocation length is short. Thus, although productivity is improved, it may be difficult to control the dislocation in the [110] crystal. As a result, products may be deteriorated in quality.

[33] Thus, it may be necessary that the neck part has a length of about 400 mm or more so that the neck part has a diameter of about 4 mm to about 8 mm to more easily control the dislocation.

[34] In the growing of the ingot (ST400), an ingot I may be grown from the neck part N. That is, an ingot having a crystal orientation [110] may be grown. That is, a wafer having a new crystal orientation which is capable of overcoming the limitations of the semiconductor device according to the related art may be manufactured. That is, a wafer having improved device efficiency may be manufactured using the ingot having the crystal orientation [110].

[35] In the growing of the ingot (ST400), the ingot may have a lifting speed of about 0.9 mm/min or more. Thus, a cooling rate of the crystalline may be increased by a growth apparatus including a cooler to improve heat resistance. Also, the dislocation may be multiplied to confirm whether a polycrystalline exists with a naked eye, thereby securing the monocrystalline.

[36] The growing of the ingot (ST400) may include a shouldering formation process for expanding a diameter of the neck part N to a target diameter and a body growth process for growing the silicon monocrystalline ingot while maintaining the target diameter.

[37] Hereinafter, an apparatus for manufacturing an ingot by using a method of growing an ingot according to an embodiment will be described. Fig. 3 is a cross-sectional view of an apparatus for manufacturing an ingot which is used for a method of growing an ingot according to an embodiment.

[38] Referring to Fig. 3, an apparatus for growing a silicon monocrystalline ingot according to an embodiment may be an apparatus used in a CZ method of methods for manufacturing a silicon wafer.

[39] An apparatus for growing a silicon monocrystalline ingot according to an embodiment includes a chamber 10, a first crucible 20 for containing a raw material, a cover part 100, a second crucible 22, a crucible rotation shaft 24, a lifting mechanism 30 for lifting an ingot, a heat shield 40 for blocking heat, and a resistance heater 70, an insulator 80, and a magnetic field generation device 90.

[40] These detailed descriptions are as follows.

[41] Referring to Fig. 3, the first crucible 20 may receive a raw material. The first crucible 20 may receive a polysilicon. Also, the first crucible 20 may receive a melting silicon in which the polysilicon is melted. The first crucible 20 may include quartz.

[42] The second crucible may support the first crucible 20. The second crucible 22 may include graphite.

[43] The first crucible 20 may be rotated in a clockwise or counterclockwise direction by the crucible rotation shaft 24. The lifting mechanism 30 to which a seed crystal is attached may be disposed above the first crucible 20 to lift the see crystal. The lifting mechanism 30 may be rotated in a direction opposite to the rotation direction of the crucible rotation shaft 24.

[44] The seed crystal attached to the lifting mechanism 30 may be immersed into a silicon melt solution SM, and then the lifting mechanism 30 may be rotated to lift the seed crystal. As a result, a silicon monocrystalline may be grown to manufacture an ingot I.

[45] Sequentially, the resistance heater 70 for applying heat into the first crucible 20 may be disposed adjacent to the second crucible 22. The insulator 80 may be disposed outside the resistance heater 70. The resistance heater 70 supplies heat for melting the polysilicon to produce the silicon melt solution SM. Also, during the manufacturing process, the resistance heater 70 may continuously supply heat into the silicon melt solution SM.

[46] The silicon melt solution SM contained in the first crucible 20 may have a high temperature. Thus, heat may be released from an interface of the silicon melt solution SM.

Here, if a large amount of heat is released, it may be difficult to maintain a proper temperature required for growing the silicon monocrystalline ingot. Thus, the heat released from the interface may be minimized, and also, it may prevent the heat from being transferred into an upper portion of the silicon monocrystalline ingot. For this, the heat shield 40 may be provided so that each of the silicon melt solution SM and the interface of the silicon melt solution SM are maintained at a high temperature.

[47] The heat shield 40 may have various shapes so as to maintain thermal environments into a desired state to stably grow the crystal. For example, the heat shield 40 may have an empty cylindrical shape to surround the periphery of the silicon monocrystalline ingot. For example, the shield 40 may include graphite, graphite felt, or molybdenum.

[48] The magnetic field generation device 90 which applies a magnetic field into the silicon melt solution SM to control convection current of the silicon melt solution SM may be disposed outside the chamber 10. The magnetic field generation device 90 may be a device which generates a magnetic field in a direction perpendicular to a crystal growth axis of the silicon monocrystalline ingot, i.e., a horizontal magnetic field (MF). In the current embodiment, the magnetic generation device 90 may acts from the process for melting the silicon. Particularly, the magnetic field generation device 90 may apply the magnetic field into a lower side of a surface of the silicon melt solution.

[49] A particular feature, structure, or effects described in connection with the embodiment is included in at least one embodiment of the invention, and is not limited to only one embodiment. Further, when a particular feature, structure, or characteristic is described in connection with any embodiment, it is submitted that it is within the purview of one skilled in the art to effect such feature, structure, or characteristic in connection with other ones of the embodiments. Therefore, contents with respect to various variations and modifications will be construed as being included in the scope of the present disclosure.

Industrial Applicability

[50] Since the apparatus and method for growing the ingot is available in the current embodiment, industrial applicability may be high.

Claims

[Claim 1] A method of growing an ingot, the method comprising:
melting a silicon to prepare a silicon melt solution;
preparing a seed crystal having a crystal orientation [110];
growing a neck part from the seed crystal; and
growing an ingot having the crystal orientation [110] from the neck part,
wherein the neck part has a diameter of about 4 mm to about 8 mm.

[Claim 2] The method according to claim 1, wherein the silicon melt solution has a doping concentration of about 8.5 x 10^{18} atoms/cm^3 to about 1.7 x 10^{19} atoms/cm^3.

[Claim 3] The method according to claim 2, wherein the silicon melt solution has a boron concentration of about 8.5 x 10^{18} atoms/cm^3 to about 1.7 x 10^{19} atoms/cm^3.

[Claim 4] The method according to claim 1, wherein the seed crystal has a doping concentration of about 8.5 x 10^{18} atoms/cm^3 to about 1.7 x 10^{19} atoms/cm^3.

[Claim 5] The method according to claim 4, wherein the seed crystal has a boron concentration of 8.5 x 10^{18} atoms/cm^3 to about 1.7 x 10^{19} atoms/cm^3.

[Claim 6] The method according to claim 1, wherein the neck part has a length of about 400 mm or more.

[Claim 7] The method according to claim 1, wherein, in the growing of the neck part, the neck part has a growth rate of about 3.0 mm/min to about 3.2 mm/min.

[Claim 8] The method according to claim 1, wherein, in the growing of the ingot, the ingot has a lifting speed of about 0.9 mm/min or more.

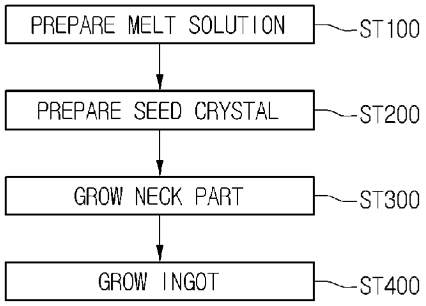
[Claim 9] The method according to claim 1, wherein, in the preparing of the silicon melt solution, a magnetic field is applied.

[Claim 10] The method according to claim 9, wherein the magnetic field is applied into a lower side of a surface of the silicon melt solution.

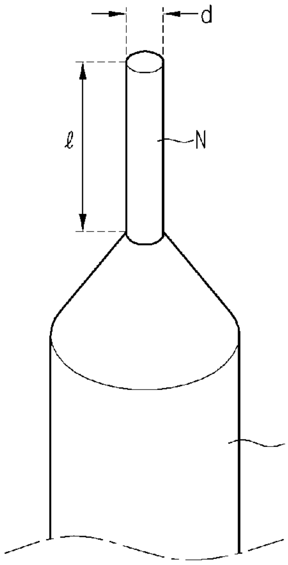
[Claim 11] The method according to claim 9, wherein the magnetic field has an intensity of about 1,500G to about 3,500 G.

[Claim 12] An ingot having the crystal orientation [110], the ingot being grown according to claim 1 to 11.

[Fig. 1]


PREPARE MELT SOLUTION
ST100
PREPARE SEED CRYSTAL
ST200
GROW NECK PART
ST300
GROW INGOT
ST400

[Fig. 2]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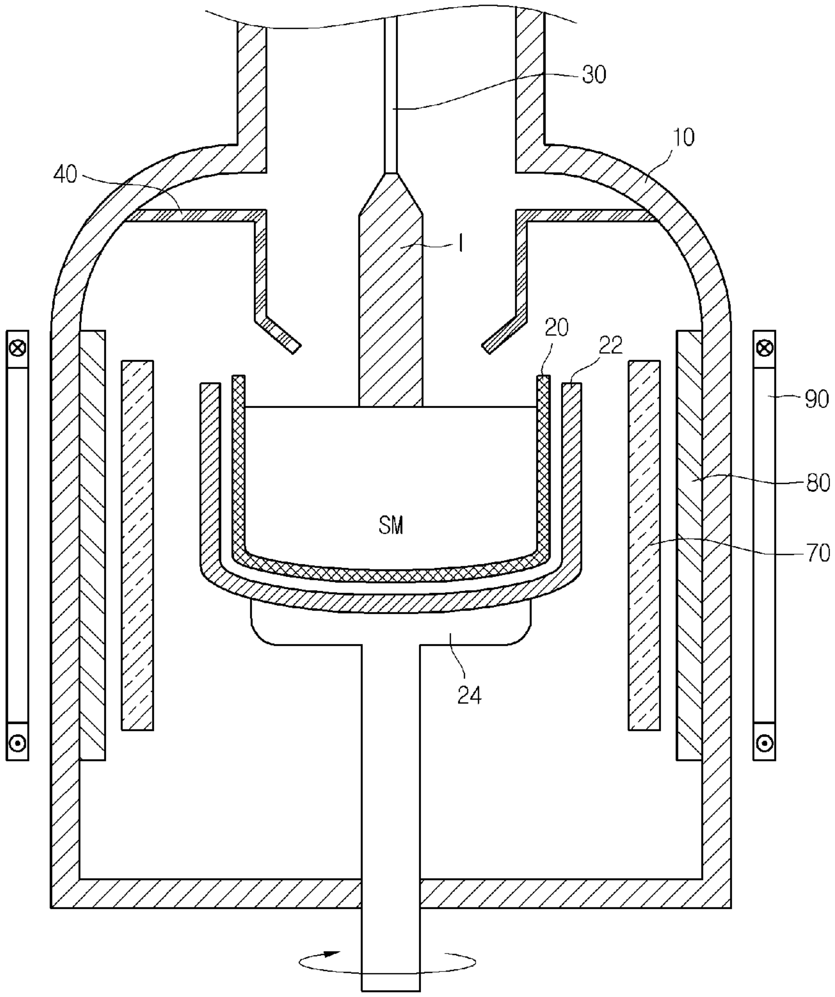
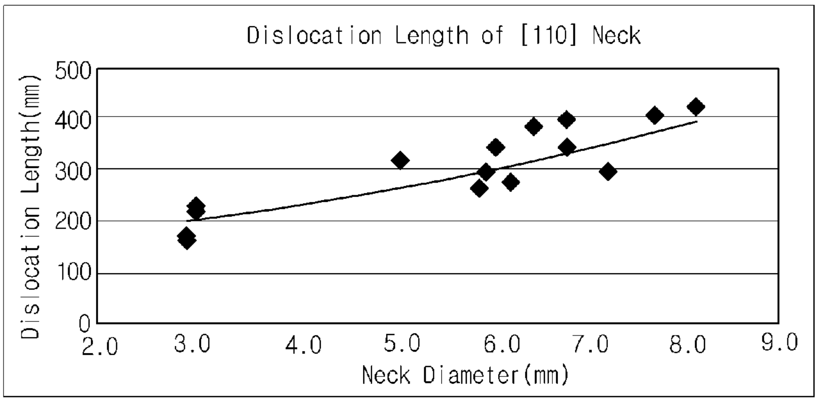
[Fig. 3]


30
10
40
I
20
22
90
80
70
SM
24

[Fig. 4]


Dislocation Length of [110] Neck
Dislocation Length(mm)
500
400
300
200
100
0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
Neck Diameter(mm)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2012/010332

A. CLASSIFICATION OF SUBJECT MATTER

C30B 15/00(2006.01)i, C30B 29/06(2006.01)i, H01L 21/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C30B 15/00; C30B 15/20; C30B 29/06; C30B 30/04; C30B 15/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & keywords: SINGLE CRYSTAL, SEED CRYSTAL, ORIENTATIN[110]

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	KR 10-2008-0090293 A (SUMCO CORPORATION) 8 October 2008 See abstract; claims 1, 2; paragraphs [0026],[0029].	1-12
A	US 2005-0160966 A1 (FUSEGAWA, I. et al.) 28 July 2005 See abstract; claims 8-10, 13; paragraph [0076].	1-12
A	US 7226506 B2 (Iida, t. et al.) 5 June 2007 See abstract; claims 6, 8.	1-12

☐ Further documents are listed in the continuation of Box C.   ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search 19 MARCH 2013 (19.03.2013)	Date of mailing of the international search report **22 MARCH 2013 (22.03.2013)**
Name and mailing address of the ISA/KR Facsimile No. 82-42-472-7140	Authorized officer KIM, Sung Gon Telephone No. 82-42-481-8746

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		EP 1498516 B1	05.01.2011
		EP 1498516 B8	02.03.2011
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