between the semiconductor substrate10, and the wiring 20 and the second interlayer insulating layer 12.

[0026] Fig. 2 is a schematic cross-sectional diagram schematically illustrating a cross section of a semiconductor substrate after the sealing composition application process.

As illustrated in Fig. 2, in the sealing composition application process, a sealing composition for a semiconductor is applied at a side of the semiconductor substrate 10 illustrated in Fig. 1 at which the first interlayer insulating layer 14 and the like are formed, to form a sealing layer 30 as a sealing layer for a semiconductor on at least the bottom face and the side face of the recess portion 16. In this process, the sealing layer 30 is also formed on the exposed face 20a of the wiring 20.

[0027] Fig. 3 is a schematic cross-sectional diagram schematically illustrating a cross section of a semiconductor substrate after the removal process.

In the removal process, a face of the semiconductor substrate after the sealing composition application process illustrated in Fig. 2 at a side at which the sealing layer 30 has been formed is subjected to heat treatment under the temperature condition of from 200°C to 425°C, to remove the sealing layer for a semiconductor located on the exposed face 20a of the wiring 20. Here, it is not essential that the sealing layer for a semiconductor located on the exposed face 20a be entirely removed; it is sufficient that the sealing layer for a semiconductor located on the exposed face 20a be removed to such an extent that the interconnection resistance between the wiring (for example, the first wiring 40 in Fig. 4 described below) that will be embedded in the recess portion 16 in a subsequent process and the wiring 20 is not increased.

As described above, the removal process enables removal of at least a part of the sealing layer located on the wiring 20 while leaving the sealing layer 30 on at least the side face of the recess portion 16.

In this way, a semiconductor device 100 which has the sealing layer 30 on at least the side face of the recess portion 16, and in which the formation of the sealing layer for a semiconductor on the wiring 20 is suppressed, can be produced.

[0028] In the above description, an example of the manufacturing method according to the first invention is illustrated; however, the first invention is by no means limited to this example.

For example, as described below, it is preferable that a washing process of washing at least the side face and the bottom face of the recess portion 16 with a rinsing liquid is provided between the sealing composition application process and the removal process. The washing process further improves the removability of the sealing layer located on the wiring.

polyethylene glycol-equivalent molecular weight distribution as measured by GPC (Gel Permeation Chromatography) method.

Specifically, the weight average molecular weight and the molecular weight distribution in the first invention are measured using an aqueous solution having an acetic acid concentration of 0.5 mol/L and a sodium nitrate concentration of 0.1 mol/L as an eluent and using an analyzer SHODEX GPC-101 and a column ASAHIPAK GF-7M HQ, and are calculated using polyethylene glycol as a reference standard.

[0061] It is also preferable that the polymer has a critical micelle concentration in an aqueous solvent of 1% by mass or more, or is a polymer that does not substantially form a micelle structure. The expression "does not substantially form a micelle structure" as used herein means that a micelle is not formed under ordinary conditions, such as in an aqueous solvent at an ordinary temperature, namely, the critical micelle concentration cannot be measured. By using such a polymer, a thin polymer layer having a thickness at a molecular level (for example, 5 nm or less) can be formed, and an increase in the dielectric constant of the interlayer insulating layer can effectively be suppressed. In addition, adhesion between the interlayer insulating layer and the wiring material is enhanced more effectively.

[0062] Further, the polymer in the first invention is preferably a polyethyleneimine having a weight average molecular weight of from 2,000 to 600,000 and a cationic functional group equivalent weight of from 43 to 430, and more preferably a polyethyleneimine having a weight average molecular weight of from 10,000 to 80,000 and a cationic functional group equivalent weight of from 200 to 400. With this configuration, diffusion of metal components into the interlayer insulating layer is suppressed more effectively, and the tightness of adhesion between the interlayer insulating layer and the wiring material is further enhanced.

[0063] The content of the polymer in the sealing composition for a semiconductor is not particularly limited. The content of the polymer may be set to be, for example, from 0.01% by mass to 1.0% by mass, and is preferably from 0.02% by mass to 0.3% by mass. Further, the content of the polymer in the composition may be adjusted also in view of the area and pore density of the surface on which the polymer layer is to be formed using the sealing composition for a semiconductor.

[0064] In the sealing composition for a semiconductor, each of the content of sodium and the content of potassium is 10 ppb by mass or less on an elemental basis. The content, 10 ppb by mass or less, indicates that sodium and potassium are not positively contained. When the content of sodium or the content of potassium exceeds 10 ppb by mass on an elemental basis, a current leakage is generated in some cases.

- NMR Measurement Results of Modified Polyethyleneimine 1 -

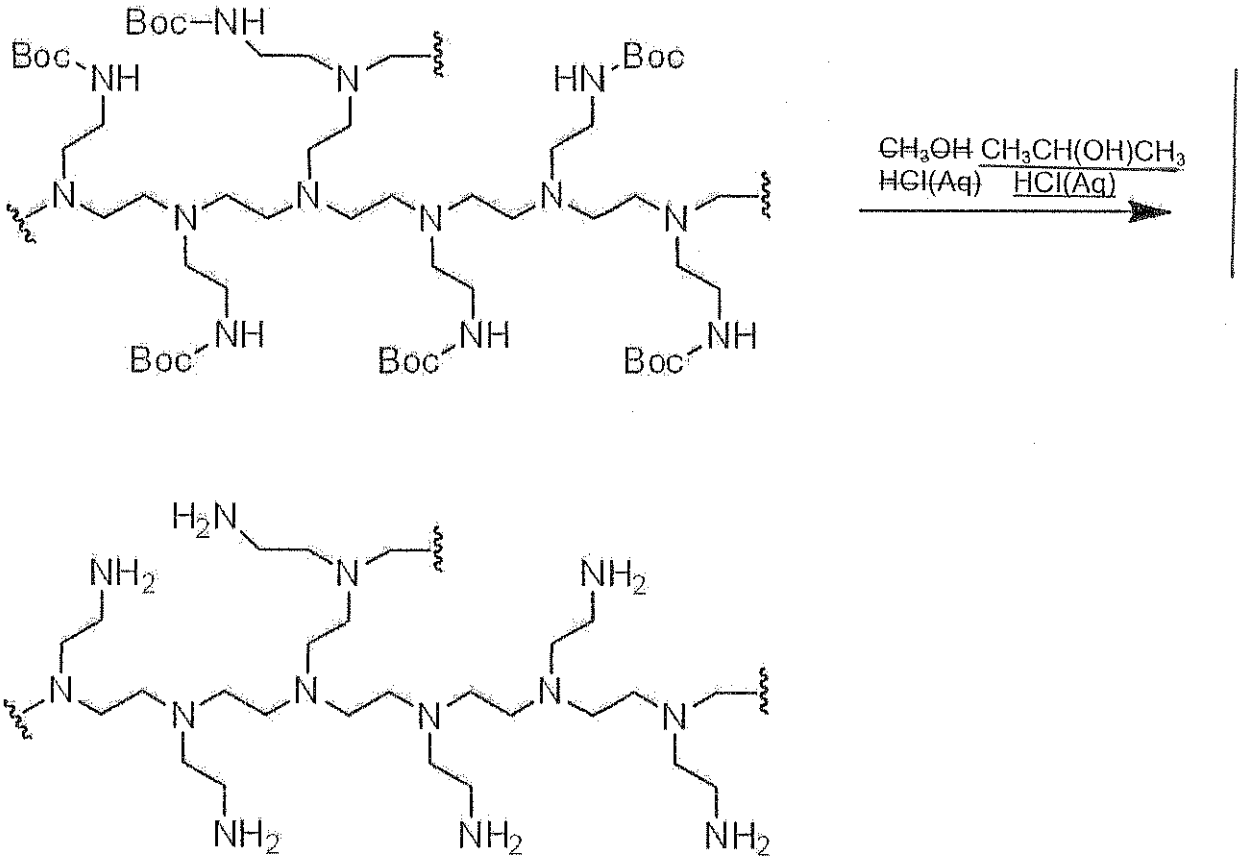
^{1}H-NMR (CD_3OD); δ 3.3-3.0 (br. s, 2), 2.8-2.5 (Br. s, 6.2), 1.45 (s, 9)

[0135] (Synthesis of Highly-branched Polyethyleneimine 1)

Highly-branched polyethyleneimine 1 was synthesized according to the following reaction scheme 2, using the modified polyethyleneimine 1 as the starting material.

[0136]

- Reaction Scheme 2 -



[0137] Detailed procedures in the above reaction scheme 2 were as follows.

124 mL of 12N hydrochloric acid were slowly added to the isopropanol solution of modified polyethyleneimine 1. The resulting solution was stirred under heating at 50°C for 4 hours while care was taken about generation of gas. Together with the generation of gas, a gummy reaction product was produced in the reaction system. After the generation of gas completed, the reaction system was cooled. After cooling, solvent that separated from the gummy reaction product was removed, and the reaction product was washed three times with 184 mL of methanol. The reaction product after washing was dissolved in water, and chlorine ions were removed using an anion exchange polymer, to obtain an aqueous solution containing 58 g of highly-branched polyethyleneimine 1.

[0174] TABLE 3

			Example 10	Example 11	Example 12	Example 13
Formation of Sealing Layer	Procedures		C → B	C → B	C → B	C → B
Washing	Rinsing Liquid, Liquid Temperature (°C)		H_2O 22°C	H_2O 22°C	Pyromellitic acid aq. (pH 2), 22°C	Pyromellitic acid aq. (pH 2), 22°C
Heat Treatment	Temperature (°C)		350	350	350	350
	Gas		N_2	N_2	~~N2~~N_2	~~N2~~N_2
	Pressure (Pa)		10,000	10,000	10,000	10,000
	Time (min)		2	2	2	2
Evaluation after Heat Treatment	Thickness of Sealing Layer [nm]	on Si	3.0	3.0	3.0	3.0
		on Cu	1.8	1.8	1.7	1.7
Plasma Treatment	Gas		H_2	H_2	H_2	H_2
	Pressure (mtorr)		150	150	150	150
	Time (sec)		20	30	20	30
Evaluation after Plasma Treatment	Sealing Property	Toluene Adsorption Amount (%)	26.8	24.4	6.0	7.0