metal based impurities, 10 ppm or less of oxygen, 5 ppm or less of nitrogen, 5 ppm or less of hydrogen, 10 ppm or less of carbon, and the remainder being Cu.

In these sputtering targets, however, the in-plane variation of the copper-manganese alloy thin film formed on a wafer is not necessarily low.

[0006] Furthermore, the present applicant has proposed a semiconductor element wiring material, which is a sputtering target for forming semiconductor copper alloy wiring and composed of Mn in an amount of 0.05 to 5 wt%, at least one element selected from Sb, Zr, Ti, Cr, Ag, Au, Cd, In, and As in a total amount of 10 wt ppm or less, and the remainder being Cu (see Patent Literature 8).

This is effective for enhancing the self-diffusion suppression function, but the purpose thereof is not a reduction in in-plane variation of the copper-manganese alloy thin film formed on a wafer.

The present applicant has disclosed a semiconductor copper alloy wiring material composed of a Cu-Mn alloy (see Patent Literature 9), in particular, has proposed a sputtering target composed of 0.05 to 20 wt% of Mn, a total amount of 500 wt ppm or less of Be, B, Mg, Al, Si, Ca, Ba, La, and Ce, and the remainder being Cu and inevitable impurities.

This is also effective for enhancing the self-diffusion suppression function, but the purpose thereof is not a reduction in in-plane variation of the copper-manganese alloy thin film formed on a wafer.

[0007]

Patent Literature 1: Japanese Patent No. 4065959
Patent Literature 2: Japanese Patent Laid-Open No. 2009-97085
Patent Literature 3: Japanese Patent Laid-Open No. 2010-248619
Patent Literature 4: Japanese Patent Laid-Open No. 2002-294437
Patent Literature 5: Japanese Patent Laid-Open No. 2008-311283
Patent Literature 6: Japanese Patent Laid-Open No. 2009-741427
Patent Literature 7: Japanese Patent Laid-Open No. 2007-51351
Patent Literature 8: Japanese Patent Laid-Open No. 2006-73863
Patent Literature 9: International Publication No. W02008/041535

SUMMARY OF THE INVENTION

[Technical Problem]

[0008] It is an object of the present invention to form a thin film having

of Mn would have 1 wt%, and was charged into the molten copper.

The molten copper-manganese alloy prepared by charging and melting Mn was cast in a water-cooled copper mold under a high vacuum atmosphere to give an ingot. Subsequently, the surface layer of the produced ingot was removed to give (φ180x60t, followed by forging at a forging ratio of 2.3 to give φ200 and then rolling at a rolling reduction of 30% to give φ440x10t.

After heat treatment at 200°C for 30 minutes, the entire target was rapidly cooled to give a target material, followed by machining into a target having a diameter of 430 mm and a thickness of 7 mm.

Table 8 shows the results of measurement of Mn composition, Vickers hardness, electrical conductivity, and thermal conductivity of these targets.

As shown in Table 8, the in-plane variation (CV value) of the Mn composition in Example 8 was 2.3% to give a target having a lower variation of the Mn composition compared to 4.3% in Comparative Example 8. The in-plane variation (CV value) of the Vickers hardness in Example 8 was 13.8% to give a target having a lower in-plane variation of the ~~electrical conductivity~~ Vickers hardness compared to 18.0% in Comparative Example 8. The in-plane variation (CV value) of the electrical conductivity in Example 8 was 2.8% to give a target having a lower in-plane variation of the electrical conductivity compared to 5.2% in Comparative Example 8. The in-plane variation (CV value) of the thermal conductivity in Example 8 was 2.6% to give a target having a lower in-plane variation of the thermal conductivity compared to 5.3% in Comparative Example 8.

[0057] Subsequently, thin films were formed by sputtering the targets of Example 8 and Comparative Example 8 for evaluating the qualities of thin films formed by sputtering. The sheet resistance of each formed thin film was measured, and the uniformity in thickness of the film was calculated. The results are shown in Table 8.

As shown in Table 8, the thin film formed using the target of Example 8 has a thickness uniformity of 3.1%. Thus, the results show that the film thickness uniformity is satisfactory even if sputtering continues for a long time, compared to the film thickness uniformity of 4.6% in the case using the target of Comparative Example 8.

[0058]

composition in Example 9 was 2.2% to give a target having a lower variation of the Mn composition compared to 4.4% in Comparative Example 9. The in-plane variation (CV value) of the Vickers hardness in Example 9 was 13.6% to give a target having a lower in-plane variation of the ~~electrical conductivity~~ Vickers hardness compared to 18.2% in Comparative Example 9. The in-plane variation (CV value) of the electrical conductivity in Example 9 was 2.6% to give a target having a lower in-plane variation of the electrical conductivity compared to 5.3% in Comparative Example 9.The in-plane variation (CV value) of the thermal conductivity in Example 9 was 2.7% to give a target having a lower in-plane variation of the thermal conductivity compared to 5.4% in Comparative Example 9.

The results shown in Tables 8 and 9 demonstrate that the in-plane variations in Mn composition, Vickers hardness, electrical conductivity, and thermal conductivity do not depend on the target diameter.

[0062]

[Table 9]

	Forgoing ratio	Rolling reduction (%)	Heat treatment temperature CC)	Heat treatment time (min)	Mn composition		Hardness		Electrical conductivity		Thermal conductivity	
					In-plane CV value (c/o)		In-plane CV value (%)		In-plane CV value (%)		In-plane CV value (%)	
Example 9	4.8	90	400	120	0	2.2	0	13.6	0	2.6	0	2.7
Comparative Example 9	2.3	30	200	30	x	4.4	x	18.2	x	5.3	x	5.4

[0063]

Examples 10, 11 and 12

In Example 10, high-purity copper (Cu) having a purity of 6 N was melted in a carbon crucible under a high vacuum atmosphere. High-purity manganese (Mn) having a purity of 5 N was adjusted so that the amount of Mn would have 0.5 wt%, and was charged into the molten copper.

The molten copper-manganese alloy prepared by charging and melting Mn was cast in a water-cooled copper mold under a high vacuum atmosphere to give an ingot. Subsequently, the surface layer of the produced ingot was removed to give φ180x151t, followed by forging at a forging ratio of 4.8 to give φ220 and then rolling at a rolling reduction of 90% to give φ700x10t.

After heat treatment at 400°C for 2 hours, the entire target was rapidly cooled to give a target material, followed by machining into a target having a diameter of 650 mm and a thickness of 7 mm.

[0064] In Example 11, high-purity copper (Cu) having a purity of 6 N was