Studies on the Influence of Polishing Process on the 6 Inch Single-Crystalline Ge Wafer TTV

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Abstract

The total thickness variation (TTV) is an important parameter to measure surface quality of Single-Crystalline Ge Wafer,it has an critical effect on the device and integrated circuits(IC) fabrication process.The paper is addressed on the effect of wafer U-turn way ,rotation speed of polishing disk, pressure of polishing head,flow of polishing solution and polishing rate on the TTV of 6 inch Single-Crystalline Ge wafer, which is less than 6μm after polishing.

Keywords

6 inch Single-Crystalline Ge wafer; TTV;polishing.

1. Introduction

High purity germanium single crystal has the characteristics of high radiation resistance, high frequency and good photoelectric performance, it is widely used in defense, military, aerospace, electronics, optical fiber, infrared optics, semiconductor and other fields[1-4],this has become a very important strategic material in the world. With the development of science and technology, its use is expanding.

From the germanium single crystal to the wafer, it needs to be rolled, sliced, chamfered, lapping (including chemical corrosion), polishing and cleaning. Slice process and chemical etching process are the key processes affecting the warping of polished wafers. The grinding process is mainly to remove the damage layer caused by sectioning process to germanium wafers, and the polishing process is the key technology to control the TTV of polished wafers [5]. With the increase of the size of germanium single crystals, the requirements for the geometric parameters of the germanium are more stringent. TTV is an important index of the surface geometry parameters, which reflects the surface properties of the germanium single crystal, and directly affects the post order epitaxial process and the performance of the device.

The paper is addressed on the effect of wafer U-turn way ,rotation speed of polishing disk, pressure of polishing head, flow of polishing solution and polishing rate on the TTV of 6 inch Single-Crystalline germanium wafer, the 6 inch germanium single crystal wafer with qualified TTV is developed, it meet the needs of domestic customers.

2. The basic principle of CMP[6]

CMP (Chemical Mechanical Polishing) is a polishing method combining the chemical reaction of the polishing liquid with the mechanical removal of the polishing machine. Under a certain pressure and the presence of the polishing slurry, a softening layer is formed on the surface of the workpiece under the action of corrosive medium in the polishing fluid. The abrasive in the polishing fluid grind the softening layer on the workpiece, so as to form a smooth surface on the surface of the polished workpiece. The polishing sketch is shown in Figure 1.

In germanium polishing process, the mechanical action comes from the friction effect between polishing cloth and abrasive liquid. Chemical action mainly depends on oxidizing agent to oxidize germanium to soluble oxide. In this article, we use lithium hypochlorite as an oxidant, and the principle of chemical polishing is as follows[7]:

Germanium is oxidized to GeO_2

$Ge + [O] \rightarrow GeO_2$

GeO_2 dissolved in water to produce Germanic acid

$GeO_2 + H_2O \rightarrow H_2GeO_3$

Germanium acid is reacted with alkaline solution to produce germanate

$H_2GeO_3 + [OH^-] \rightarrow [GeO_3^{2-}] + H_2O$

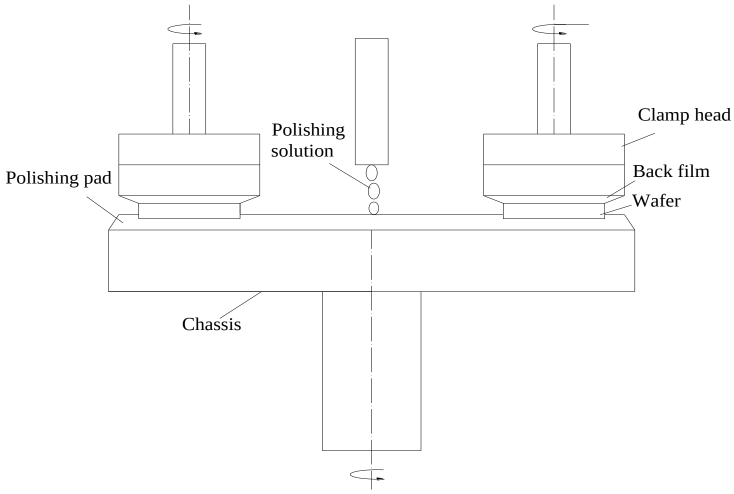

Fig.1 The polishing sketch

3. Experimental study

3.1 Experimental design

In this study, 24 slices of 6 inch germanium corrosion were grown with VGF (vertical gradient freeze) method, with a thickness of 665±3μm and a crystal direction of <100>. The ingredients used for the polishing solution are lithium perchlorate, SiO_2 colloid, sodium carbonate and water. The equipment is made of domestic single side polishing machine. Before polishing, the 24 piece of germanium chemical corrosion film is divided into 12 groups (each 2 group), placed in the 1# cassette. When polishing, every 10 minutes, the corrosion film is rotated along clockwise direction 90 degrees until a week of rotation. After polishing, the polishing wafer is placed in the 2# cassette, its TTV value is to be measured. The process parameters of each group were recorded during the experiment.

Fig. 2 Single side polishing machine

3.2 Experimental result

These 6 inch germanium polished wafers in the 2[#] cassette were placed Corning UltraSort150 flatness tester platform, automatic measuring of each piece of polished 13 point thickness, the TTV value obtained as shown in table 1.

Table.1Thickness and TTV value of 24 pieces of 6 inch germanium single crystal before and after polishing

Serial number	Thickness before polishing (μm)	Thickness after polishing (μm)	TTV before polishing (μm)	TTV after polishing (μm)
1	662.50	632.19	3.10	4.04
2	662.11	632.72	3.17	5.63
3	666.75	634.02	1.13	3.12
4	664.11	637.30	3.16	4.03
5	663.84	633.10	3.02	3.97
6	665.21	632.75	3.01	4.49
7	665.35	634.23	2.19	2.74
8	665.51	633.68	2.88	3.56
9	664.36	636.11	3.02	3.25
10	662.19	635.15	1.06	1.66
11	665.75	633.74	2.17	2.91
12	665.55	636.22	2.78	2.92
13	665.68	632.88	3.22	3.38
14	665.84	632.42	1.92	2.47
15	664.81	635.47	2.88	3.87
16	664.76	636.15	3.31	5.02
17	663.50	635.24	2.34	4.31
18	664.33	634.23	3.28	3.23
19	667.51	635.77	3.24	5.46
20	665.26	633.02	3.09	3.84
21	667.30	636.38	1.68	2.59
22	663.64	632.61	2.85	4.31
23	664.10	633.50	2.97	3.73
24	663.13	630.89	1.99	2.14

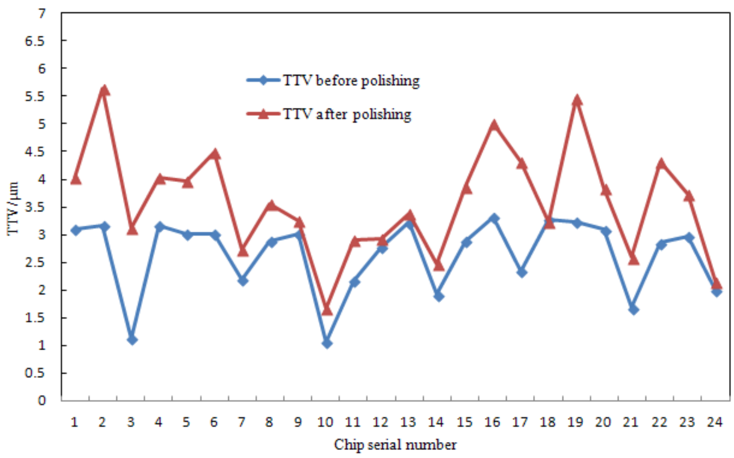

Fig.3 TTV change diagram of 24 pieces of 6 inch germanium single crystal before and after polishing

It is seen from table.1 and fig.3, before polishing, TTV of 24 pieces of 6 inch Germanium single crystal wafer is distributed below 3.5μm, after polishing, the change of TTV is within 6μm.Among them, the TTV of 2# germanium single crystal wafer is the highest, which is 5.63μm.Its surface is shown as shown in Fig.4 and fig.5.It can be seen that the surface with a clear saw has been polished and turned into a bright and clean surface.

We simulated the surface of 2# germanium single crystal wafer, as shown in figures 6 and 7. Before polishing, there was a small bump on the surface of the 2# germanium single crystal wafer. After polishing, the convex part spread to the surrounding area, and its area increased gradually.

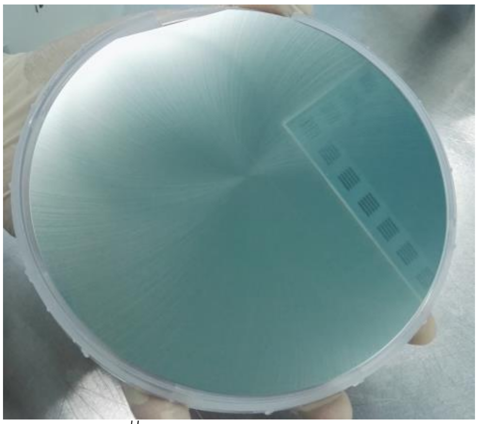

Fig.4 2# germanium single crystal wafer before polishing

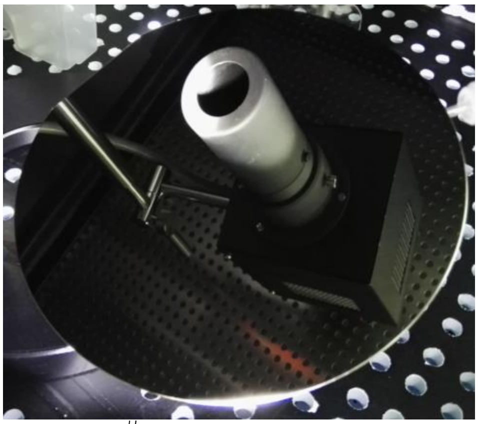

Fig.5 2# germanium single crystal wafer after polishing

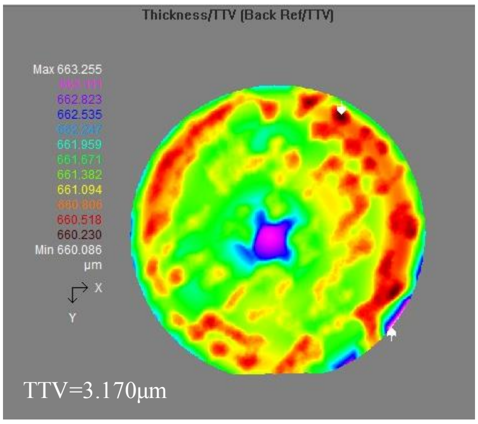

Fig.6 Surface simulation diagram of 2# germanium single crystal wafer before polishing

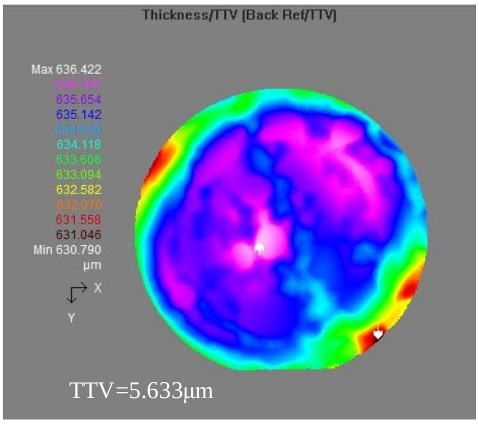

Fig.7 Surface simulation diagram of 2 # germanium single crystal wafer after polishing

3.3 Result analysis

After the experiment, we get the following results:

(1)The TTV value can be effectively reduced by using the rotating head of germanium single crystal wafer.

(2)When the other parameters unchanged, TTV value of germanium single crystal wafer decreases with increasing polishing speed, when polishing speed is accelerated to a certain extent, TTV value does not decrease, but increased quickly, this is because the polishing speed is accelerated to a certain extent, the polishing disc is out of balance. Appear high low jitter phenomenon, so that the TTV value of the germanium single crystal wafer is changed.

(3)When other polishing parameters and removal remain unchanged, low polishing rate will prolong the polishing time of germanium single crystal wafer, the TTV value becomes larger, with the increase of polishing rate, we correspondingly increase the pressure of polishing head and polishing liquid flow, the germanium single crystal wafer has a best the value of TTV. However, excessive pressure causes the fragmentation or the TTV value to be worse, and the excessive flow rate also causes the TTV value to become worse. In addition, in the case of small pressure and flow, the phenomenon of running film will appear.

4. Conclusion

Through this study, we find out the effect of wafer U-turn way ,rotation speed of polishing disk, pressure of polishing head, flow of polishing solution and polishing rate on the TTV of 6 inch Single-Crystalline germanium wafer, which greatly improve the TTV of 6 inch germanium wafers, and control them below 6μm, which meets the needs of domestic customers.

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