Chapter 3

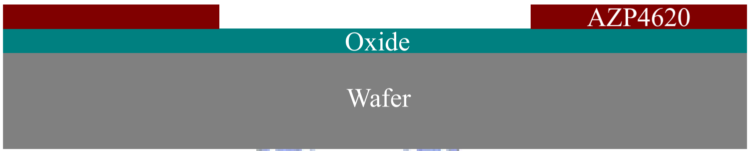
Fabrication, Bonding and Dicing

3.1 Fabrication of Testing Device

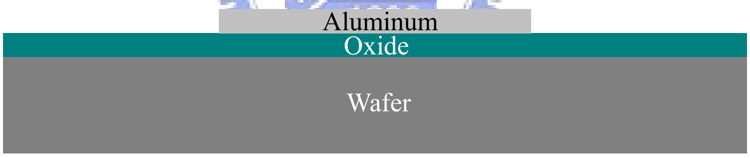
The fabrication process flows of two different testing devices are described in the following sections.

3.1.1 Fabrication of Dew Point Sensor

The fabrication process flow of dew point sensor is shown in Fig.20



5000Å wet oxide is grown for electric isolation. 13μm AZP4620 photoresist is spin coating on oxide and patterned



2μm aluminum is deposited by evaporation and lift-off in acetone with ultrasonic agitation

Fig.20 Process flow of dew point sensor

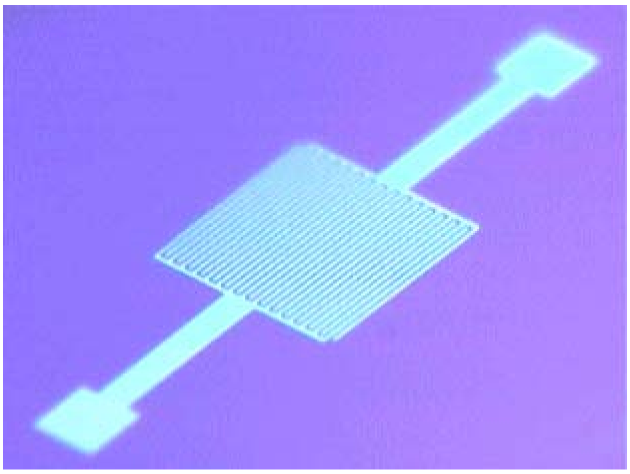
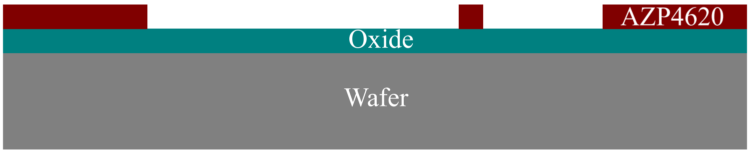


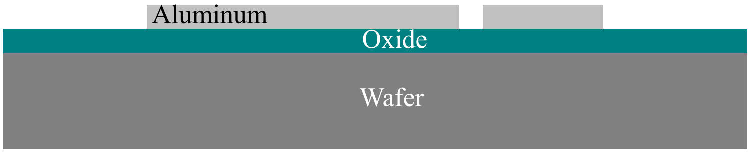
Fig.21 Optical picture of dew point sensor

3.1.2 Fabrication of Overlapping Parallel Capacitor

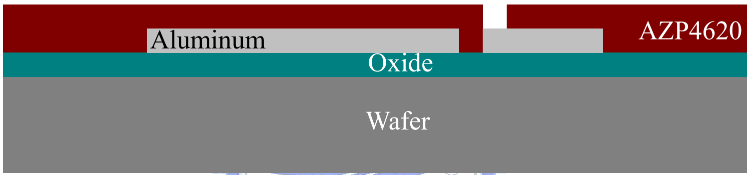
The fabrication process of overlapping parallel capacitor is shown in Fig.22



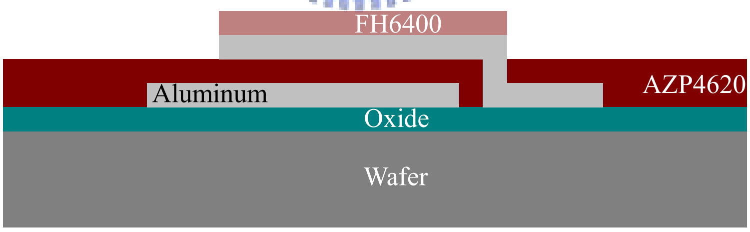
5000Å wet oxide is grown for electric isolation. 5μm AZP4620 photoresist is spin coating on oxide. Lower electrode and contact pads are patterned (Mask#1)



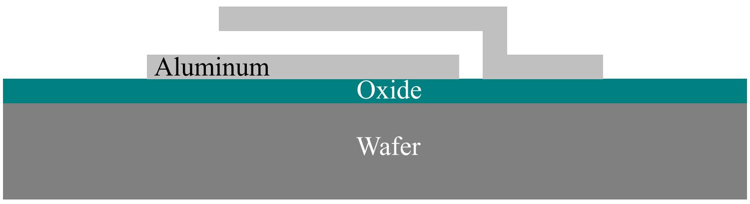
1μm aluminum is deposited by evaporation and lift-off in acetone with ultrasonic agitation



5μm AZP4620 photoresist is spin coating as the sacrificial layer. Anchor patterned (Mask#2)



3μm aluminum is also deposited by evaporation. 1μm FH6400 photoresist is spin coating and patterned (Mask#3). Phosphorous acid wet etching



Structure released by acetone and IPA, separately

Fig.22 Process flow of overlapping parallel capacitor

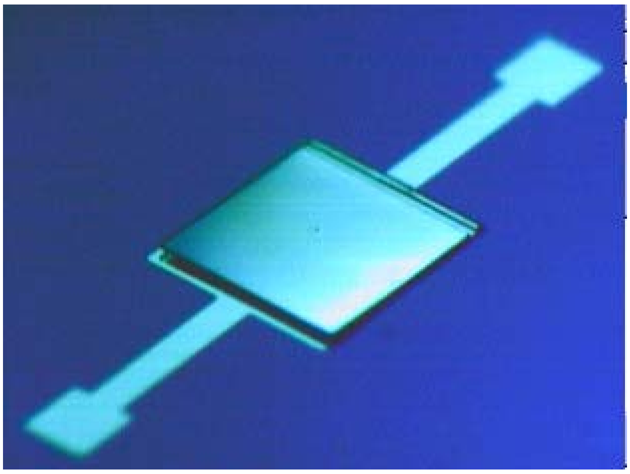


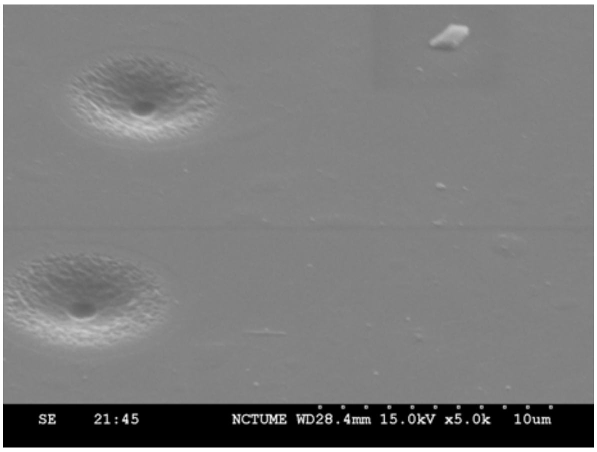
Fig.23 Optical picture of overlapping parallel capacitor

3.2 Glass Cap Fabrication

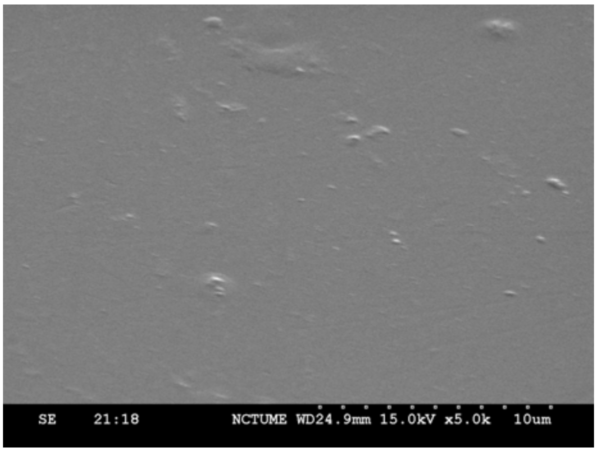
Glass is wet etching by hydrofluoric acid. The major problem is to find out suitable masking materials with good adhesion to glass. One of the choices is polysilicon which deposits by LPCVD [14]. But mobile ions inside glass such as sodium will diffuse under high temperature and contaminate the furnace, made the furnace unsuitable for other electronic device production in the future. Single crystal silicon with anodic bonding on glass is an excellent masking layer [12]. The adhesion between glass and silicon by anodic bonding is superior and can be used for glass etch through purpose. However, this method is a little bit expensive and takes nearly eight hours to remove the masking silicon by using KOH or TMAH. An alternative choice is metal. Many metals, such as gold, nickel, copper, are inactive to HF and can be used as the masking layer. Unfortunately, these metals get very poor adhesion toward glass; additional adhesion layer must be used. Different combinations of adhesion layer/masking layer are tested, and the result is shown in Table 2.

Adhesion Layer	Masking Layer	Lift-Off by Ultrasonic Agitation	Additional P.R. Layer	Surface Condition	Comment
—	AZP4620	—	—	***No data***	Peel off after 3-5min in HF(49%)
Cr	Ni	OK	With	***Very rough*** surface	
Cr	Cu	Cu peel off slightly	With	***Smooth**** with ***slightl***y pinhole	Less smooth than gold masking
Cr	Au	Au peel off	With	***Smooth*** with ***slightly*** pinhole	
Cr	Au	Au peel off	Without	***Smooth*** with ***serious*** pinhole	
Ti	Au	Au peel off slightly	Without	***No data***	Gold lift-off instantly
—	α-silicon	OK	With	***Rough*** surface	
α-silicon	Au	OK	With	***Smooth*** with ***slightly*** pinhole	Sputtering without opening chamber

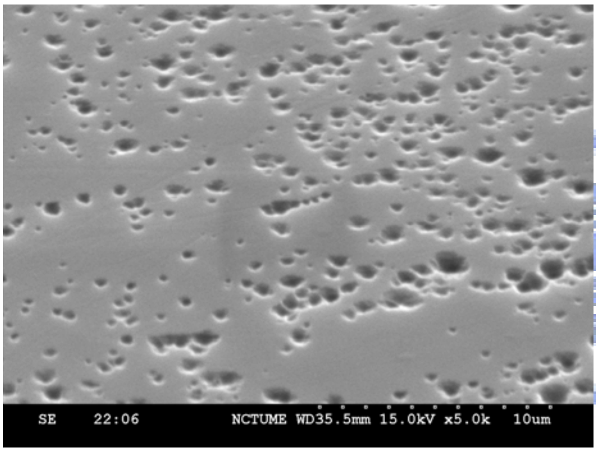
Table 2. Different masking materials for glass wet etching



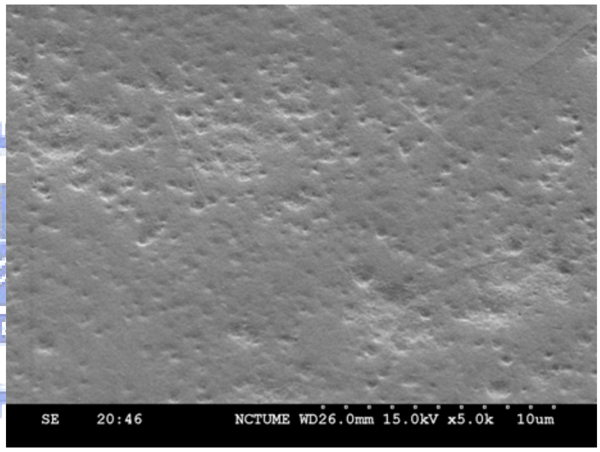
α-silicon / Au / PR Masking



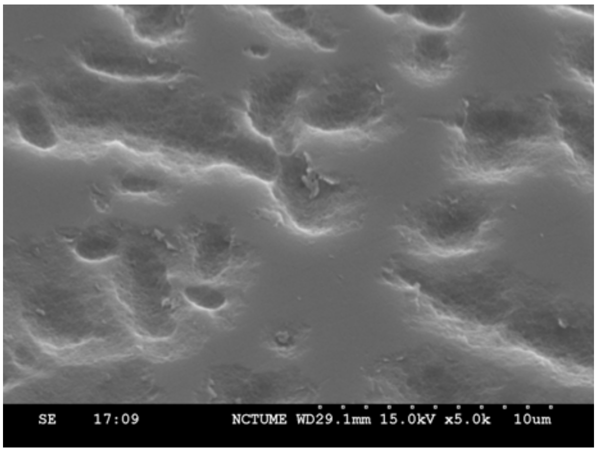
Cr / Au / PR Masking



α-silicon / PR Masking



Cr / Cu / PR Masking



Cr / Ni / PR Masking

Fig.24 SEM pictures of glass surfaces after HF (49%) wet etching by using different masking materials

In the early stage of glass cap fabrication, Cr/Au was utilized as the masking materials. Nevertheless, serious pinholes were observed (Fig.25) after wet etching process due to the defects of sputtering film. Pinholes will severely influence the bonding quality and uniformity and may cause bonding fail locally. Therefore, pinholes have to be eliminated as far as possible.

Photoresist is utilized as the third masking layer to keep out pinholes after HF wet etching. Because of the transparent nature of glass, this photoresist layer can be defined through backside exposure in order to simplify the whole process. Hard bake which usually uses to increase the resistance of photoresist is unnecessary in this process. Hard bake seems to dry the photoresist, and makes the cracking of photoresist much more easily during HF wet etching. With additional photoresist masking layer, pinholes decreasing effectively, as shown in Fig.26.

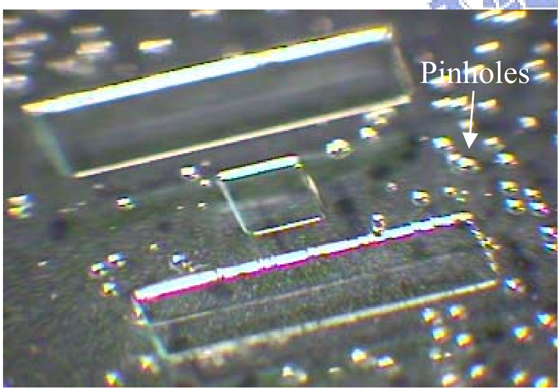


Fig.25 Glass without PR masking

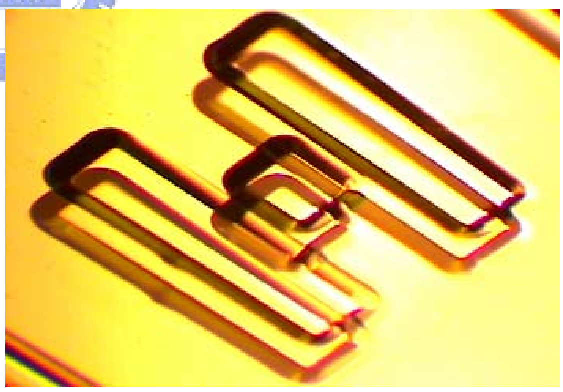
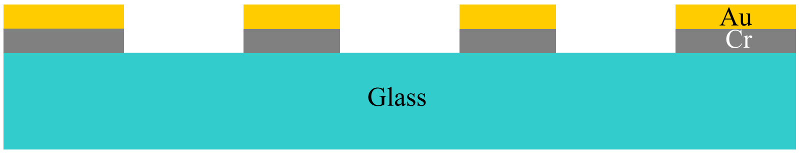


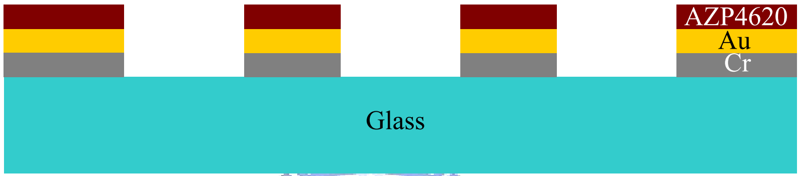
Fig.26 Glass with PR masking

The process flow of glass protection cap is shown as Fig.27

13µm AZP4620 is spin coating and patterned



400Å/1500Å Cr/Au are deposited by sputtering and lift-off by acetone with ***very gentle*** agitation



Again, 13µm AZP4620 is spin coating and patterned through backside exposure

Glass is wet etching by hydrofluoric acid (49%) with back side protection

Masking materials are removed by acetone and CR-7T, separately. Remove back side protection

Fig.27 Process flow of glass protection cap

3.3 Wafer Bonding

Unlike photoresist, UV curable adhesive cannot be soft baked. In the whole bonding process, UV curable adhesive remains in liquid phase. Contact-separate-align techniques which usually use in conventional contact aligner cannot be adopted directly in the UV curable adhesive bonding and need modification. Since there is no special equipment which designs for UV curable adhesive bonding, a home made transparent vacuum chuck which made by acrylic is built for this purpose. The chuck can fix on mask holder of contact aligner and suck glass cap by vacuum. By taking advantage of align and contact mechanism between mask holder and wafer stage, glass cap alignment and bonding can be achieved easily.

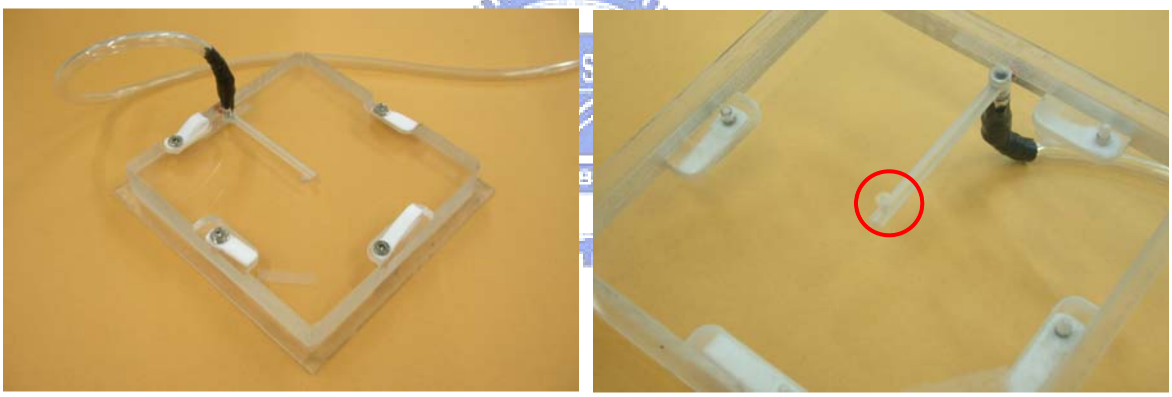


Fig.28 Single point transparent vacuum chuck. Design for wafer bonding

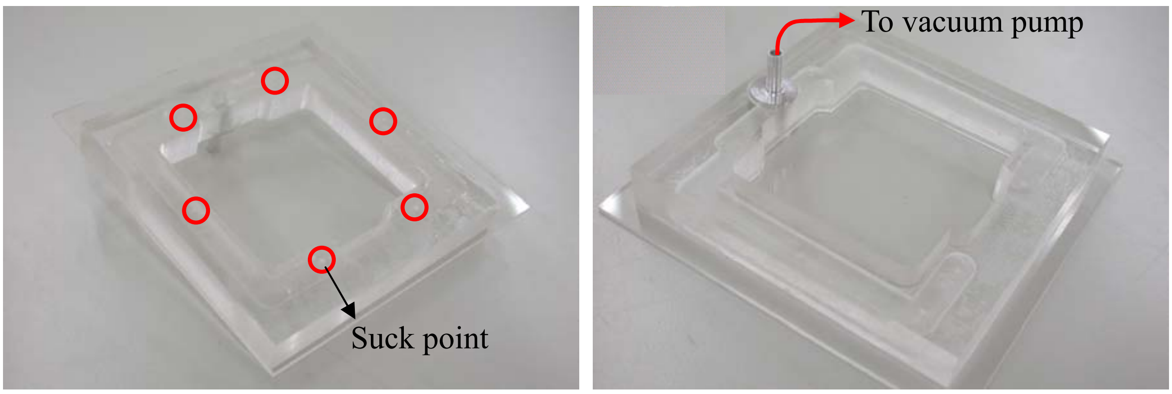


Fig.29 Six points transparent vacuum chuck. Design for 4 inch wafer bonding. Sucking with multiple points could avoid possible deflection of glass cap

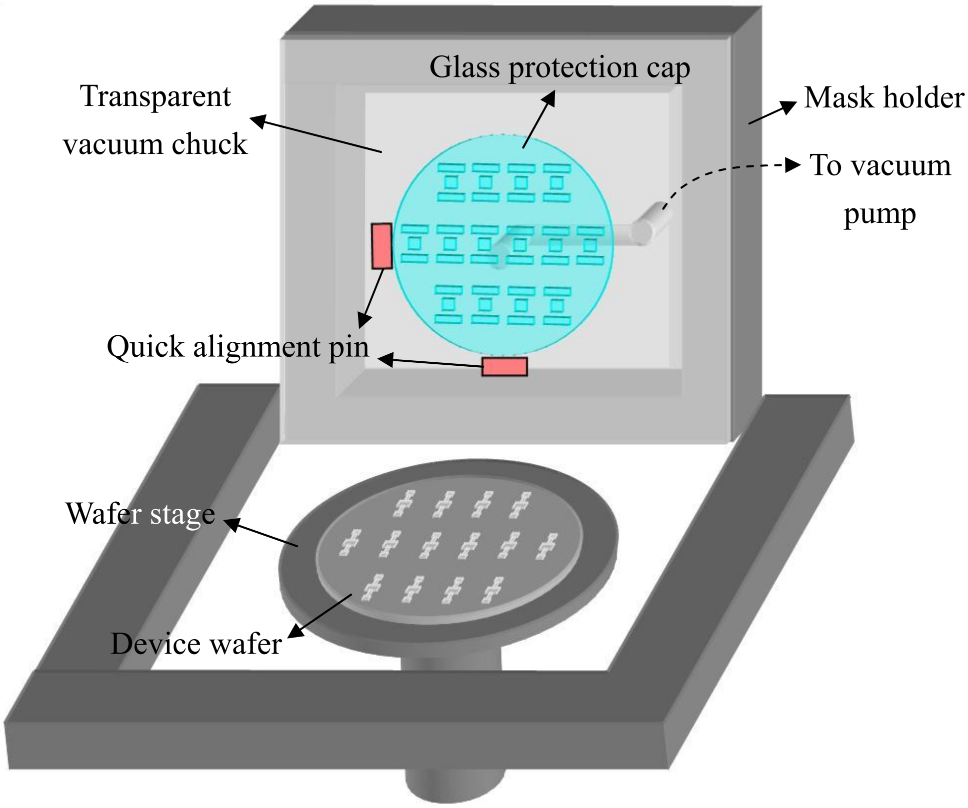


Fig.30 Wafer bonding setup diagram

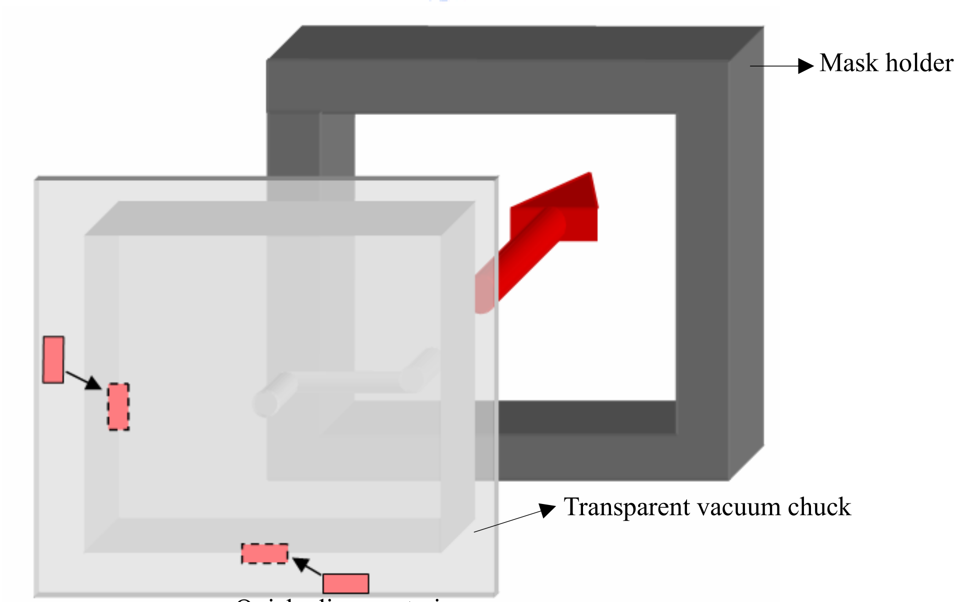


Fig.31 Transparent vacuum chuck is fixed on mask holder of contact aligner. Quick alignment pins which made by plastic are stuck on chuck by double side tape

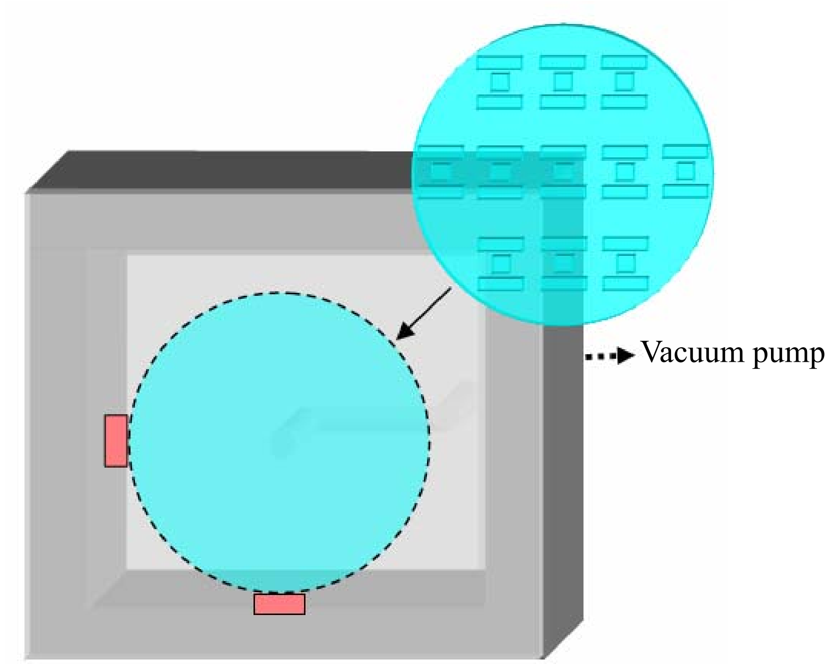


Fig.32 Glass protection cap positions by quick alignment pins. Vacuum pump on, to suck glass protection cap

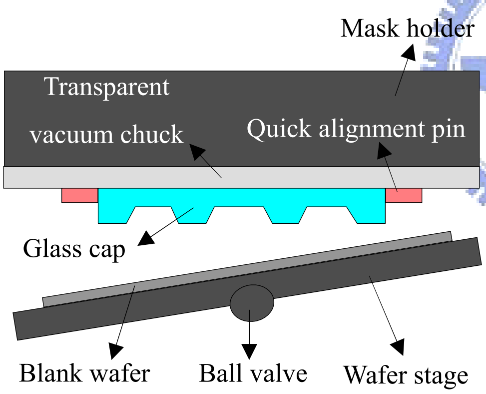


Fig.33 Side view of contact aligner after mask holder face down

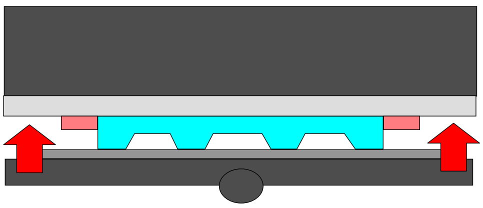


Fig.34 Blank wafer is fixed on wafer stage by vacuum. Wafer stage rises up and contacts with glass protection cap

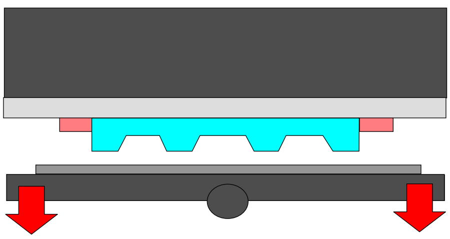


Fig.35 The level of wafer stage is fixed by vacuum. Wafer stage descends

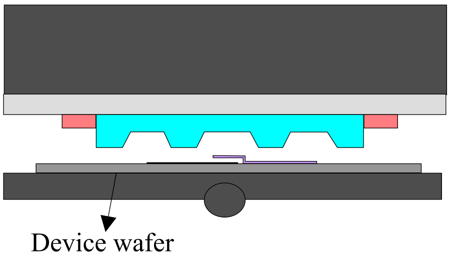


Fig.36 Blank wafer is replaced with device wafer. Alignment between glass cap and device is made carefully through optical microscope

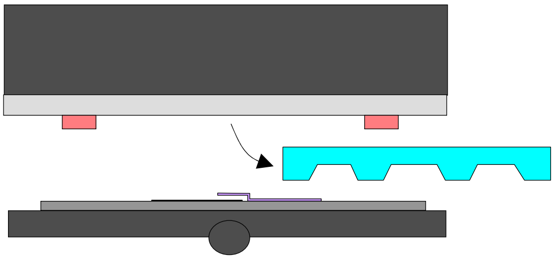


Fig.37 Glass protection cap is removed from vacuum chuck

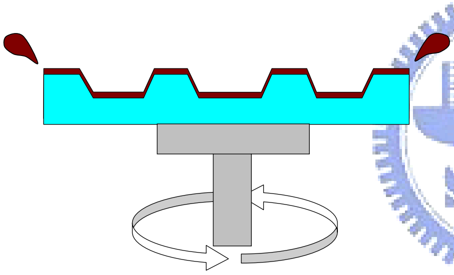


Fig.38 UV curable adhesive is spin coating on glass protection cap

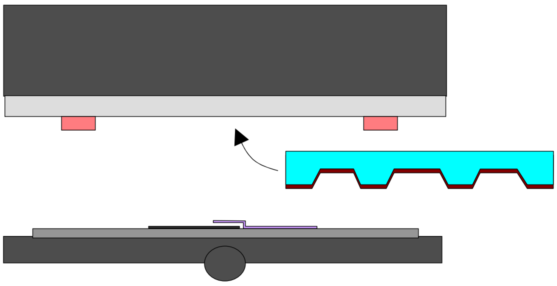


Fig.39 Glass cap with adhesive positions by quick alignment pins and fixes by vacuum

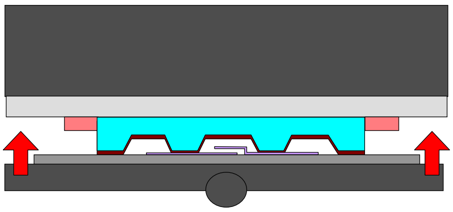


Fig.40 Again, alignment between glass cap and device is made carefully through optical microscope. After alignment is done, wafer stage rises up. Device wafer contacts with glass cap

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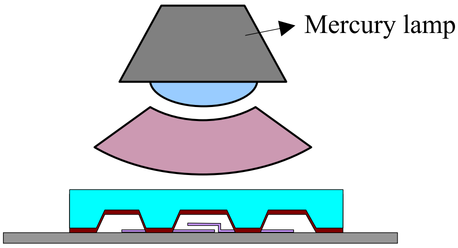


Fig.41 Device wafer with glass cap on top is moved carefully under mercury lamp. UV light flood exposure to cure the adhesive

3.4 Double Spin Procedure

As mentioned before, UV curable is spin coating on glass cap instead of stamping or other methods. The major consideration is uniformity control. Nevertheless, there are adhesive residues inside cavities by spin coating. These residues may damage devices thus must be removed.

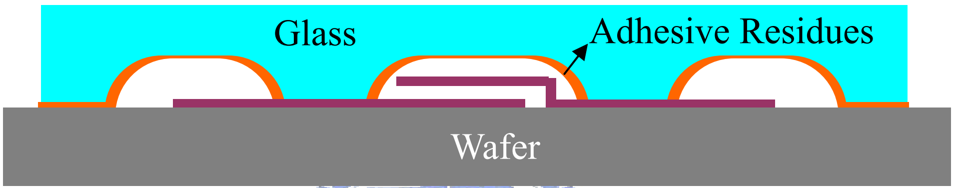


Fig.42 Device after bonding diagram.

To solve this problem, "double spin" produce is developed to drive out adhesive residues inside cavities. The procedure is simple: after UV curable adhesive is spin coating normally, glass with adhesive is transferred onto a home made vertical frame and spin again, as shown in Fig.43. By taking the advantage of centrifugal force, residues originally inside cavities reflow toward the bonding width, more space in height is available for device, as shown in Fig44.

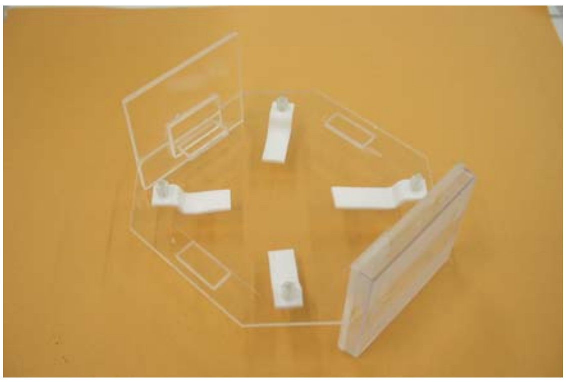
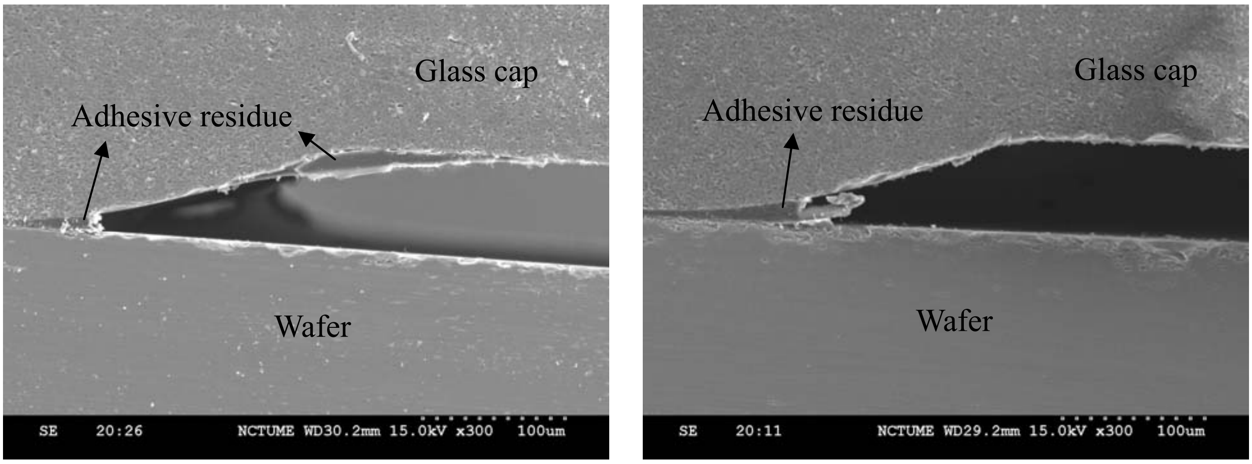


Fig.43 Vertical frame design for double spin



One-step spin coating   With double spin procedure

Fig.44 Caparison of two different spin procedure

3.5 Dicing

3.5.1 Dicing Strategy

To expose contact pads for signal input/output, glass over contact pads have to be removed after bonding. But the removal of glass over contact pads is somehow troublesome. Pyrex 7740 glass is difficult to etch through by using chemical wet etching or sand blasting. Besides, additional etching mask or etching stop layer may need to protect contact pads or wiring underneath. Laser drilling is rather costly and none batch process. To overcome these problems, a special dicing strategy is made to remove glass over contact pads. By carefully adjusting the height of dicing blade, the glass over contact pads will be freed and washed out by cooling water jet without damaging the wiring or contact pads underneath. Additional depths of the cavities are needed to avoid dicing blade damage the contact pads due to uneven flatness of stage. The process flow is shown as Fig.45.

3D View **Side View**

Fig.45 (a) 3D view and side view of packaged device before dicing

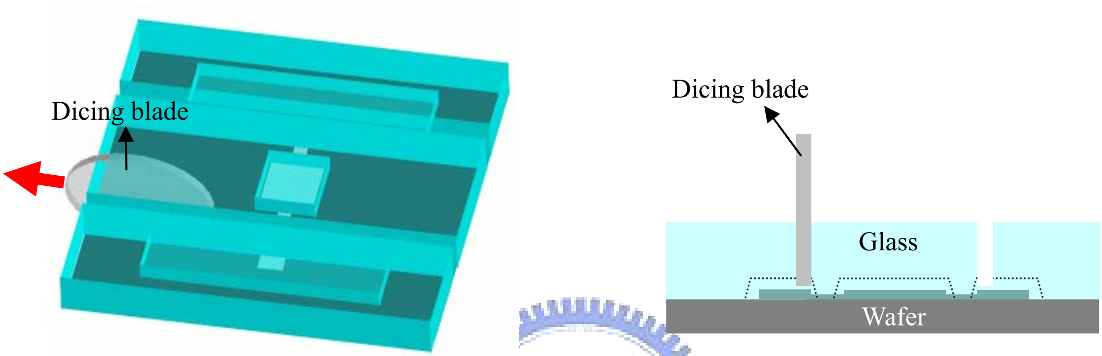


Fig.45 (b) Dicing blade is slightly above silicon substrate; separate the glass over contact pads with the glass over test device

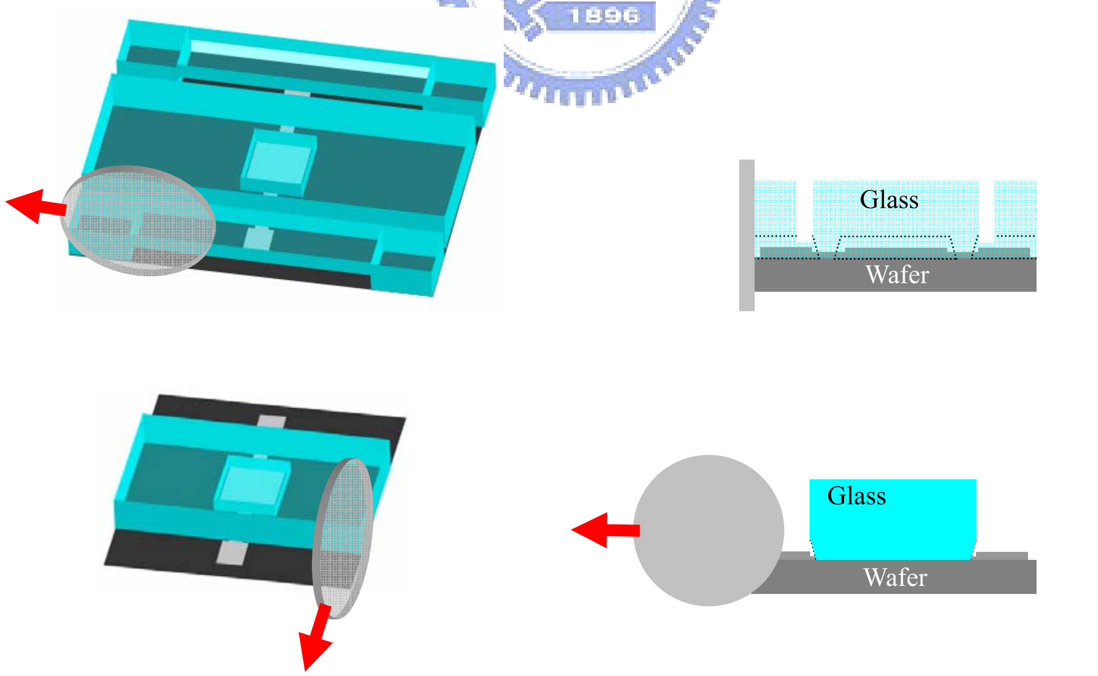


Fig.45 (c) Dicing saw cut through glass and silicon substrates simultaneously, freeing the glass over contact pads. These glass sheets immediately wash out by cooling water jet

3.5.2 Dicing Process

Dicing saw is support by ITRI (Industrial Technology Research Institute). The dicing process is shown as following.

1. Wafer is mounted on frame by blue tape, as shown in Fig.46. The thickness of blue tape is about 80μm. The thickness of blue tape must take into consideration in the following dicing process.

Fig. 46 Wafer mounter (Left). Wafer is mounted on frame by blue tape (Right).

2. Frame with wafer is transferred into the stage of dicing saw. (Fig.47)

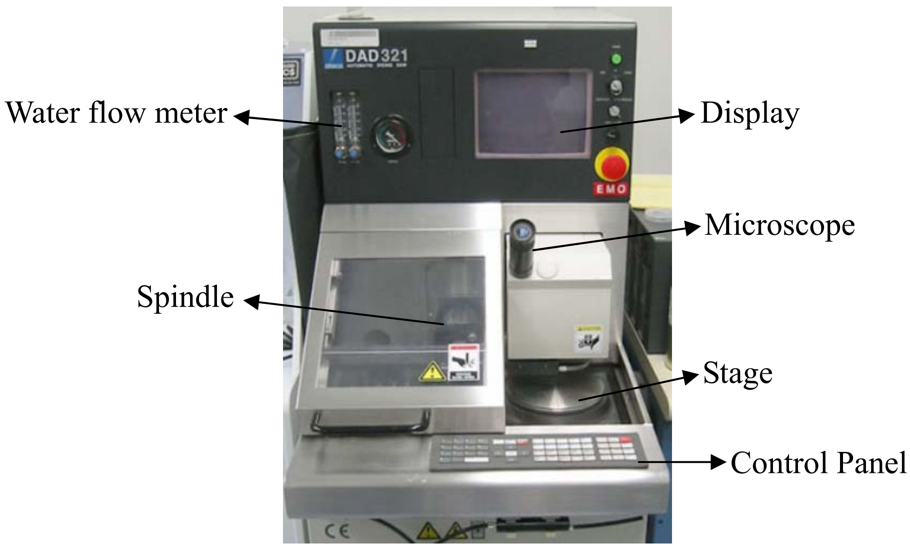


Fig.47 Dicing saw

3. Dicing parameter setup.

Fig.48 Dicing saw parameter setup

"切割片厚度" means the thickness of the wafer to be diced. "透切厚度" means the thickness of blue tape. "刀片高度" means the distance between the edge of blade to the stage. The diagram is shown in Fig.49.

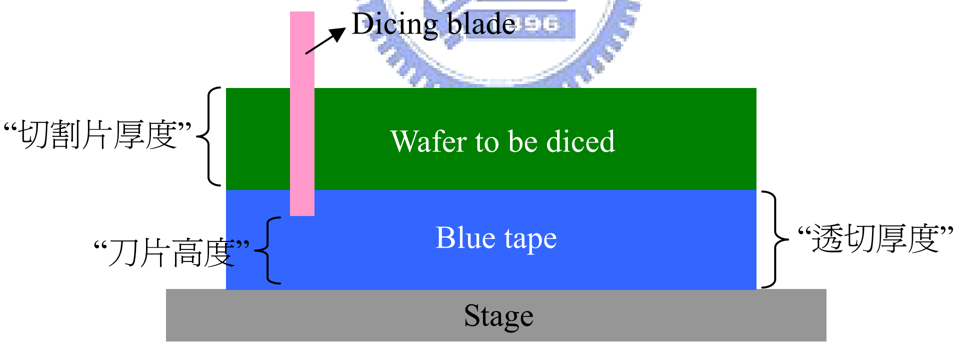


Fig.49 Dicing saw parameter diagram

For the first two cuts, the "separation cut", "切割片厚度" should be set to 1.050mm(0.525mm silicon wafer + 0.525mm glass). "刀片高度" should be set to 0.635mm(0.080mm blue tape + 0.525mm silicon wafer + 0.030mm distance between wafer and dicing blade), as shown in Fig.50.

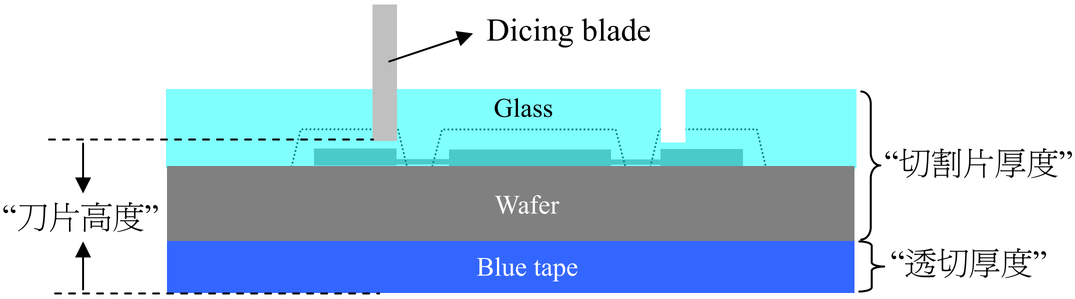


Fig.50 Separate cut diagram

For the following four cuts called “die cut”, the “刀片高度” is set to 0.060mm. Other parameters remain the same.

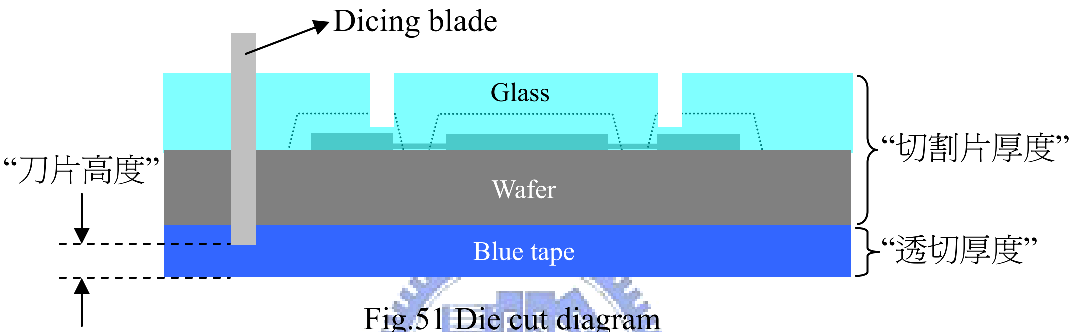


Fig.51 Die cut diagram

After dicing, diced wafer with frame is transferred into wafer cleaner. Wafer is spun and cleaned by water jet, as shown in Fig.52.

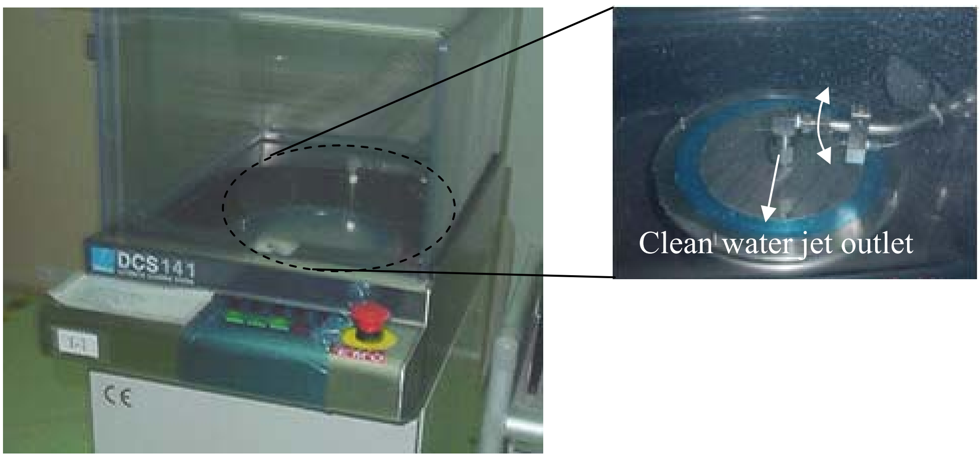


Fig.52 Wafer cleaner