Chapter 4

Results and Discussion

4.1 Wafer Bonding and Dicing Results

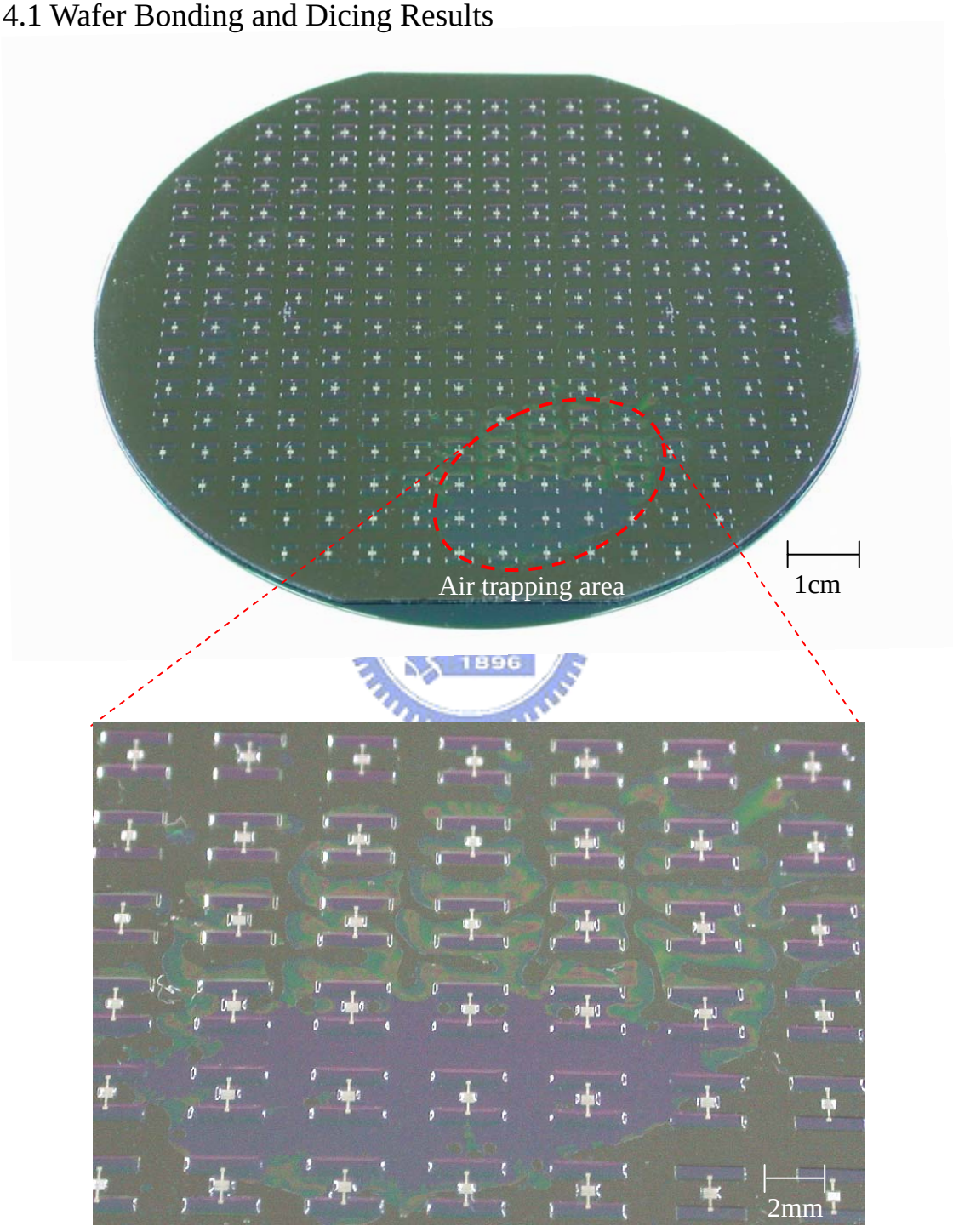

Fig.53 Four inch wafer bonding result (up) and enlarge view of air trapping area (down) ***before*** dicing operation.

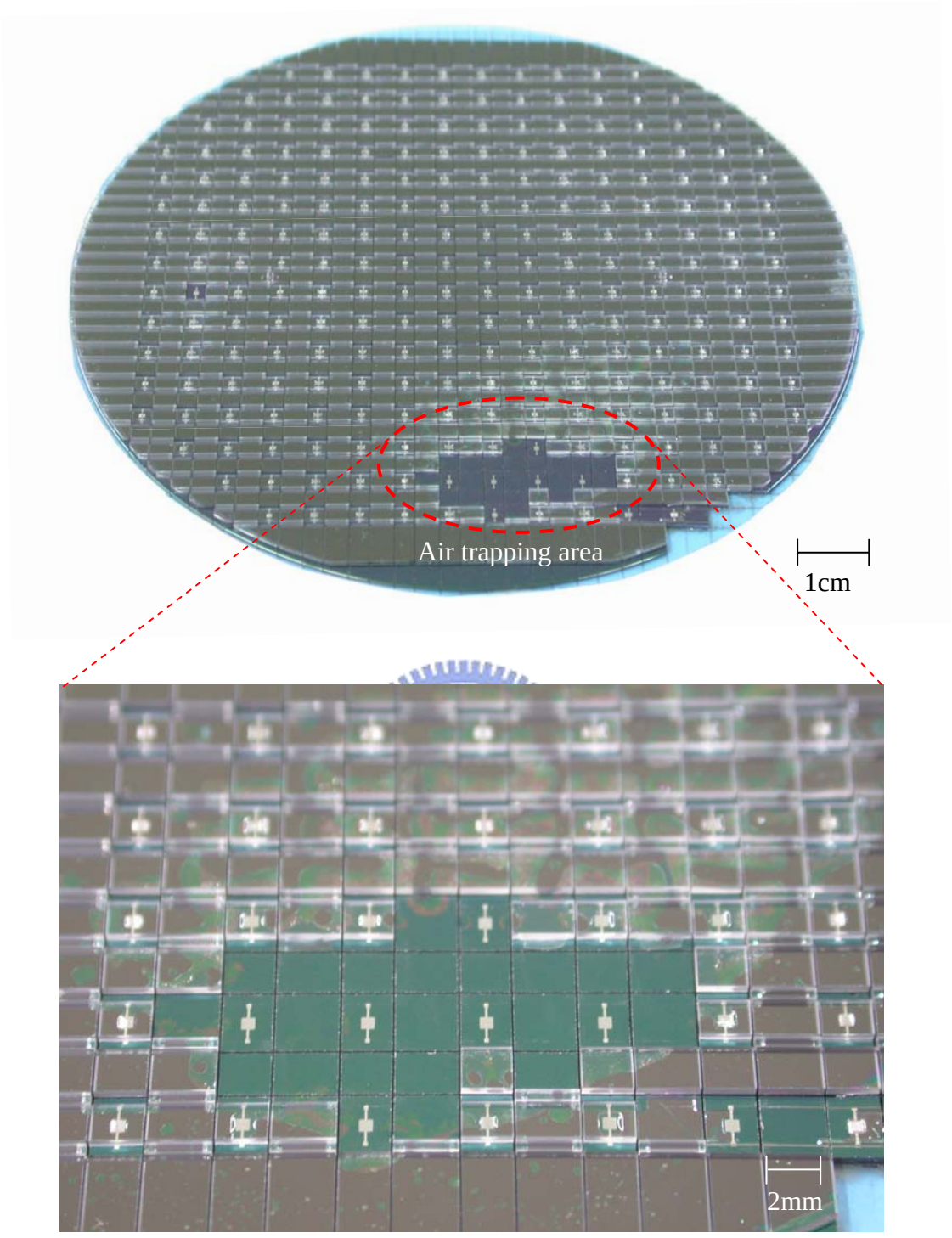

Fig.54 Four inch wafer bonding result (up) and enlarge view of air trapping area (down) ***after*** dicing operation. In the air trapping area, bonding fail locally, glass protection cap was washed out by cooling water jet during dicing operation.

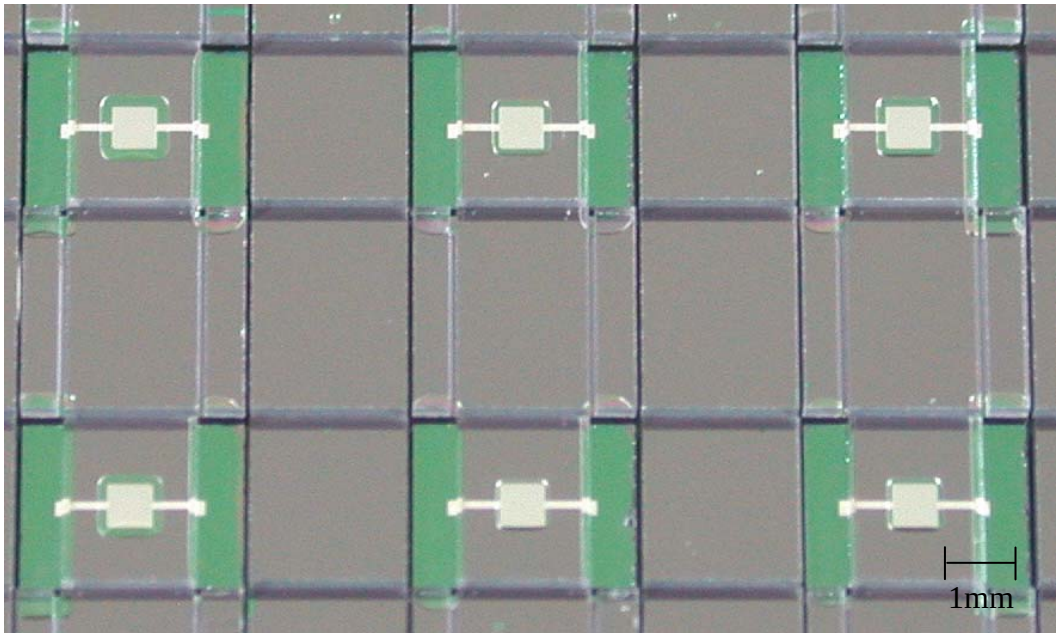

Fig.55 Packaged dew point sensors. In this area, no obvious air trapping, bonding is quite successful. Also, contact pads were exposed successfully by using specific dicing strategy.

In Fig.53 and Fig.54 , there were air trapping inside the bonding region. This phenomenon occurred during the contact step of bonding process. Rim area contacted prior to inner area, so air had no way out and trapped inside. This phenomenon may due to:

1. The reflow of UV curable adhesive, since it remained in liquid phase during contact step.
2. Uneven thickness of UV curable adhesive after spin coating.
3. Poor flatness of home made transparent vacuum chuck.
4. Uneven sucking forces of vacuum chuck which cause glass cap to warp. This problem is especially obvious in single point vacuum chuck.

These problems may solve by the improvement of bonding tool, or bonding can be performed under vacuum environment. Still, the reflow problem of UV curable adhesive needs to be overcome.

4.2 Packaged Result of Overlapping Parallel Capacitor

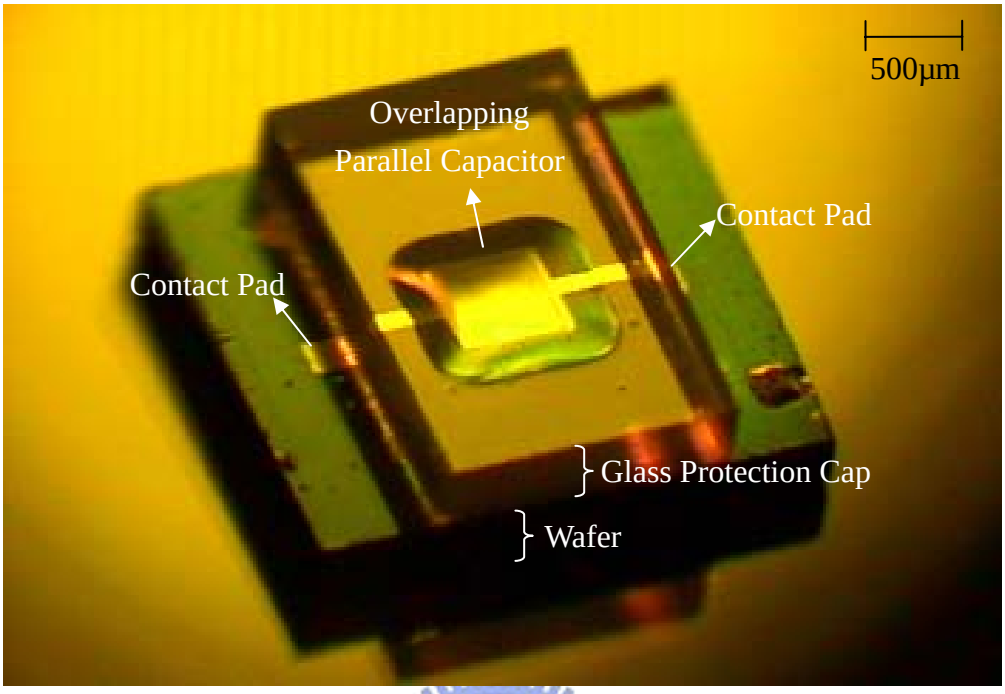

Fig.56 A packaged overlapping parallel capacitor under 3D optical microscope

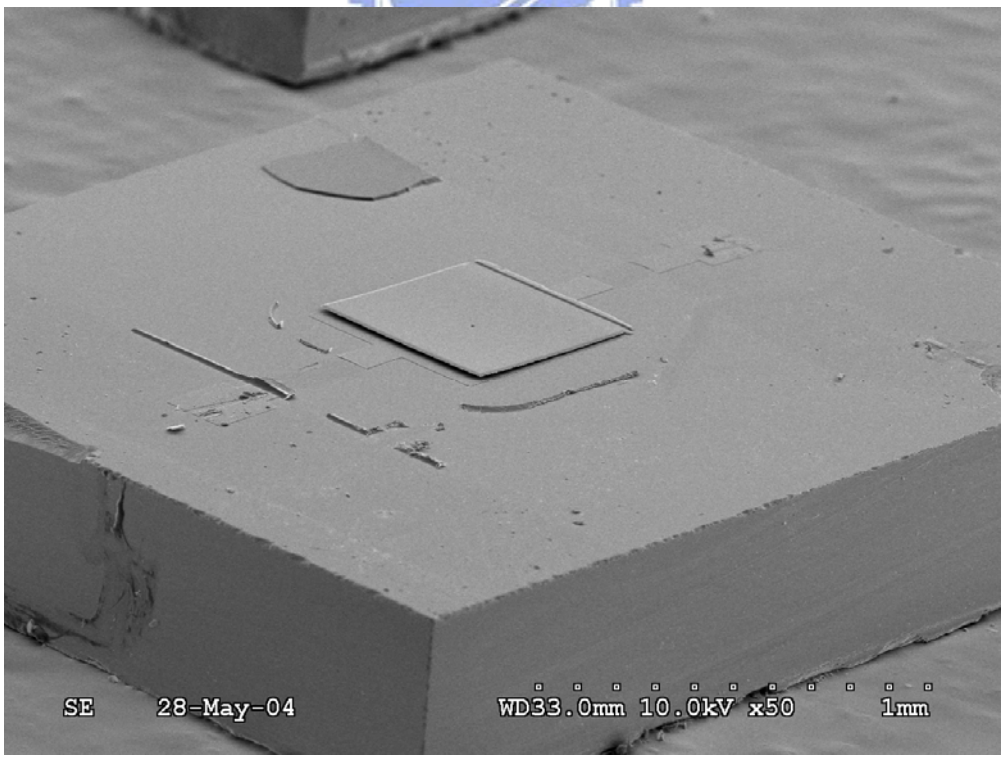

Fig.57 Glass cap is removed carefully by using cutting nipper and freestanding microstructure is examined under scanning electron microscope

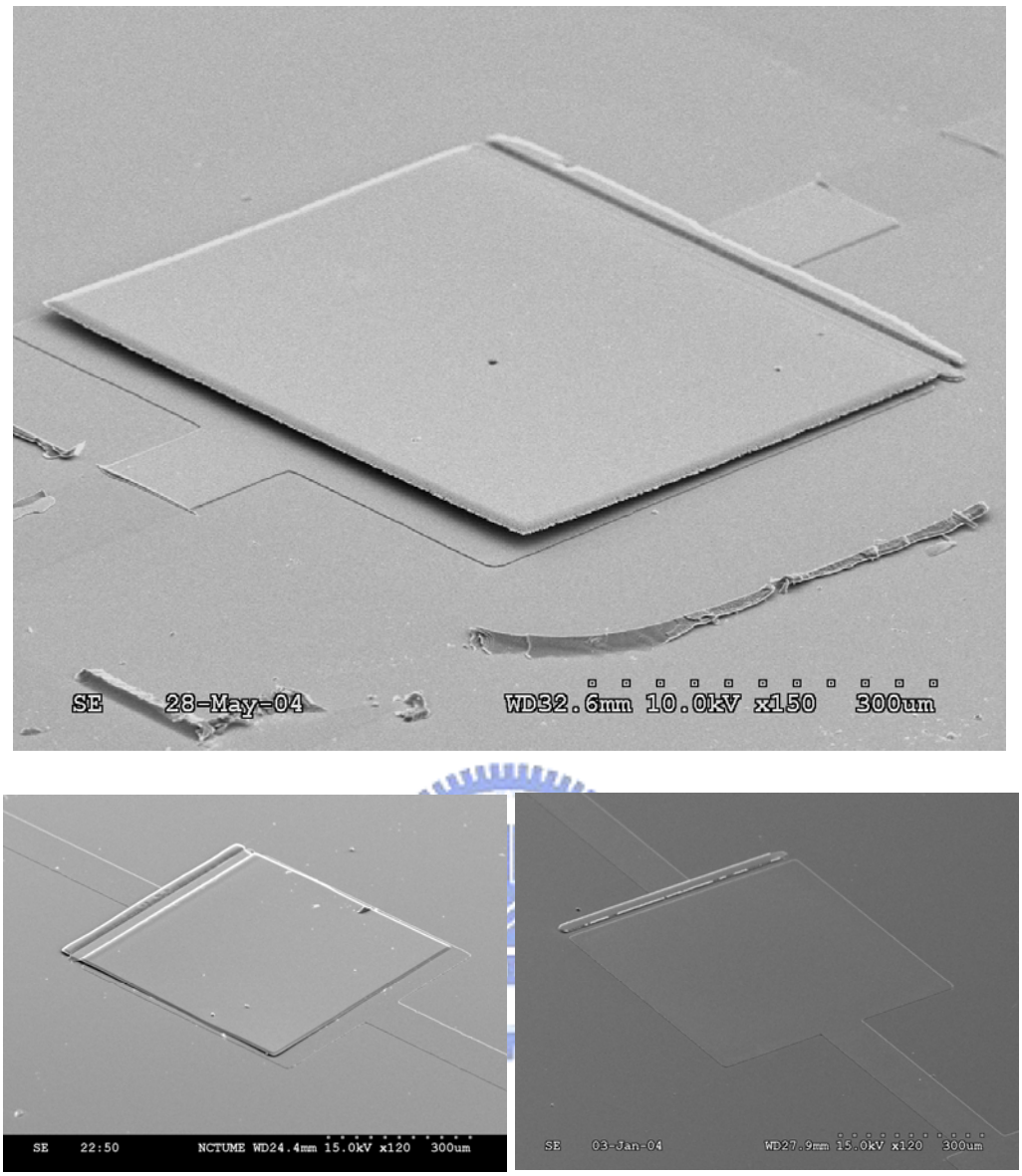

Fig.58 After decapping, packaged freestanding microstructure (up) shows no stiction (down-left) or structural damage (down-right) after dicing operation. Prove that UV curable adhesive bonding is capable to protect MEMS device from dicing operation.

4.3 Device Testing by Applying Voltage

Fig.59 Overlapping parallel capacitor before applying voltage.

Fig.60 Overlapping parallel capacitor while applying voltage. Upper electrode moved downward by electrostatic force

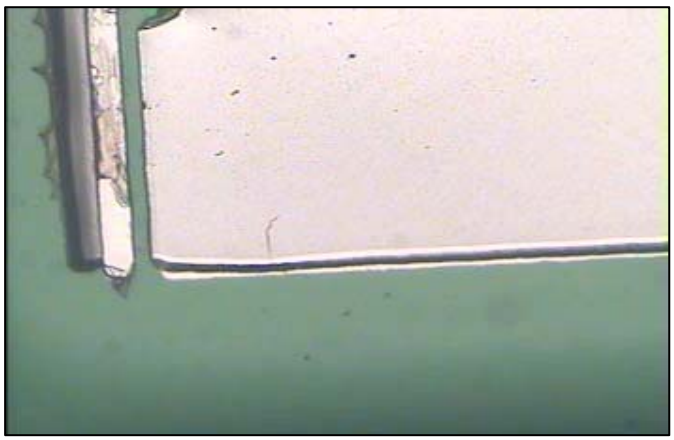

Fig.61 Overlapping parallel capacitor after applying voltage. Anchor and upper electrode were separated

4.4 Boiling Water Accelerated Lifetime Testing

To evaluate the lifetime of package, packaged dew point sensors are put into water with different temperature. Due to the oxidation of contact pads, the measurement of capacitance can not be performed. To solve this problem, dew is observed through optical microscope instead of capacitance measurement. When dew appears as shown in Fig.63, package is regarded as a failure.

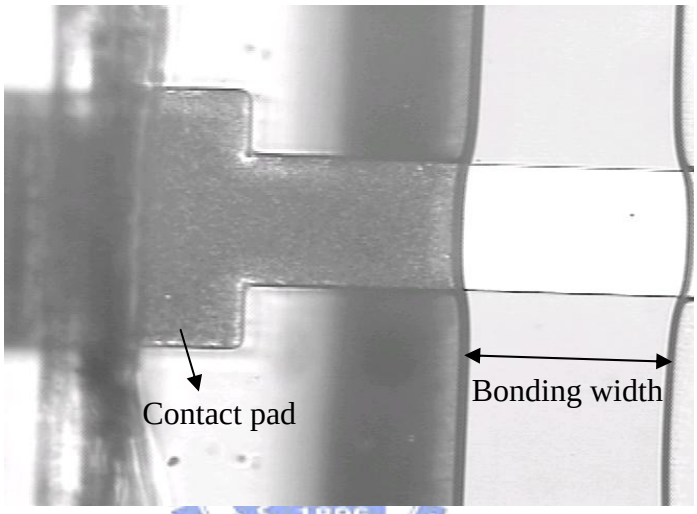

Fig.62 Contact pad oxidation in boiling water.

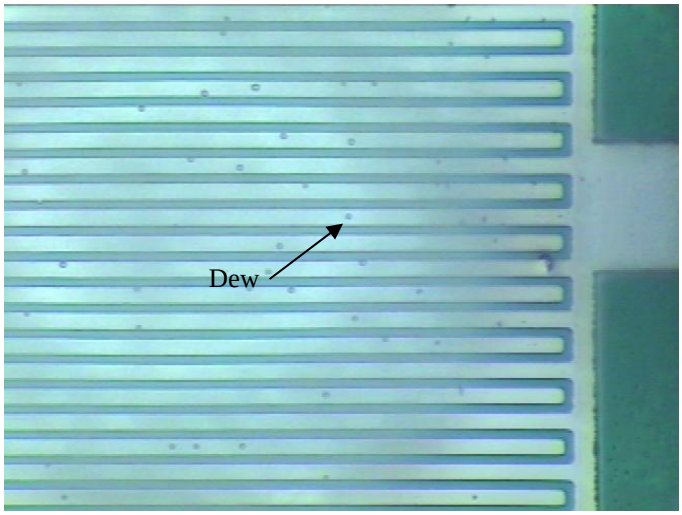

Fig.63 Dew condense on comb fingers

The bonding width is determined by optical scale. There are two bonding width on each side, the minimum side will be chosen.

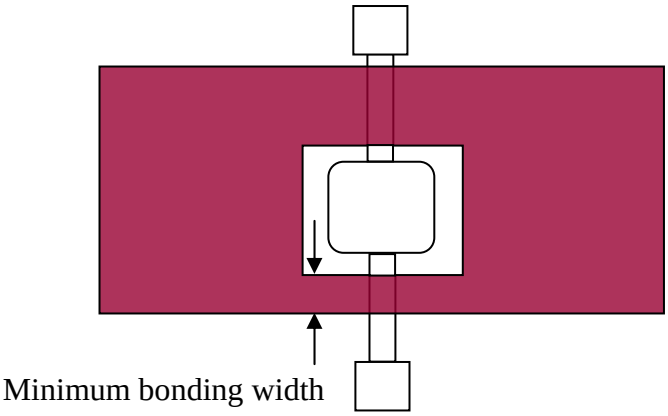

Fig.64 Minimum bonding width diagram

The lifetime of each data point is a four dies average with average minimum bonding width about 188μm. The lifetime at 298K is calculated by the following equation:

$$t = C\exp\left(\frac{Q}{RT}\right) \qquad (1)$$

Where t is the time to failure, T is the temperature, Q is activation energy and R is the ideal gas constant. The calculate lifetime at 298K in water is about 23days

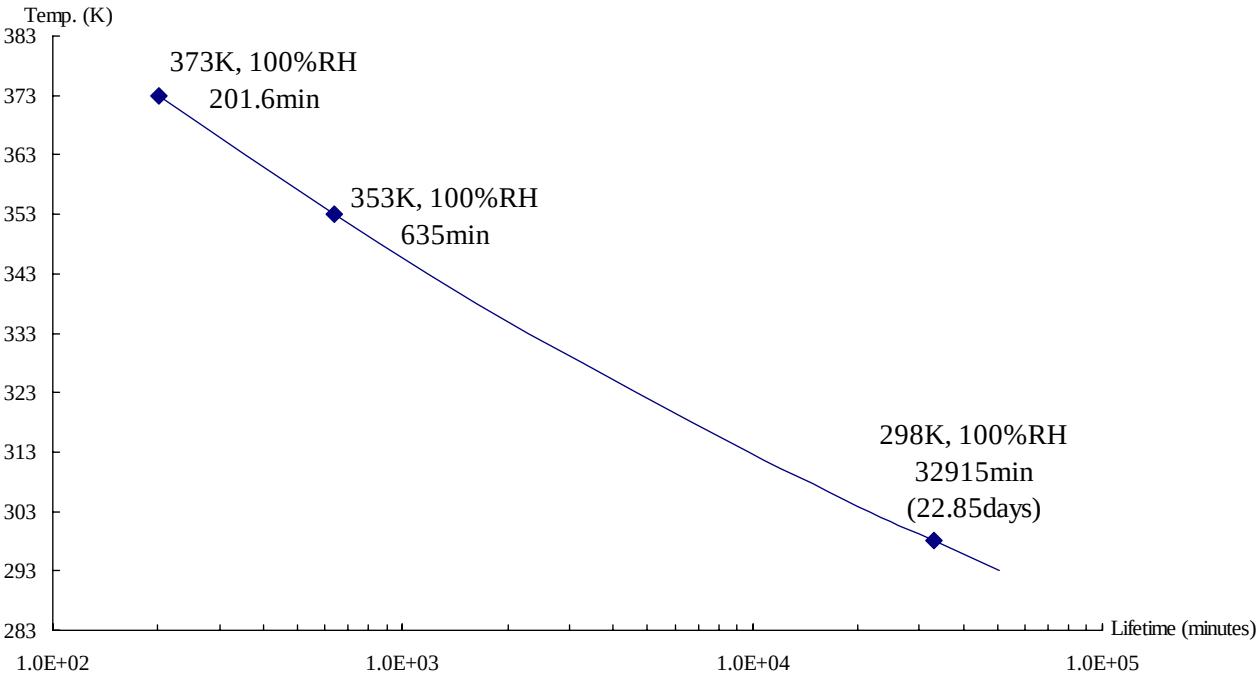

Chart2. Lifetime v.s. temperature

4.5 Conclusion

A room temperature wafer level package is achieved by using UV curable adhesive. The hermeticity and bonding strength is good enough to protect a freestanding microstructure from possible damages or contaminations in wet dicing process. This method dramatically decrease bonding temperature down to room temperature, implies that transparent plastic cap such as polycarbonate can be utilized as the protection cap. Low cost, low processing temperature, provide another choice for MEMS device package. This method may especially welcome for temporary protection of MEMS device or package of disposable device.