Consideration for Back end of Line (BEOL) Photoresist Process Tools

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BEOL or WLCSP (Wafer level chip scale packaging) takes advantage of many techniques utilized in the manufacture of the chip in what is generally called the Front end fo Line (FEOL). One of the principal processes utilized is the Photolithographic process to perform such steps as redistribution layer, under bump metallization, and bump formation. The photolithographic processing steps are discussed below.

1. Photoresist spin coat

a. Wafer Handling steps

i. The substrate is automatically withdrawn from a cassette which may be in a SMIF pod. Alternatively for 300mm wafers a FOUP opener may be employed.

ii. The substrate is precisely positioned on a rotatable vacuum chuck such that the center of the substrate is coincident with the center of rotation of the vacuum chuck.

iii. After photoresist is applied the substrate is baked (normally on a heated plate provided for the purpose.)

iv. The substrate is returned to the cassette or to a second cassette.

b. Photoresist coating steps

i. The substrate is rotated at a speed of approximately 500 rpm and a pre-wet dispense using the same solvent used in the photoresist, normally NMP or PGMEA is briefly dispensed and "spun" off at a speed of about 1500 rpm The purpose of this step is to remove any dust particles from the wafer surface that could affect the quality of the deposited film and to effectively pre-wet the surface of the wafer with a monolayer of solvent molecules so that the surface can more readily accept the photoresist. This also has the effect of reducing the quantity of photoresist that needs to be applied thereby reducing chemical costs. The small quantity of solvent used is more than compensated by the reduced quantity of photoresist required.

ii. The rotational velocity of the substrate is maintained at about 1500 rpm and the photoresist is dispensed at the center of the wafer for about 1 second. It is important that this be done immediately after the last Newton ring of solvent has evaporated.

iii. The rotational velocity of the substrate is increased to the speed at which the desired photoresist thickness is obtained. This speed will be highly dependent upon the resist viscosity. The acceleration to achieve the desired velocity will be on the order of 4,000 to 8,000 rpm per second. Precise control of both the acceleration and the velocity will determine the uniformity of the film thickness within a given substrate, from substrate to substrate and lot to lot.

c. The wafer is normally baked on a hot plate after having been coated on the spin Coater. Some considerations that can be unique to BEOL process are for the most part owing to the relatively thick films that are used in such processes.

i. Because the cast films are relatively thick be they photoresist or some other pattern able material such as Polyimide or BCB they produce substantial effluent when heated. Furthermore, they may need to be heated in steps or gradually so as to prevent "skinning" of the resist and the resultant blisters or voids in the baked film that may eventuate. To ovecome these issues it is necessary to do the following:

1. programmatically lower the pins toward the hot plate either step wise or simply very slowly but controllably and uniformly, this is done with servo motors for best results.
2. the hot plate chamber should eliminate the possibility of solvent reflux on the wafer. This can happen when the effluent solvent condenses on a relatively cold surface in the hot plate oven chamber and can then drip on the product wafer surface. This is best done by ensuring that the effluent is directed only towards surfaces that are nearly as hot as the hot plate and disposed below rather than above the product wafer.
3. The back side of the wafer should be maintained in proximity to the hot plate rather than in direct contact this will minimize cleaning issues and provide superior uniformity, the proximity can be programmable or fixed.

d. Other critical aspects of producing defect free uniform spin cast films

i. Exhaust of the spin cup 360 degrees

ii. Material selection of the dispense valves, tubes, etc.

iii. Adequate provision for elimination of any "final drop".

iv. A means of back side rinse without creating wet spots on the wafer back side.

v. A means of properly centering the wafer with respect to the spin chuck.

vi. Proper material selection, cleaning and draining of the spin cup.

vii. A means of keeping the dispense tip free of dried resist.

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About Mr. Gary Hillman

Mr. Gary Hillman has enjoyed a long and distinguished career in the engineering and semiconductor industries. A graduate of the Georgia Institute of Technology with a B.S. in Ceramic Engineering, Mr. Hillman began his career with Corning Glass Works in Corning, New York.

Mr. Hillman has made multiple critical contributions while working at a variety of companies during his long and successful career, including receiving a patent for the semiconductor industry's first practical "robotic" wafer handling system while working at Machine Technology, Inc. in Parsippany, New Jersey. Since then, Mr. Hillman has 22 patents to his credit.

Mr. Hillman served as the Chairman of SEMI Standards in 1987 and Chairman of SEMI in 1989.

In 1994, Mr. Hillman and a group of others formed Service Support Specialties, Inc. and Creative Design Corporation. Service Support Specialties, also known as S-Cubed, evolved over time into a leading manufacturer of Photoresist processing tools and associated robotics.

Mr. Hillman has helped to develop significant advances in the engineering and semiconductor industries. He and his dedicated team at S-Cubed work to meet and exceed the needs of their customers.