Thin films

Lecture (4) (part one)

Spin coating

Spin coating is currently the predominant technique employed to produce uniform thin films of photosensitive organic materials with thickness of the order of micrometers and nanometers. In many cases the coating material is polymeric and is applied in the form of a solution from which the solvent evaporates. Spin coating was first studied for coating of paint and pitch.

This process has been widely used in the manufacture of integrated circuits optical mirrors, color television screens and magnetic disk for data storage Centrifugal force drives the liquid radial outward. The viscous force and surface tension causes a thin residual film to be retained on the flat substrate. The film thins by the combination of outward fluid flow and evaporation.

. However, at an engineering level the viscous flow effects dominates early on while the evaporation processes dominate later. Fluid flow on a flat spinning substrate is one of the most important physical processes involved in spin coating.

Several processing parameters involved in the spinning process are: dispense volume, final spin speed (w), final film thickness, solution viscosity, solution concentration (c), spin time, etc. The film forming process is primarily driven by two independent parameters, viscosity and spin speed. The range of the film thickness easily achieved by spin coating is 1–200 micrometers. The Spin Coating Systems (SCS) was show in fig.(1)

Fig(1): The Spin Coating Systems

Key stages of spin coating

The physics of spin coating can be effectively modeled by dividing the whole process into four stages sketched in Figure 2, which are deposition, spin-up, spin-off and evaporation of solvents. The first three are commonly sequential, but spin-off and evaporation usually overlap. Stage 3(flow controlled) and stage 4 (evaporation controlled) are the two stages that have the most impact on final coating thickness. Clearly stage 3 and stage 4 describe the two processes that most be occurring simultaneously throughout all times (viscous flow and evaporation)

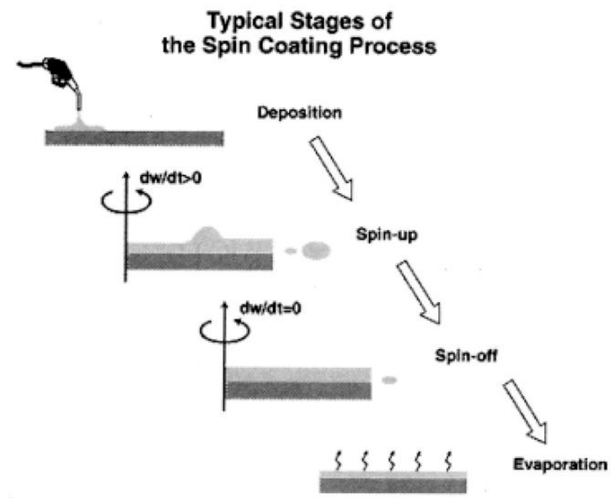

Fig: (2): Key stages of spin coating process.

a.Deposition

During this stage, solution is allowed to fall on rotating substrates from microsyrings and the substrate is accelerated to the desired speed. Spreading of the ion takes place due to centrifugal force and height is reduced to critical height. This is the stage of delivering an excess of the liquid to be coated to the surface of the substrate a portion of which's immediately covered or "wetted". No matter what way is used the amount of liquid deposited through excessive is limited and this stage ends when delivery ceases.

b.Spin-up

The second stage is when the substrate is accelerated up to its final, desired, rotation speed. This stage is usually characterized by aggressive fluid expulsion from the wafer surface by the rotational motion. Ultimately, the wafer reaches its desired speed and the fluid is thin enough that the viscous shear drag exactly balances the rotational accelerations.

c. Stable fluid out flow

The third stage is when the substrate is spinning at a constant rate and fluid viscous forces dominate fluid thinning behavior. This stage is characterized by gradual fluid thinning. . Mathematical treatments of the flow behavior show that if the liquid exhibits Newtonian viscosity (i.e. is linear) and if the fluid thickness is initially uniform across the wafer (albeit rather thick), then the fluid thickness profile at any following time will also be uniform.

d.Evaporation

When spin-off stage ends the film drying stage begins. During this stage centrifugal out flow stops and further shrinkage is due to solvent loss. This results in the formation of thin film on the substrate. The fourth stage is when the substrate is spinning at a constant rate and solvent evaporation dominates the coating thinning behavior. During the evaporation stage the suspended or dissolved solids may grow so concentrated at the liquid surface as to form a high viscosity, low diffusivity layer .

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