On the Level

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➤ Advanced controls are often necessary for the thin ceramic tape requirements of many advanced electronic components.

Tape casting is the process by which ceramic slurry is cast onto a continuously moving belt to form ceramic tape. Ceramic tape can be used in a variety of applications, including fuel cells and as individual layers in multi-layer ceramic substrates that serve as interconnect packages to provide the connection from a microchip to a PC board.

As a cast sheet, the tape has a final thickness variation that is a product of many variables. All of the raw materials used in the slip formulation must be as consistent as possible, and the belt speed and wet thickness both need to be accurately controlled to achieve the desired thickness. In addition, air flow and baffling must be properly developed to provide the best results. For the thin tape requirements of many advanced electronic components, however, additional controls are often necessary.

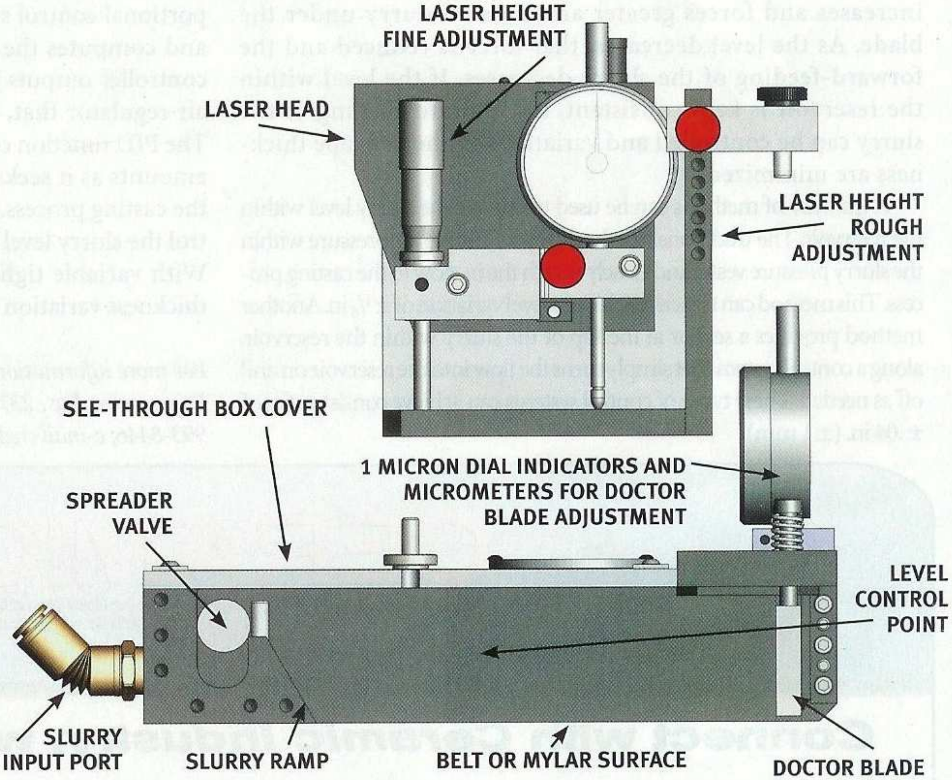

Figure 1. Slurry reservoir and laser head.

Casting Reservoirs

Tape casting machine manufacturers typically provide a doctor blade assembly that is mounted to the machine's frame structure. With independent micrometer adjustment capabilities at each end, the assembly provides users with the ability to precisely level the doctor blade to the belt or Mylar®, thereby ensuring that the wet thickness is consistent across the cast. Although this design offers rigidity and accurate adjustment, it fails to compensate for the minute variations in the belt and Mylar. At first glance, one would assume that the belt is exactly the same throughout its length, but even very small variations in the belt can become significant as tape thicknesses decrease.

Casting reservoirs that ride on the belt or Mylar eliminate these minute variations because they are referenced to the top of the belt, as opposed to the frame of the casting machine. The reservoir houses the doctor blade and keeps it in perfect position in relation to the belt. These reservoirs can be built in whatever width is required, and they typically feature a ramped entry surface to allow the make-up slurry to enter the reservoir with as little impact on the process as possible.

Some of these reservoirs include built-in spreader manifolds to introduce the slurry through multiple ports, thereby reducing the center-weighted effect of a single-entry port. More-advanced reservoirs feature spreader valves that create a ribbon of slurry flowing down the entrance ramp.

Reservoirs are also available as open containers that are either covered with tape or include a window cover to contain the volatile vapors and prevent the "skinning-over" of the slurry. Advantages of the window cover include less mess (since the required cleaning of the tape covering is avoided) and the ability to seal in the vapors while still being able to see what is taking place within the reservoir.

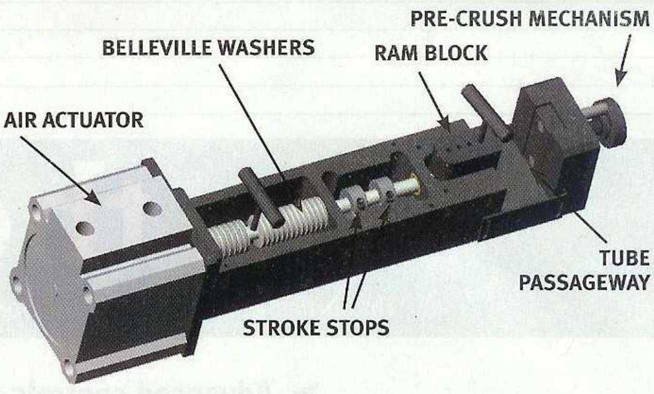

Figure 2. Proportional pinch valve (U.S. patent no. 6695278).

Level Control

Once the appropriate type of reservoir is selected, the level of the slurry within the reservoir should be controlled to a very accurate tolerance to eliminate head pressure variation. Effective slurry level control can enable a ± 10% process to be as tight as ± 1%. At any level of reservoir depth, the head pressure (i.e., the weight of the slurry) forces slurry to push forward and actually flow under the doctor blade at a rate faster than the belt motion, which causes a slightly greater wet thickness than the preset blade gap.

As the level increases in the reservoir, the head pressure increases and forces greater amounts of slurry under the blade. As the level decreases, that force is reduced and the forward-feeding of the slurry decreases. If the level within the reservoir is kept consistent, the forward-feeding of the slurry can be controlled and variations to the dry tape thickness are minimized.

A number of methods can be used to control the slurry level within the reservoir. The traditional method is to adjust the air pressure within the slurry pressure vessel and closely match the in-flow to the casting process. This method can typically achieve a level variation of ± $^1/_8$ in. Another method provides a sensor at the top of the slurry within the reservoir, along a control system that simply turns the flow into the reservoir on and off as needed. These types of control systems can achieve consistencies of ± .04 in. (± 1 mm).

Advances in level control utilize a laser sensor that measures variations down to the sub-micron range, coupled with a proportional control system that takes the feedback from the laser and computes the trend using a PID process controller. The controller outputs proportional air pressure via a proportional air regulator that, in turn, drives a proportional pinch valve. The PID function controls the pinching of the tubing by minute amounts as it seeks a constant open level that exactly matches the casting process. This type of system has been shown to control the slurry level within the reservoir to ± .004 in. (± .1 mm). With variable tightness controlled to this level, the dry tape thickness variation tightens accordingly. 🌐

For more information regarding tape casting control, contact Credence Engineering Inc., 237 W. La Vieve Lane, Tempe, AZ 85284; call (480) 993-8446; e-mail credence@cox.net; or visit http://credenceeinc.com.