Basic Processing for Polyimide Coatings

Polyimide Application

In most microelectronic applications polyimide coatings are typically spin applied to the substrate. This same process and basic tool set is also used to apply liquid photoresists. For optimal adhesion to silicon, oxides and most metals, adhesion promoters are required. Some polyimides have built in adhesion promoters, while others require the application of a separate adhesion promoter or coupler prior to polyimide application. Adhesion promoters are also applied by spin coating.

While spin coating assures the best uniformity and coating quality, other application techniques that have been used for applying polyimides include draw, spray, extrusion, roller, dip and drop coating.

Polyimide Patterning

Three common patterning techniques are wet etch, dry etch and the use of a photodefinable polyimide. Both wet etch and photodefinable polyimides are patterned prior to final cure. Dry etch processing requires that the polyimide layer be fully cured prior to the etch process.

Wet Etch Patterning

Wet etch patterning utilizes wet chemistry in conjunction with a liquid photoresist to define the desired pattern in the polyimide layer. Wet etch processing is typically used to pattern coarse features such as bond pads or large vias. An aspect ratio of 1 to 5 can be achieved reliably.

The base process involves the spin coating and partial curing of the polyimide layer, using one or more in-line hot plates or sometimes a convection oven. A layer of positive photoresist is coated over top, baked and imaged. The photoresist is then developed with a standard TMAH-based developer (0.26N). The developer will simultaneously wet etch the underlying polyimide in the imaged areas. After develop/etch and a water rinse, the photoresist is stripped using a liquid photoresist stripper. The patterned polyimide wafer is then fully cured to complete the imidization process and remove residual solvent.

Photodefinable Polyimides

Photosensitive polyimides permit the patterning of relatively fine features. An aspect ratio of 1 to 1 can be achieved in fully cured films.

The basic process involves the spin coating of the polyimide and a drying step, using one or more in-line hot plates or a convection oven. The polyimide layer is then exposed on a standard I or G line lithography tool. A negative tone photo mask is usually required since most photodefinable polyimides are negative acting. After imaging, the wafer is developed on a traditional track line. After develop and rinse the polyimide layer is cured to both imidize the film and remove the photo package.

Dry Etch Patterning and Laser Ablation

Dry etch patterning is typically used when an aspect ratio greater than 1 to 1 is required for very fine feature sizes.

The process begins with the application and full cure of the polyimide layer. After curing, a nonerodible photoresist or dry etch mask is applied over the polymer layer. Thin films of aluminum or CVD oxide are typically used. Photo resist is applied and imaged over the etch mask to define the desired pattern. The wafer or substrate is then placed in a plasma or reactive-ion etcher, typically of parallel plate configuration. Process parameters and gas mixture are then optimized to pattern the etch mask. The gas mixture is switched to an oxygen/CF4 blend and parameters are set to etch the underlying polyimide and remove the photoresist. The etch mask is then stripped by switching back the etch parameters or by using a wet process. Laser ablation also begins with a fully cured film. The specific patterning process depends upon the laser tool configuration.

Polyimide Curing

Curing the polyimide film involves the removal of the solvent carrier or other volatiles from the layer and the imidization or hardening of the polymer into an intractable polyimide film. This curing process is typically done in steps. Hot plates are commonly used for the initial bake after poly apply. Post apply bakes can range from 50°C to 150°C on one or more in-line hot plates. A furnace or programmable oven is used for the final cure. Final curing is usually done between 280°C - 400°C depending on the application.