SPIN-ON CARBON COMPOSITIONS FOR LITHOGRAPHIC PROCESSING

BACKGROUND OF THE INVENTION

Related Applications

This application claims the priority benefit of a provisional application entitled SPIN-ON CARBON COMPOSITIONS FOR LITHOGRAPHIC PROCESSING, Serial No. 61/545,313, filed October 10, 2011, incorporated by reference herein.

Field of the Invention

The present invention relates to methods of forming a carbon-rich (spin-on carbon) layer from a polyamic acid for use in a multilayer stack and the microelectronic structures thereof.

Description of the Prior Art

As the semiconductor industry continues to shrink the size of features, a single layer photoresist lacks sufficient thickness to complete pattern transfer to a substrate. As a result, trilayer stacking (photoresist-hardmask-carbon layers) is typically used to transfer the pattern made by the photoresist to the substrate. The carbon layer can be formed by chemical vapor deposition (CVD) or spin-coating. However, CVD processes are expensive, have low-throughput, and subject the wafer to harsh conditions. Currently, epoxy cresol novolacs are the most common material for fabrication of spin-on carbon ("SOC") layers, but this material has low thermal stability and low carbon content, leading to high sublimation and poor wiggling resistance during pattern transfer to silicon substrates. Additionally such a layer is difficult to remove after curing. Other SOC layers have been formed that are removable by dry etching. However, drying etching requires harsh processing conditions and special equipment, making the process less than desirable.

There is a need for improved SOC layers that exhibit high thermal stability and optical constants, while also being wet removable (developer soluble). Furthermore, these layers should prevent or minimize line "wiggling," which is present in many prior art processes.

SUMMARY ~~OF THE INVENTION~~

The present ~~invention~~ disclosure provides a method of forming a microelectronic structure. The method comprises providing a substrate having a surface. Optionally, one or more intermediate

layers are formed on the surface, there being an uppermost intermediate layer on the surface, if one or more intermediate layers are present. A composition is applied to the uppermost intermediate layer, if present, or to the substrate surface, if no intermediate layers are present. The composition comprises a polyamic acid dissolved or dispersed in a solvent system. The composition is heated to form a spin-on carbon or carbon-rich layer, with the carbon-rich layer being developer soluble, and exhibiting a weight loss of less than about 10% at a temperature of about 400 °C for about 10 minutes.

The ~~invention~~ present disclosure also provides a novel microelectronic structure. The structure comprises a microelectronic substrate having a surface and optionally one or more intermediate layers on the surface. There is an uppermost intermediate layer on the surface, if one or more intermediate layers are present. A carbon-rich layer is on the uppermost intermediate layer, if present, or on the substrate surface, if no intermediate layers are present. The carbon-rich layer: comprises a crosslinked polyamic acid; is developer soluble; and exhibits a weight loss of less than about 10% at a temperature of about 400°C for about 10 minutes.

In one aspect there is provided a method of forming a microelectronic structure, said method comprising: providing a substrate having a surface; optionally forming one or more intermediate layers on said substrate surface, there being an uppermost intermediate layer on said substrate surface, if one or more intermediate layers are present; applying a composition to said uppermost intermediate layer, if present, or to said substrate surface, if no intermediate layers are present, said composition comprising a polyamic acid dissolved or dispersed in a solvent system; heating said composition to form a carbon-rich layer, said carbon-rich layer being developer soluble, and exhibiting a weight loss of less than about 10% at a temperature of about 400 °C for about 10 minutes.

In another aspect, there is provided a microelectronic structure comprising: a microelectronic substrate having a surface; optionally one or more intermediate layers on said substrate surface, there being an uppermost intermediate layer on said substrate surface, if one or more intermediate layers are present; a carbon-rich layer on said uppermost intermediate layer, if present, or on said substrate surface, if no intermediate layers are present, said carbon-rich layer: comprising a crosslinked polyamic acid; being developer soluble; and exhibiting a weight loss of less than about 10% at a temperature of about 400 °C for about 10 minutes.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

Figure ("Fig.") 1 is a scanning electron microscope ("SEM") photograph of the positive-tone development photolithography (40L/80P, 16.8 mJ) demonstrated in Example 26;

Fig. 2 is an SEM photograph of the negative-tone development photolithography (53S/105P, 19.6 mJ) carried out in Example 27;

Fig. 3 is an SEM photograph of the etched, spin-on carbon layer formed in Example 28;

Fig. 4 shows the thermogravimetric analysis ("TGA") curve of SOC formulation E-2 from Example 29;

Fig. 5 is an SEM photograph of SOC formulation E-2 filling isolated deep contact hole, as described in Example 30;

Fig. 6 is an SEM photograph of SOC formulation E-2 filling dense deep contact hole, as described in Example 30;

Fig. 7 is an SEM photograph showing an OptiStack® SOC110D pattern after C_4F_8/Ar etching, as described in Example 32; and

Fig. 8 is an SEM photograph showing the pattern of Formulation E-2 after C_4F_8/Ar etching, as described in Example 33.