CLAIMS

What is claimed is:

1. A method of modulating local stress on a substrate, the method comprising:

providing a bowed semiconductor substrate;

depositing a UV-curable film on the bowed semiconductor substrate; and

selectively curing one or more first regions of the UV-curable film by exposing the one or more first regions to ultraviolet (UV) radiation and using a first pre-patterned mask so as to locally modulate stress on the UV-curable film, wherein the UV-curable film mitigates bowing of the bowed semiconductor substrate.

2. The method of claim 1, further comprising:

providing the first pre-patterned mask between a UV source and the semiconductor substrate, wherein the first pre-patterned mask includes one or more openings corresponding to the one or more first regions of the UV-curable film.

3. The method of claim 2, further comprising:

measuring warpage across the bowed semiconductor substrate to determine localized stresses on the bowed semiconductor substrate; and

patterning the one or more openings in a mask to form the first pre-patterned mask, the one or more openings being patterned based on at least the localized stresses on the bowed semiconductor substrate.

4. The method of claim 1, wherein the one or more first regions of the UV-curable film is exposed to the UV radiation according to a controlled time, temperature, intensity, and/or wavelength of UV radiation for locally modulating the stress in the one or more first regions of the UV-curable film.

5. The method of claim 4, wherein a temperature of exposure to UV radiation is between about 200°C and about 500°C.

6. The method of claim 4, wherein a time of exposure to UV radiation is between about 1 minute and about 60 minutes.

7. The method of claim 4, wherein an intensity of the UV radiation is between about 1 $\mu W/cm^2$ and about 10 W/cm^2.

8. The method of any one of claims 1-7, wherein the UV-curable film includes silicon nitride.

9. The method of any one of claims 1-7, wherein the UV radiation is configured to locally modulate stress on the UV-curable film by an amount between about 200 MPa and about 4000 MPa.

10. The method of claim 9, wherein an as-deposited stress of the UV-curable film in the one or more first regions is less than about -100 MPa, and wherein a post-cured stress of the UV-curable film in the one or more first regions is greater than about 100 MPa.

11. The method of any one of claims 1-7, wherein the UV-curable film has a thickness between about 25 nm and about 100 nm.

12. The method of any one of claims 1-7, wherein the bowed semiconductor substrate is asymmetrically bowed having a warpage greater than about $\pm$ 300 μm.

13. The method of any one of claims 1-7, wherein depositing the UV-curable film on the bowed semiconductor substrate occurs on a backside of the bowed semiconductor substrate.

14. The method of any one of claims 1-7, wherein selectively curing the one or more first regions of the UV-curable film by using the first pre-patterned mask causes one or more exposed regions of the UV-curable film to become more tensile in stress compared to one or more non-exposed regions of the UV-curable film.

15. The method of any one of claims 1-7, further comprising:

selectively curing one or more second regions of the UV-curable film by using a second pre-patterned mask that selectively exposes the one or more second regions

to UV radiation, wherein the selectively curing the one or more second regions occurs under different conditions than selectively curing the one or more first regions.

16. A method of preparing a mask for localized stress modulation, the method comprising:

patterning one or more openings in a mask to form a pre-patterned mask, the one or more openings being patterned based on at least a stress map of a semiconductor substrate and/or pre-determined die pitch of the semiconductor substrate; and

providing the pre-patterned mask to an ultraviolet (UV) chamber, wherein the pre-patterned mask is configured to cause one or more exposed regions of a UV-curable film deposited on the semiconductor substrate to become more tensile compared to one or more non-exposed regions of the UV-curable film when the semiconductor substrate is exposed to UV radiation.

17. The method of claim 16, further comprising:

receiving a stress map of a semiconductor substrate indicating levels of asymmetric bowing in one or more areas of the semiconductor substrate.

18. An apparatus for modulating stress on a substrate, the apparatus comprising:

a processing chamber comprising:

a substrate support for supporting a bowed semiconductor substrate, and

an ultraviolet (UV) source for exposing the bowed semiconductor substrate to UV radiation; and

a controller configured with instructions for performing the following operations:

provide the bowed semiconductor substrate in the processing chamber having a UV-curable film deposited on a front side or backside of the bowed semiconductor substrate; and

selectively cure one or more first regions of the UV-curable film by using a

first pre-patterned mask that selectively exposes the one or more first regions to ultraviolet (UV) radiation so as to locally modulate stress on the UV-curable film, wherein the UV-curable film mitigates bowing of the bowed semiconductor substrate.

19. The apparatus of claim 18, wherein the controller is configured with instructions for varying time, temperature, intensity, and/or wavelength of UV radiation when selectively curing the one or more first regions of the UV-curable film.

20. The apparatus of claim 18 or 19, further comprising:

a deposition chamber separate from the processing chamber;

wherein the controller is further configured with instructions for performing the following operation:

deposit the UV-curable film on the front side or backside of the bowed semiconductor substrate.