CLAIMS

1. A chemical mechanical polishing apparatus, comprising:

a platen to support a polishing pad;

a carrier head comprising a rigid housing, the carrier head configured to hold a surface of a substrate against the polishing pad;

a motor to generate relative motion between the platen and the carrier head so as to polish the substrate;

an in-situ carrier head monitoring system including a sensor positioned to interact with the housing and to detect vibrational motion of the housing and generate signals based on the detected vibrational motion; and

a controller configured to

generate a value for a carrier head status parameter based on received signals from the in-situ carrier head monitoring system, wherein the carrier head status parameter indicates an impending fault prior to the fault occurring, and

change a polishing parameter or generate an alert based on the carrier head status parameter.

2. The apparatus of claim 1, wherein the in-situ carrier head monitoring system comprises the sensor mounted to an outer surface of the housing, and wherein the detected motion is a detected vibration.

3. The apparatus of claim 2, wherein the sensor is mounted to a top surface of the housing,

4. The apparatus of claim 2, wherein the sensor comprises an accelerometer.

5. The apparatus of claim 1, wherein the in-situ carrier head monitoring system comprises the sensor spaced from and configured to direct electromagnetic energy to the outer surface of the housing.

6. The apparatus of claim 5, wherein the sensor comprises a displacement sensor.

7. The apparatus of claim 6, wherein the displacement sensor is configured to monitor vertical displacement of the housing.

8. The apparatus of claim 6, wherein the displacement sensor is an optical displacement sensor.

9. The apparatus of claim 8, wherein the optical displacement sensor is configured to generate measurements at a frequency in a range from 1 kHz to 100 kHz and to determine a displacement in the carrier head at a resolution of less than 1 μm.

10. The apparatus of claim 8, wherein the sensor comprises a laser interferometer.

11. The apparatus of claim 1, wherein the carrier head comprises a gimbal mechanism, and the in-situ carrier head monitoring system comprises a strain sensor mounted to the gimbal mechanism, and the detected motion is a detected angular deflection of the housing from a rotational axis of the gimbal mechanism.

12. The apparatus of claim 11, wherein the gimbal mechanism is a flexible gimbal mechanism or a ball-in-socket gimbal mechanism.

13. The apparatus of claim 1, wherein the controller is further configured to determine a polishing endpoint based on the carrier head status parameter.

14. The apparatus of claim 1, wherein the carrier head status parameter comprises a carrier head displacement, a shear force, a carrier head rotation speed, or a carrier head type.

15. The apparatus of claim 1, wherein the vibrational motion occurs at a frequency above a frequency threshold.

16. A method of polishing, comprising:

holding a substrate against a polishing surface of a polishing pad with a carrier head;

generating relative motion between the substrate and polishing pad;

monitoring a vibrational motion of the carrier head with an in-situ carrier head monitoring system to generate a signal based on the motion;

generate a value for a carrier head status parameter based on the signals from the in-situ carrier head monitoring system, wherein the carrier head status parameter indicates an impending fault prior to the fault occurring; and

changing a polishing parameter or generating an alert based on the determined carrier head status parameter.

17. The method of claim 16, wherein monitoring the carrier head comprises monitoring an angular deflection of the carrier head with respect to an axis of rotation of the carrier head, and the signal is a strain signal.

18. The method of claim 16, wherein monitoring the carrier head comprises monitoring a vertical displacement of the carrier head with respect to the in-situ head monitoring system, and the signal is an optical signal.

19. The method of claim 16, wherein monitoring the carrier head comprises monitoring a vibration of the carrier head, and the signal is an acceleration signal.