CLAIMS

What is claimed is

1. An apparatus for catalyst influenced chemical etching, comprising:

a process chamber to house a semiconductor wafer which comprises a catalyst on at least one surface of the semiconductor wafer and an etchant;

a plurality of actuators configured to control environmental properties within the process chamber; and

a control system to control a rate of the catalyst influenced chemical etching across the semiconductor wafer by adjusting the environmental properties via the plurality of actuators.

2. The apparatus as recited in claim 1, wherein the environmental properties comprise temperature, vapor pressure, electric field, etchant concentration, etchant composition, and illumination.

3. The apparatus as recited in claim 1, further comprising: a plurality of sensors to detect an etch state.

4. The apparatus as recited in claim 3, wherein the etch state comprises one or more of the following: an etch depth, a material porosity, number of alternating layers etched, an electrical conductivity of doped semiconducting material in contact with an etchant, optical properties of features, and electrical properties of features measured during and/or after the catalyst influenced chemical etching.

5. The apparatus as recited in claim 1, further comprising: a send ahead wafer that is processed through equipment and an offline metrology system to sense an etch state of the send ahead wafer.

6. The apparatus as recited in claim 5, wherein the offline metrology system estimates process excursions noticed in the send ahead wafer.

7. The apparatus as recited in claim 1, further comprising: a drying mechanism configured to prevent collapse of high aspect ratio structures.

8. The apparatus as recited in claim 1, wherein local and/or global etch depth is monitored using one or more of the following:

local electric field measurements based on voltage, current, capacitance, resistance, or inductance;

optical measurements using cameras, optic cables or spectrophotometers and image processing; and

thermal measurements using thermal chucks or micromirrors.

9. The apparatus as recited in claim 8, wherein the optical measurements are performed at an IR wavelength that allow process monitoring through silicon.

10. The apparatus as recited in claim 1, wherein local and/or global etchant concentrations are monitored during the catalyst influenced chemical etching using:

refractive index measurement of an etchant solution; or

conductance of the etchant solution.

11. The apparatus as recited in claim 1, wherein local and/or global etchant concentrations are controlled during the catalyst influenced chemical etching using:

flow control and circulation of the etchant;

spinning of a substrate;

diffuser to create uniform etchant concentrations;

temperature gradients for diffusion of etchants;

local addition of chemicals to drive diffusion of etchants;

acoustic streaming;

jetting of air; or

local addition of depleting components of the etchant.

12. The apparatus as recited in claim 1, wherein an etchant solution is maintained at low temperatures for near-zero etch rate, and local heating is used to start, control or stop an etch per die.

13. The apparatus as recited in claim 1, wherein the catalyst influenced chemical etching is performed using vapor phase etchants.

14. The apparatus as recited in claim 1, wherein the etchant is in vapor or ionic form, the apparatus further comprises:

a thermal chuck for controlling local temperatures; and

a monitor for monitoring vapor pressure.