CLAIMS

1. **A point-of-use chemical-dosing system** for a semiconductor wet-processing tool, the system comprising:
   a. a sealed cartridge having a fluoropolymer-wettable fluid path and containing a single process-chemical concentrate;
   b. a quick-connect coupler on the cartridge, the coupler including a self-sealing valve that prevents liquid or vapour release when the cartridge is undocked;
   c. an inline sensor manifold fluidly coupled to the concentrate, the manifold incorporating at least (i) an ionic-contamination sensor capable of resolving < 0.01 parts per billion metal ions, (ii) a conductivity sensor and (iii) a temperature sensor;
   d. a fast-response, non-metallic isolation valve having a mechanical open- or close-time not exceeding 30 milliseconds and fluidly positioned between the concentrate and a base-liquid line of the wet-processing tool; and
   e. a control unit configured to
   (i) sample the inline sensor manifold at a rate of at least 5 hertz;
   (ii) compare sensed values with a predefined concentration set-point;
   (iii) actuate the isolation valve in sub-second pulses to inject micro-doses of the concentrate directly into a continuous base-liquid stream until the sensed values return within ± 0.5 percent of the set-point; and
   (iv) generate and store, for each valve actuation, a digital batch record that includes a time stamp, a sensor-data vector, a cartridge identifier and a pulse-volume value.
2. The system of claim 1, wherein the inline sensor manifold further comprises a particle-count sensor capable of detecting particles having diameters of 5 nanometres to 50 micrometres at a concentration resolution of 0.1 counts per millilitre.
3. The system of claim 1 or 2, wherein the control unit achieves a total latency from sensor-deviation detection to concentrate injection of no greater than 0.6 seconds.
4. The system of any one of claims 1–3, wherein the cartridge includes an embedded RFID or NFC tag storing at least a chemical identity, batch number and expiry date, the control unit being further configured to inhibit the isolation valve unless an RFID/NFC interrogation confirms recipe compatibility.
5. The system of any one of claims 1–4, further comprising a static mixer having an internal volume not greater than 50 millilitres located downstream of the isolation valve, the mixer producing 99 percent homogeneity of the injected concentrate with the base-liquid in a residence time not exceeding 0.05 seconds.
6. The system of any one of claims 1–5, wherein the isolation valve is a piezo-actuated diaphragm valve fabricated entirely of PTFE, PFA or perfluoro-elastomer wetted materials.
7. The system of any one of claims 1–6, wherein the control unit organises multiple cartridges into hierarchy tiers and prioritises execution of a wafer-critical tier over a preventive-maintenance tier when simultaneous sensor deviations are detected.
8. The system of any one of claims 1–7, wherein the digital batch record conforms to SEMI E143 or an equivalent semiconductor-equipment communication standard.

9. The system of any one of claims 1–8, wherein the quick-connect coupler is a key-coded fluoropolymer coupling that prevents attachment of an incorrect-chemistry liner.
10. The system of any one of claims 1–9, wherein a disposable liner bottle attachable to the cartridge has a capacity selected from 5 litres, 10 litres or 20 litres and is replaceable without purging the base-liquid line and without halting wafer production.

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11. **A method of supplying process chemistry to a semiconductor wafer**, the method comprising:
    a. flowing a base liquid through a static mixer at a volumetric flow rate of 10 millilitres per second to 100 millilitres per second;
    b. detecting in real time, upstream of the wafer and no more than 15 centimetres downstream of a concentrate-injection point, at least ionic-contamination and conductivity values of the flowing liquid;
    c. injecting one or more pulses of a single-chemistry concentrate from a sealed cartridge into the flowing liquid, each pulse having a volume not exceeding 1 percent of the instantaneous flow volume;
    d. repeating steps (b) and (c) until the detected conductivity is within ± 0.5 percent of a predefined set-point; and
    e. delivering the mixed liquid to the semiconductor wafer within 2 seconds of the first detection in step (b).
12. The method of claim 11, wherein step (c) is executed by a piezo-actuated valve having a stroke time not greater than 30 milliseconds.
13. The method of claim 11 or 12, wherein the pulses of concentrate are scheduled by a proportional-integral-derivative control algorithm having a loop period of 100 milliseconds or less.
14. The method of any one of claims 11–13, further comprising logging a digital record comprising a time stamp, sensor data, cartridge identification and pulse-volume data for each pulse injected.
15. The method of any one of claims 11–14, wherein an alarm signal is transmitted to a host system if ionic contamination exceeds 10 parts per trillion for more than two consecutive sensor samples.
16. The method of any one of claims 11–15, wherein the injected concentrate reduces total chemical consumption by at least 30 percent compared with an open-loop bolus-dosing method that delivers an equivalent mass of concentrate within the first 4 hours of processing.

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17. **A disposable chemistry liner** for use in the system of claim 1, the liner comprising:
    a. a one-piece PFA body having a nominal capacity of 20 litres and leachables not exceeding 10 parts per trillion of metallic ions after a 200 degree-Celsius de-ionised-water rinse; and
    b. an RFID tag mounted in a chemically-resistant cap, the tag carrying at least a unique identifier, chemical name, batch number and expiry date.
18. The liner of claim 17, wherein a keyed protrusion on the cap mates with a recess in the quick-connect coupler and prevents fluidic sealing unless the keyed geometry matches a recipe code provided by the control unit.

19. The system of claim 1, wherein the control unit further performs predictive maintenance by trending baseline sensor drift, valve current draw and valve stroke count and issuing a predictive-maintenance alert when any parameter exceeds a predetermined threshold.
20. The system of claim 1, wherein the cartridge, the sensor manifold and the static mixer are fabricated entirely from materials compliant with SEMI F57/F104 purity standards, and the assembled system passes a metals-extractables test of < 10 ppt total metals after 24 hours of 18 megohm-centimetre water exposure at 80 °C.