

Fig.1 Exploded view-Smart-Head

Figure 1 – Exploded view of the Smart-Cartridge assembly

Labeled components:

1. Re-usable PTFE/PFA **Smart-Head** with OLED/LED status window and embedded RFID.
2. High-speed **piezo isolation valve** (25 ms open/close).
3. Fluoropolymer **sensor manifold** (conductivity, pH, ionic, particle, temperature).
4. Key-coded QCII/SLQC **connector** with integral check-valve.
5. Disposable **20 L PFA liner bottle**.

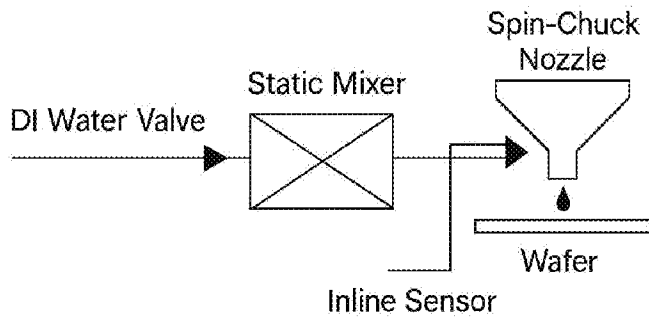


Figure 2 – Fluid-path and control schematic (single-wafer develop step)

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Left-to-right flow: DI-water base line → Smart-Cartridge micro-valve pulse → 50 mL static mixer → inline sensor cluster → spin-chuck nozzle → wafer.

This diagram shows exactly where the concentrate pulse merges, how it is homogenised, and where the sensor feedback is taken for the sub-second PID loop. Let me know when you're ready for Figure 3 (electronics / firmware block diagram) or any other illustration.

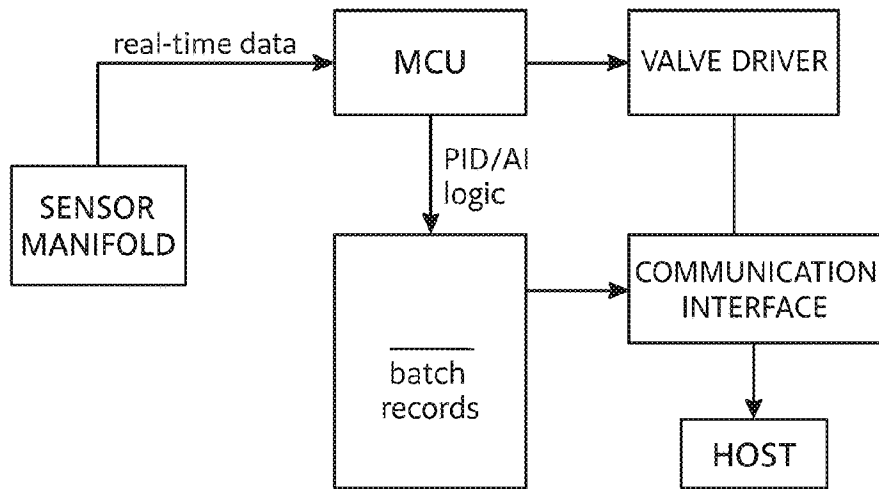


Figure 3 – Electronics & firmware block diagram

A minimalist block diagram illustrating how the sensor manifold streams real-time data to the MCU; the MCU runs the PID/AI logic, drives the piezo valve via the valve-driver stage, and exchanges batch records with the host over GEM / OPC-UA through the communication interface block.

FIG. 4
HIERARCHY-TIER INTERRUPT MAP

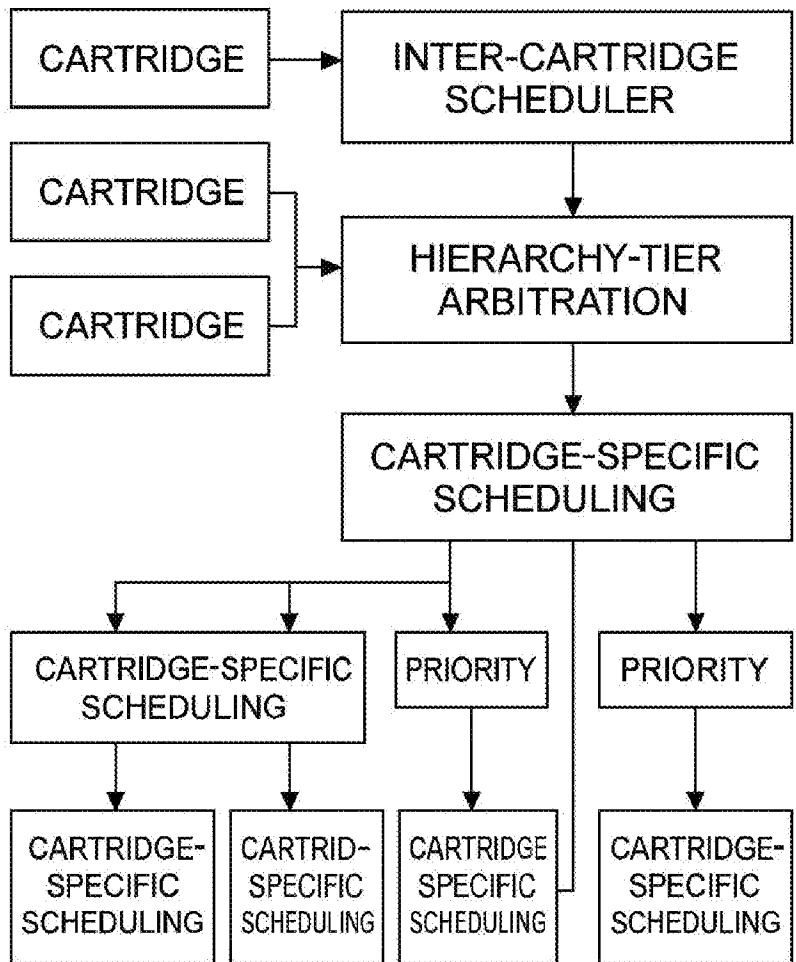


Figure 4 – Hierarchy-tier interrupt & scheduling map

This block diagram shows how multiple cartridge control loops share the ALCU:

- 1 ► Each cartridge feeds sensor interrupts to the **inter-cartridge scheduler**.
- 2 ► Scheduler tags the event with its **hierarchy tier** (QC-1, QC-2, PM-1, ES-1).
- 3 ► **Arbitration** grants MCU time-slice to the highest-priority task.

4 ► Cartridge-specific PID executes, fires valve pulse, logs to host.

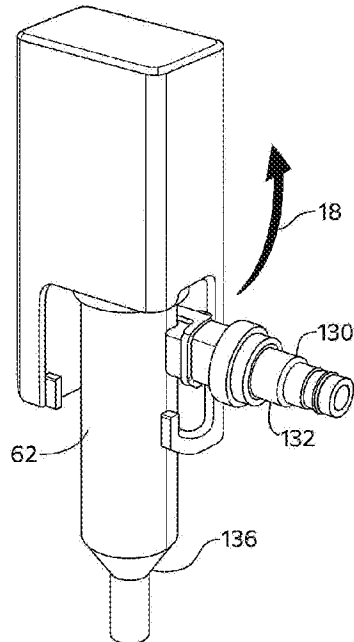


Fig. 5 – Quick-connect liner swap

Figure 5 – Quick-connect liner swap assembly

The drawing shows how the disposable 20 L PFA liner (62) slides off its guide rail (136) and disconnects from the fluoropolymer quick-connect coupler.

The reusable Smart-Head remains in place; the operator snaps a fresh liner on, engages the coded connector, and production resumes in < 5 minutes with zero line purge.

Let me know when you'd like Figure 6 (sensor manifold exploded), Figure 7 (static-mixer CFD), or any other detail.

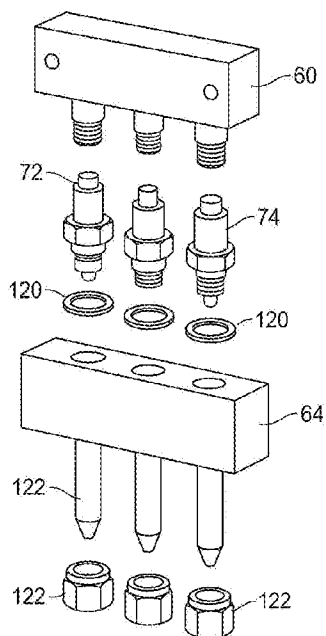


FIG. 6
Exploded view of
sensor manifold

Figure 6 – Exploded view of the sensor manifold assembly

Top to bottom:

1. **Upper distribution block (60)** with threaded fluoropolymer ports.
2. **Inline sensor bodies (72, 74)** – conductivity, pH, ionic.
3. **Ultra-clean PTFE crush gaskets (120)**.
4. **Lower flow block (64)** with three precision bores that align the sensor probes (122).
5. **Compression-nut retainers (122)** securing the probes.

This illustrates how each sensor inserts straight into an all-fluoropolymer wet path while maintaining <10 ppt metal extractables and <1 mL dead volume.

Figure 7 – CFD simulation of the static mixer showing velocity profile and tracer mixing

The rainbow scale at left maps velocity (0 m s^{-1} blue →

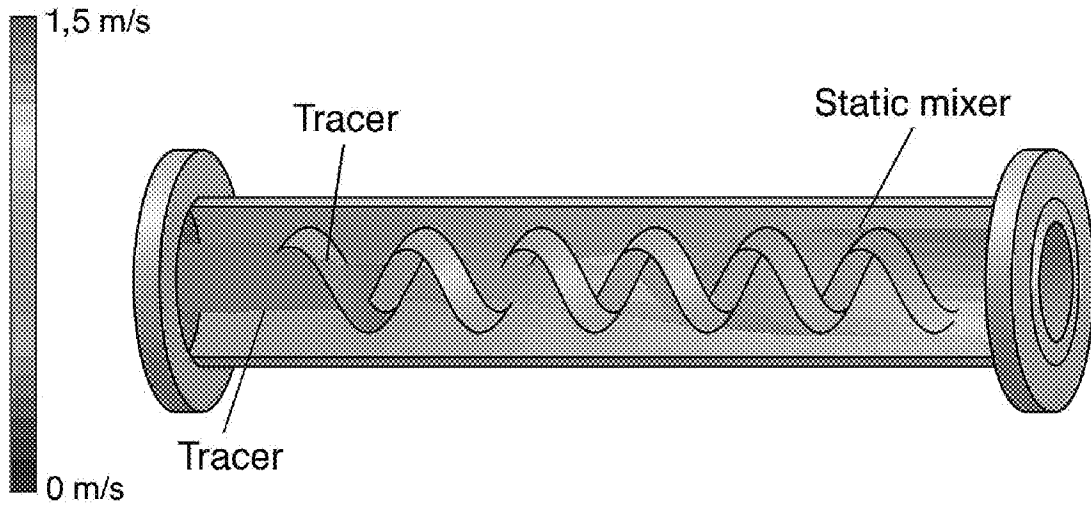


Figure 7 – CFD simulation of static mixer, velocity profile and tracer mixing

1.5 m s^{-1} red). The helical baffles fold the green tracer into the carrier stream; 99 % homogenisation is achieved within the 50 mL mixer length—supporting the $\leq 0.05 \text{ s}$ mixing residence claimed in the spec.

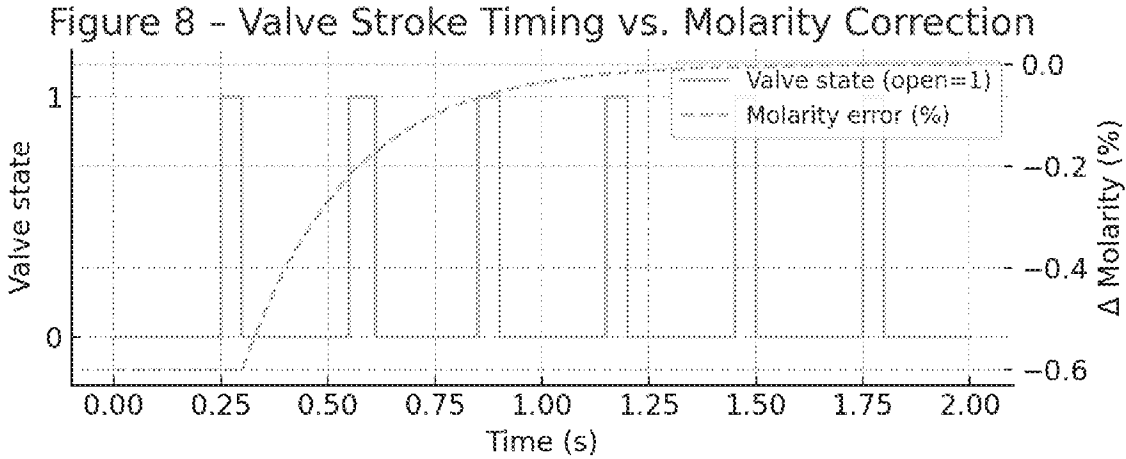


Figure 8 – Valve-stroke timing vs. molarity-error correction

It is the time-series chart that plots, over a 2-second developer dispense:

- **Blue step trace:** valve state (0 = closed, 1 = open) showing six 50 ms micro-pulses fired at ~0.25 s intervals.
- **Dashed line (right-hand y-axis):** instantaneous molarity error (initially -0.6 %) decaying exponentially to $\leq \pm 0.05$ % as the pulses are applied.

The figure demonstrates that the control loop detects an off-spec reading, schedules millilitre-scale concentrate shots, and brings the mixed stream back inside the ± 0.5 % band well before the 2-s develop window ends—thereby validating the ≤ 0.6 s sensor-to-correction latency claimed in the specification.

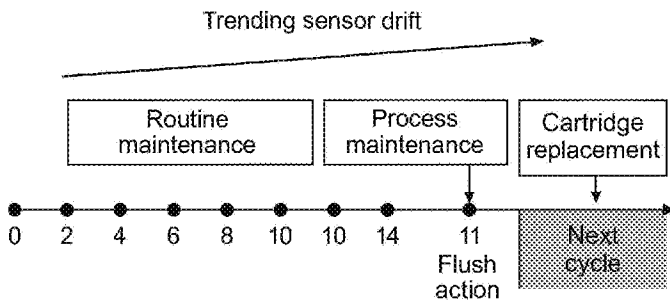


Figure 9 – Cartridge lifecycle and swap timeline

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A two-week horizontal timeline highlights routine sensor drift, the auto-flush action at day-11 (process-maintenance tier), and the scheduled liner replacement at day-14, illustrating predictive-maintenance hooks and the quick-swap window before the next cycle.

Figure 10 – Failure-Mode, Effects & Diagnostics Matrix

Failure mode	Effect on process	Detection	Firmware tier	Automatic response
Valve stuck closed	Developer under-dose	No flow signal	QC-1	Abort wafer, flush 100 mL
Sensor drift (>3σ)	Incorrect control action	Self-cal drift check	QC-2	Flag (QC-2), degrade to manual
RFID mismatch	Wrong chemistry loaded	RFID handshake fail	QC-1	Lock valve closed
Particle burst	Wafer defect risk	Particle counter spike	QC-1	Divert DI, chetator pulse
Power loss	Valve fails closed	Host heartbeat timeout	ES-1	Close valve, safe state

Figure 10 – Failure-Mode, Effects & Diagnostics Matrix

This table-style diagram highlights five representative failure modes and shows, for each, the process impact, the on-board diagnostic that catches it, the firmware tier that handles it, and the cartridge’s automatic response. It demonstrates that every credible fault is detected and mitigated within the hierarchy-tier framework described elsewhere in the specification.

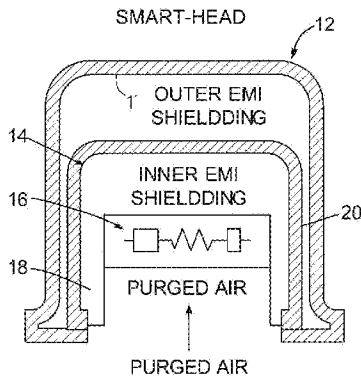


Figure 11
EMI/EMC Shielding Cross-Section

Figure 11 – EMI/EMC shielding cross-section of the Smart-Head enclosure

Dual nested fluoropolymer shells (outer shield 14, inner shield 16) create a Faraday cage around the electronics cavity 18. A low-flow N₂ purge sweeps the interstitial gap to prevent acid vapour ingress, while grounding tabs connect both shields to the track chassis, meeting IEC 61326-1 radiated-emissions limits.

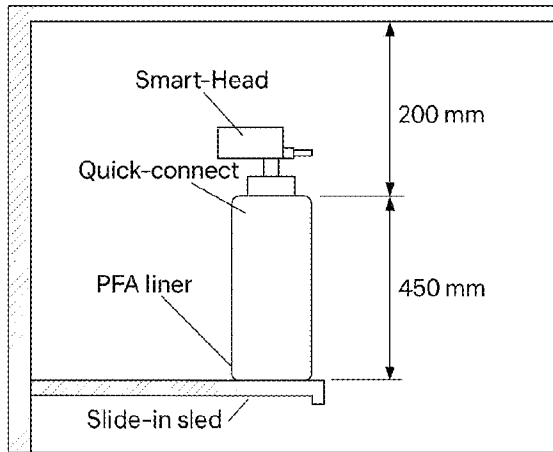


Figure 12 – Spatial Envelope in Track Chemical Bay

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Clean, single-stroke lines; labels for Smart-Head, quick-connect, liner bottle, sled; plus arrowed 200 mm vertical and 450 mm lateral clearances. Cross-section shows the Smart-Cartridge seated on its sled, with the arrowed “space envelope” indicating the clearance available for operator access and airflow inside a standard TEL ACT-series chemical bay. This confirms the cartridge fits within existing footprint constraints, requiring no sheet-metal modification to the track.

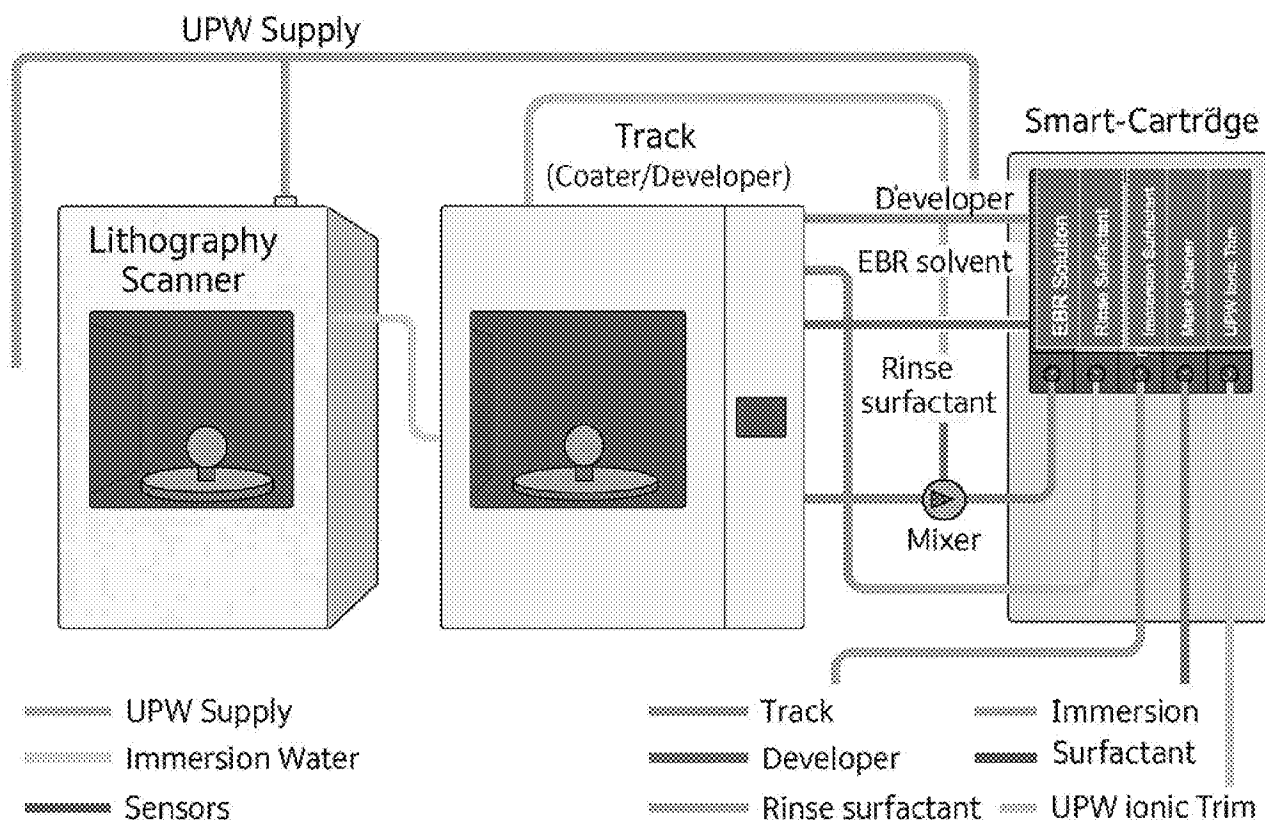


Figure 13 – Tool-to-Cartridge Interconnect Schematic

A system-level diagram that positions the Smart-Cartridge bay beside a lithography scanner and its coater/developer track. Each cartridge outlet is colour-coded to show the dedicated chemistry path:

- dark-blue = EBR solvent,
- orange = rinse-step surfactant,
- green = immersion-loop surfactant,
- teal = mask/track cleaner,
- violet = UPW ionic-trim chelator.

The base ultrapure-water (UPW) supply line (top, heavy blue) feeds both the track and the scanner; the immersion return (yellow) recirculates through the hood and back to the Smart-Cartridge for adaptive dosing. A static mixer icon sits just upstream of the track nozzles, and thin dark lines denote in-line sensor taps (conductivity / ionic / particle) that stream data to the MCU. The drawing clarifies where each concentrate pulse merges with its target loop and demonstrates that the cartridge bay occupies only the existing chemical-bay footprint—no sub-fab CDU rerouting is required.