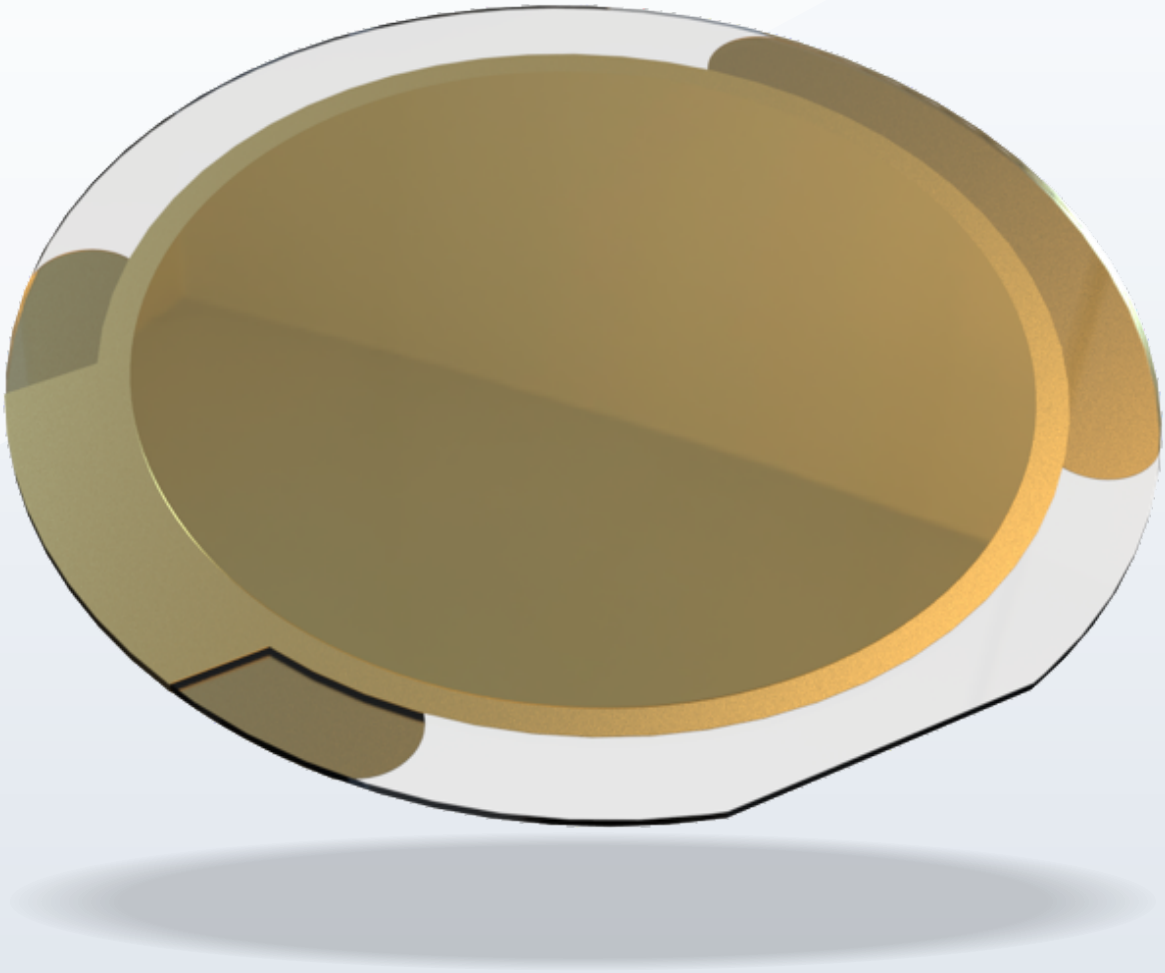
QUARTZ CRYSTAL MICROBALANCE SENSOR

AT5-14-12-AU-WRAP

SPECIFICATIONS, CLEANING AND CARE



openQCM devices are released as scientific open hardware instruments, and they are intended solely for use for SCIENTIFIC, RESEARCH and DEVELOPMENT APPLICATION, DEMONSTRATION, OR EVALUATION PURPOSES and are not considered to be finished end-products fit for general consumer use.

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DATE
11 November 2026

VERSION
1.0

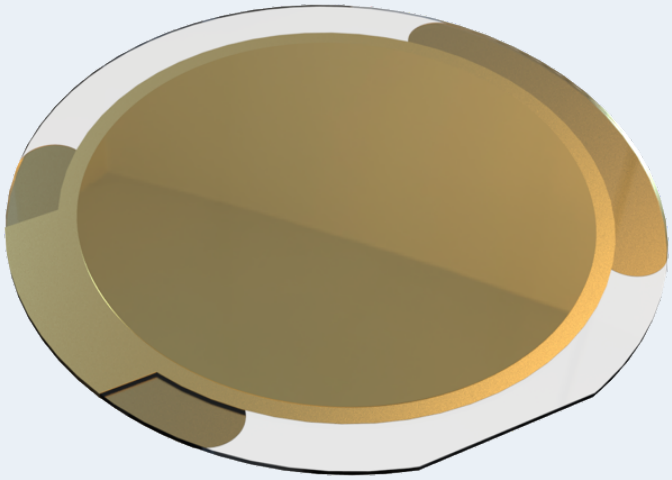
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QUARTZ CRYSTAL MICROBALANCE SENSOR

AT5-14-12-AU-WRAP

5 MHz Quartz Sensors, Gold

BOX OF 10 PIECES



AU 5 MHZ

FREQUENCY	BLANK DIAMETER	ELECTRODES	SURFACE
5 MHz	14 mm	12 / 5 mm	Au

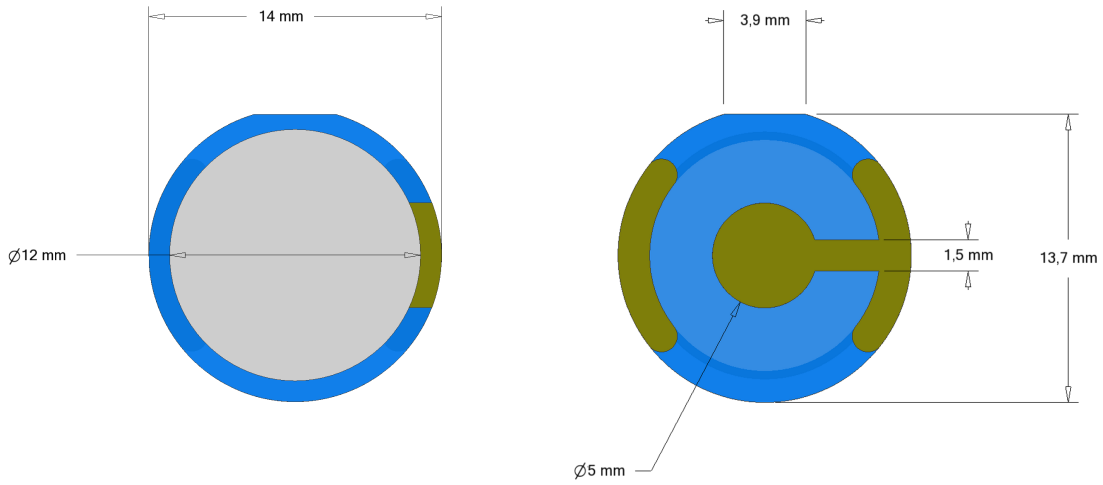
KEY FEATURES

- 5 MHz
- 14.0 MM SENSOR DIAMETER
- 12.0 / 5.0 MM ELECTRODE DIAMETER
- Au (gold) ELECTRODE (with Ti adhesion layer)
- WRAPPED ELECTRODES (SINGLE SIDE CONTACT)
- FOR LIQUID BIOSENSING

DESCRIPTION

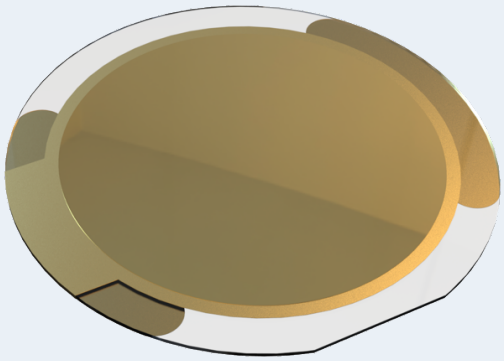
The Quartz Crystal Microbalance (QCM) sensor is a 5 MHz AT-cut crystal optimized for liquid biosensing applications. The sensor features Au (gold) electrodes on a titanium adhesion layer, which ensures robust electrode adhesion and consistent electrical properties across multiple binding and regeneration cycles. The front electrode is wrapped around the edge of the blank, so both electrodes are contacted from the back face only.

2D DIMENSIONS



FRONT (SENSING SIDE) BACK (CONTACT SIDE)

3D VIEWS



FRONT (SENSING SIDE)

MECHANICAL

Nominal blank diameter	14.0 mm (13.97 ± 0.03 mm)
Nominal blank thickness	≈ 0.33 mm (AT cut, 5 MHz fundamental)
Crystal axes orientation	Yes, orientation flat on the blank edge
Surface appearance	Transparent, polished
Edge bevel	Yes

GENERAL

Sensor design	Plano-Plano
Angle of cut	AT, 35° 15′ ± 3′
Oscillation mode	Fundamental
Frequency vs Temp stability	< ± 15 ppm (0 to +50 °C)
Operating temperature	-20 °C to +125 °C
Storage temperature	-40 °C to +125 °C
Compatibility	openQCM™, Q-SENSE™

ELECTRICAL

Nominal frequency	5.000 MHz
Frequency tolerance	± 5 kHz @ 25 °C
Resonance resistance	< 15 Ω
Shunt capacitance, C0	< 7 pF
Q-value	> 100 000
Mass sensitivity (Sauerbrey, n = 1)	17.7 ng cm^{-2} Hz^{-1}

ELECTRODES

Front electrode diameter	12.0 mm
Front electrode material	Gold (Au)
Back electrode diameter	5.0 mm
Back electrode material	Gold (Au)
Adhesion layer	Titanium (Ti)
Layer thickness	~10 nm Ti / ~200 nm Au
Electrode configuration	Wrapped front electrode, single side contact

PACKAGING & STORAGE

Sensor package type	Box
Storage quantity	10 pieces
Package protection	Package is protected with a vacuum sealed plastic bag
Storage recommendation	After opening plastic vacuum bag preferably store in dust free dry Air or Nitrogen @ room temperature.

AT5-14-12-AU-WRAP

CLEANING AND CARE

BEFORE YOU START

The sensing film is only about 200 nm thick and sits on a 10 nm titanium adhesion layer. Titanium and chromium are the two adhesion metals used for thin film electrodes on quartz, and they fail in different ways: titanium is attacked by fluoride, hot alkali and piranha, chromium by peroxide, ceric ammonium nitrate and anodic polarization [1, 2]. Along the edge of the electrodes and on the wrapped contact the adhesion layer is exposed, so a reagent that only attacks the adhesion metal can still undercut and lift the electrode. The procedures below were chosen to be safe for both adhesion metals and for the quartz substrate. Where no procedure written for QCM sensors is published, methods developed for the same surface in other fields (electrochemistry, microfabrication, surface science, food processing) were adapted to these limits, and the source of each step is given.

HANDLING AND MOUNTING

- Hold the sensor only at the outer edge of the quartz, with clean plastic tipped tweezers and powder free nitrile gloves. Never touch or wipe the electrodes or the wrapped contact area.
- Dry with a gentle stream of filtered, oil free nitrogen blown from the center outwards. Do not let droplets evaporate on the electrode: they leave rings of residue [3].
- Mount the sensor with the sensing face towards the measurement chamber and tighten the holder finger tight only. Clamping force shifts the resonance frequency: three point clamping changed the frequency of 10 MHz crystals by up to 3 ppm [4], and the force-frequency effect of AT-cut quartz is described in [5].
- After mounting, wait for the frequency to stabilize in the measurement medium before taking the baseline. Swelling O-rings and contact pressure cause slow drift in the first minutes.
- Do not use ultrasonic baths. No study quantifies cavitation damage on thin film QCM electrodes, but cavitation is itself used as a delamination test for sub-micrometre coatings, so we treat it as a risk for the film and for the thin blank.
- Use one fixed pretreatment for a whole series of measurements. Different cleaning methods give different surface states and therefore different sensor responses [6].

CLEANING PROCEDURES FOR GOLD ELECTRODES

Gold is chemically noble, but a clean gold surface takes up hydrocarbons from the air within minutes [7] and binds sulfur compounds and proteins strongly. The procedures below are ordered from the gentlest to the most aggressive: always start with the lowest level that restores the baseline. They were compared on openQCM 10 MHz gold sensors by Wasilewski et al. [8], who found electrochemical cleaning the least invasive, oxygen plasma intermediate and piranha the most damaging. Use ultrapure water (18 MΩ cm) and filtered nitrogen throughout. Potentials are given vs Ag/AgCl.

LEVEL 1 ROUTINE CLEANING BETWEEN MEASUREMENTS

1. Flush the measurement chamber with the measurement buffer, then with ultrapure water.
2. Remove the sensor and rinse the gold face with absolute ethanol or isopropanol, then with ultrapure water. These solvents do not etch gold, titanium or chromium [1].
3. For protein residues, immerse for 10 to 15 min at room temperature in alkaline SDS (5 mg/mL SDS in PBS adjusted to pH 11 with NaOH), then rinse thoroughly with water [9]. Removal of blood proteins from gold is only partial: if the baseline does not recover, go to Level 3.
4. Dry with nitrogen and check the baseline (see VERIFYING CLEANLINESS).

LEVEL 2 STANDARD PRE-USE CLEANING

For new sensors and to remove organic films and adventitious carbon. Choose route A (no potentiostat needed) or route B (electrochemical QCM users).

1. **Route A, dry oxidation.** Rinse the gold face with acetone, then ethanol or isopropanol, then ultrapure water, and dry with nitrogen.
2. Oxidize the organic contamination with either a low power oxygen plasma (about 20 W, 0.5 mbar, 60 to 90 s; 22 W for 85 s caused no damage on openQCM sensors [8]) or UV/ozone for 15 to 30 min with the sensor a few millimetres from the lamp [10, 11].
3. Both treatments leave a thin gold oxide (about 1.7 nm after UV/ozone [12]). Immerse the sensor in absolute ethanol for 20 min to reduce it [13, 14], rinse with water and dry with nitrogen. Use the sensor within one hour, or start the functionalization immediately.
4. **Route B, electrochemical cleaning.** After the solvent rinse of step 1, run 10 cathodic sweeps in 50 mM KOH from −0.1 V to −1.2 V at 50 mV/s [8, 15].
5. Optionally activate the surface in nitrogen purged 50 mM H_2SO_4, cycling between −0.4 V and +1.4 V at 100 mV/s until the voltammogram is reproducible (about 12 cycles) [8]. Do not exceed +1.5 V and keep the number of cycles low: anodic cycling removes gold and thin films are quickly corroded [11].
6. Rinse with water and dry with nitrogen.

LEVEL 3 DEEP CLEANING AND REGENERATION

- **Thiol monolayers (preferred).** Reductive desorption in 0.5 M KOH by sweeping to about −1.2 V, repeated until no desorption peak is left [8, 16]. Without a potentiostat, immerse in 0.5 M $NaBH_4$ for 10 min at room temperature, then rinse with water and ethanol [17].
- **Monolayers and organic films, dry method.** Oxygen plasma removes alkanethiolate monolayers in less than 60 s without roughening the gold, but leaves gold oxide and oxidized sulfur [18]. Follow with the

ethanol immersion of Level 2, step 3, or with the KOH sweep of step 4.

- **Proteins and proteins on monolayers.** Alkaline SDS as in Level 1, then oxygen plasma or the electrochemical sequence of Level 2. Hydrogen peroxide mediated UV photo-oxidation in liquid regenerates gold QCM crystals covered by thiols and proteins while preserving roughness better than piranha [19].
- **Last resort only: acid piranha.** Piranha caused the largest loss of performance and surface damage on openQCM sensors [8], etches titanium at 240 nm/min [1] and causes delamination of gold films [20]. If it is used at all, limit the exposure to 1 to 2 min at room temperature, rinse thoroughly and expect to lose the sensor. Never use it on chromium adhesion layers.

CHEMICAL COMPATIBILITY

RATING	AGENT	WHY
SAFE	**Water, buffers, ethanol, isopropanol, acetone, methanol**	No measurable etching of Au, Ti, Cr or quartz [1]
SAFE	**Low power O_2 or Ar plasma, short**	No damage at 22 W for 85 s on openQCM sensors [8]
SAFE	**UV/ozone up to 30 min**	Leaves a thin gold oxide [12]
SAFE	**Dilute KOH and H_2SO_4 (50 mM) for cyclic voltammetry**	Compatible within the potential limits given above [8, 11]
SAFE	**Alkaline SDS (pH 11)**	Compatible [9]
CAUTION	**H_2O_2 and alkaline peroxide mixtures**	Hot H_2O_2 etches chromium at 110 nm/min [1]: avoid on Cr adhesion layers
CAUTION	**Anodic cycling above +1.5 V, many cycles; chloride with anodic potential**	Removes and corrodes thin gold [11]
NEVER	**Acid piranha**	Not for routine use. Ti 240 nm/min, Cr above 16 nm/min [1]; damage on openQCM sensors [8]
NEVER	**Aqua regia, also diluted**	Dissolves gold at 680 nm/min [1]
NEVER	**KI/I_2 gold etchant, cyanide**	Dissolves gold (660 nm/min for KI/I_2) [1]
NEVER	**HF, buffered HF, fluorides**	Ti 1100 nm/min, etches quartz, lifts Cr on Au [1]
NEVER	**Chromium etchants (ceric ammonium nitrate)**	Undercut the Cr adhesion layer at 170 nm/min [1]
NEVER	**Hot concentrated KOH or NaOH**	Etch quartz, soften Ti [1, 21]
NEVER	**Mercury and mercury vapour**	Absorbed by thin gold films [22]
NEVER	**Abrasives, polishing, wiping**	Remove the 200 nm film

VERIFYING CLEANLINESS

- **Water contact angle.** Truly clean gold is hydrophilic [23, 24]; the angle rises as hydrocarbons adsorb and levels off within about 2 h in laboratory air [7]. Measure within 10 min of cleaning and compare with the value of a new sensor.
- **Cyclic voltammetry in dilute H_2SO_4.** A clean surface shows the gold oxide formation region and one sharp oxide reduction peak, with no extra peaks, and reproducible cycles [11, 25]. The reduction charge (about 390 µC cm^{-2}) gives the real area [26]; a stable value between cleanings shows the film is not being eroded.
- **Redox probe.** In 10 mM ferri/ferrocyanide the peak separation approaches 59 mV on a clean electrode and increases with contamination [8, 15].
- **Frequency.** After cleaning, frequency and dissipation in the same medium and at the same temperature should return to the values of the bare sensor. In air, 1 nm of gold corresponds to about 109 Hz [27].

STORAGE AFTER USE

Clean gold is recontaminated within minutes and the contamination keeps evolving for days [7]. Store the sensor dry in a clean, closed glass or PTFE container, under nitrogen if available, and repeat Level 2 before critical measurements. For monolayer work transfer the sensor directly from cleaning to the thiol solution.

TEMPERATURE

The operating and storage temperature ranges of this sensor are listed in the GENERAL table. Within those ranges please consider the following.

- **Frequency vs temperature.** The resonance frequency of AT-cut quartz follows a cubic function of temperature whose shape depends on the cut angle [5, 28]. The cut of this sensor keeps the intrinsic drift small around room temperature, but over wide temperature ranges the frequency change is much larger than the mass signals of interest.
- **Measurements in liquid.** The viscosity and density of the liquid change with temperature and shift the frequency [29]. In water near 25 °C the shift is about +8 Hz/°C at 5 MHz (calculated from the Kanazawa-Gordon equation with the viscosity of water [30]). Control the temperature of the measurement chamber to better than 0.1 °C and let it settle after every liquid change [3].
- **Cleaning temperature.** Wet cleaning steps in this datasheet are performed at room temperature or slightly above, never above the limit given for each step. Never flame anneal, oven anneal or quench the sensor.
- **Adhesion layer.** Titanium diffuses along the grain boundaries of gold and reaches the surface from about 250 to 300 °C [31, 32]; chromium does the same and oxidizes at the surface at about 300 °C [33, 34]. The surface chemistry and the adhesion of the electrode change long before the quartz is damaged.
- **Quartz.** The resonator quality degrades above about 300 °C [35], cooling stresses between 200 and 550 °C create Dauphiné twins that ruin the resonator [36], and at 573 °C quartz goes through the alpha to beta transition with a sharp change of thermal expansion [37].

WHEN TO REPLACE THE SENSOR

Every cleaning cycle removes a little material and changes the surface. On openQCM 10 MHz gold sensors three regeneration cycles reduced the sensor performance by 7 % with electrochemical cleaning, 16 % with oxygen plasma and 25 % with piranha [8]. Replace the sensor when one of the following occurs [3]:

- cracks or chips on the edge of the quartz, scratches or holes in the electrode;
- peeling of the electrode, visible from the contact side, or permanent discoloration;
- noisy or unstable baseline, higher motional resistance (lower Q, higher dissipation);
- the frequency in air drifts from cycle to cycle, showing that the film is being consumed;
- the cleanliness test of this datasheet no longer passes after a deep cleaning.

Record the resonance frequency in air of every new sensor and after each deep cleaning: comparing the values is the simplest way to follow the condition of the electrode.

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