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Corrosion properties of biodegradable AZ31 and ZK60 magnesium alloys: in-situ study

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1st Corrosion and Materials Degradation Web Conference
17/05/2021 - 19/05/2021

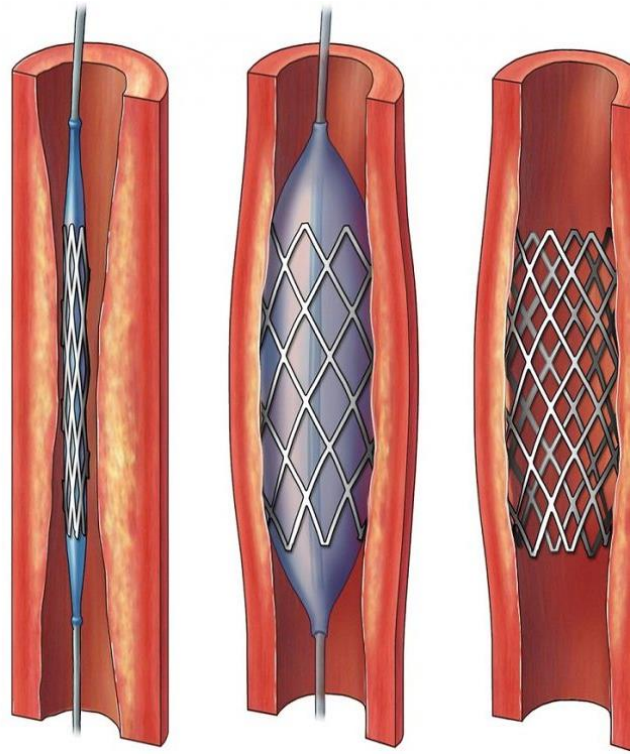
Biodegradable magnesium alloys

Promising applications

- Biodegradable bone implants
- Biodegradable coronary stents
- Biodegradable medicine filaments

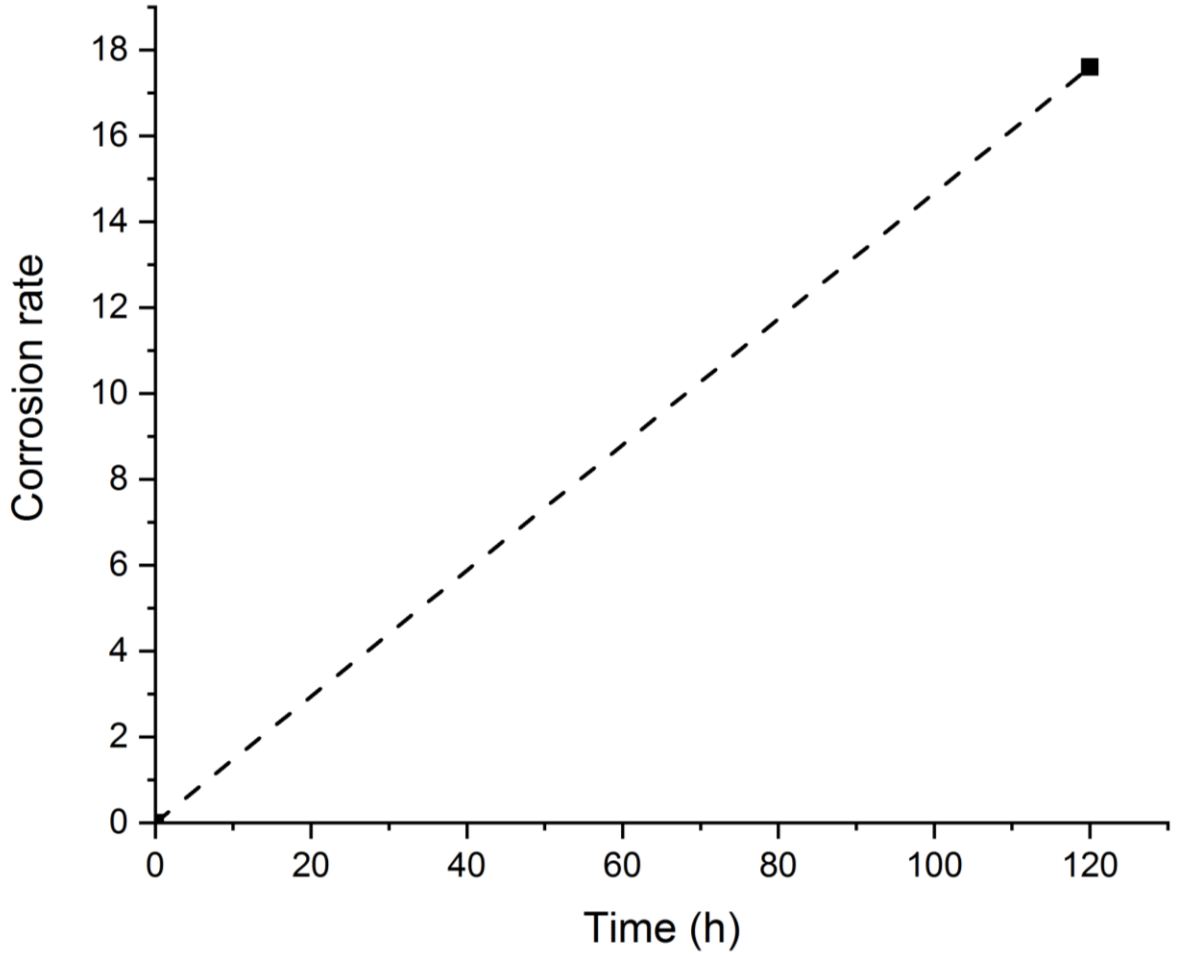
Properties and requirements

- Biocompatibility and low cytotoxicity
- High mechanical properties
- Optimal bioresorption rate



Corrosion properties of biodegradable alloys: investigation methods

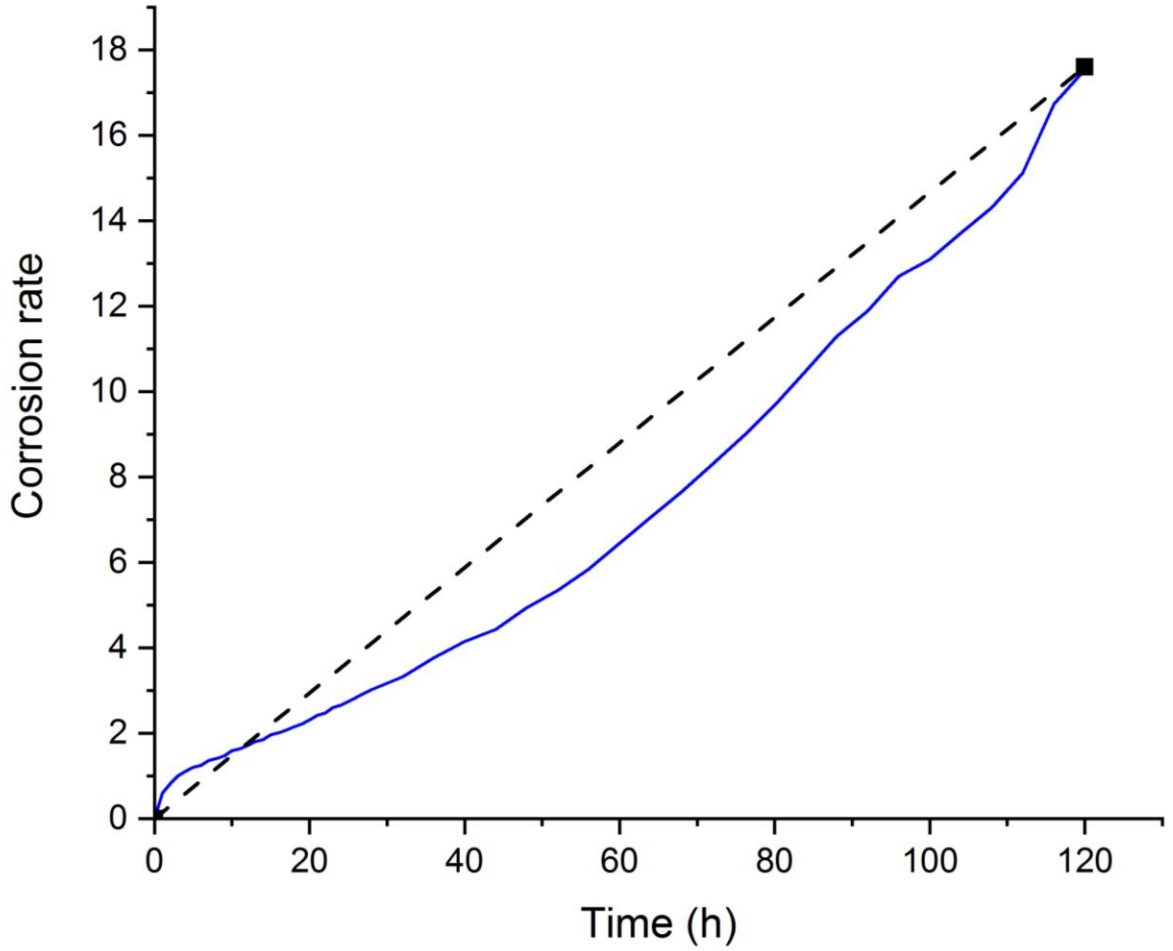
Weight loss method



Corrosion properties of biodegradable alloys: investigation methods

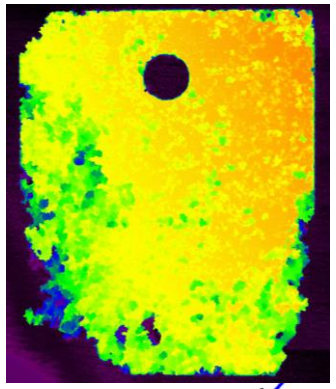
Hydrogen evolution method

Weight loss method

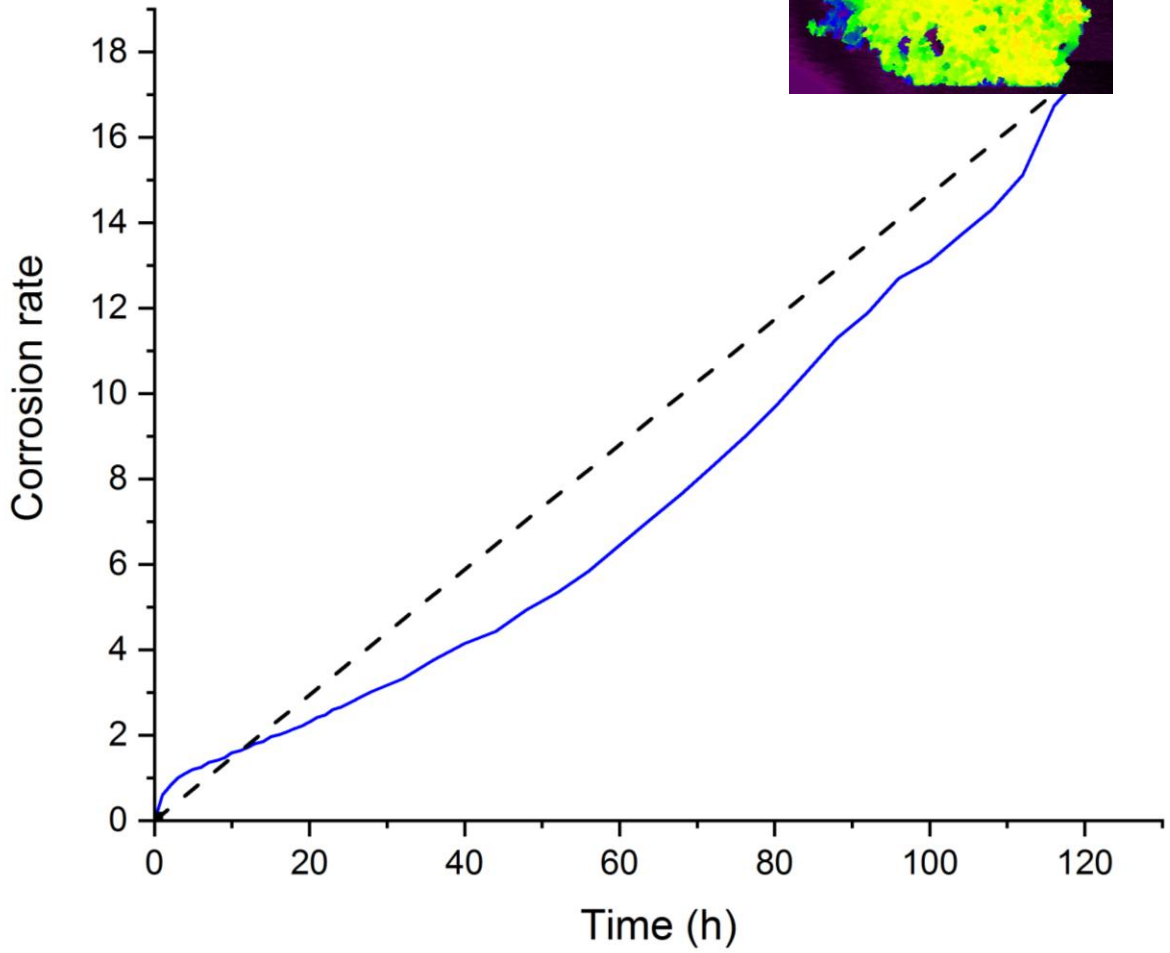


Corrosion properties of biodegradable alloys: investigation methods

Hydrogen evolution method



Weight loss method

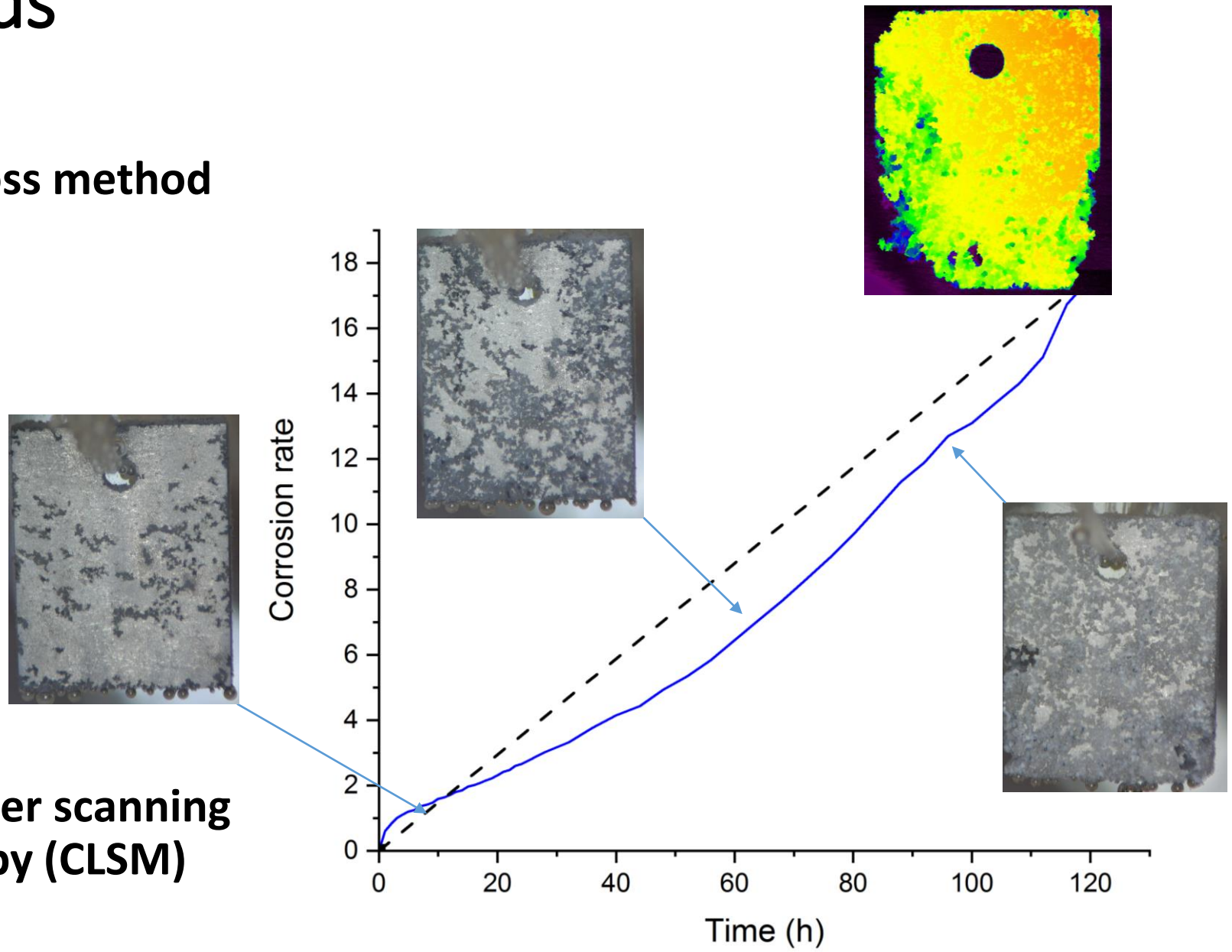


Confocal laser scanning microscopy (CLSM)

Corrosion properties of biodegradable alloys: investigation methods

Weight loss method

Hydrogen evolution method

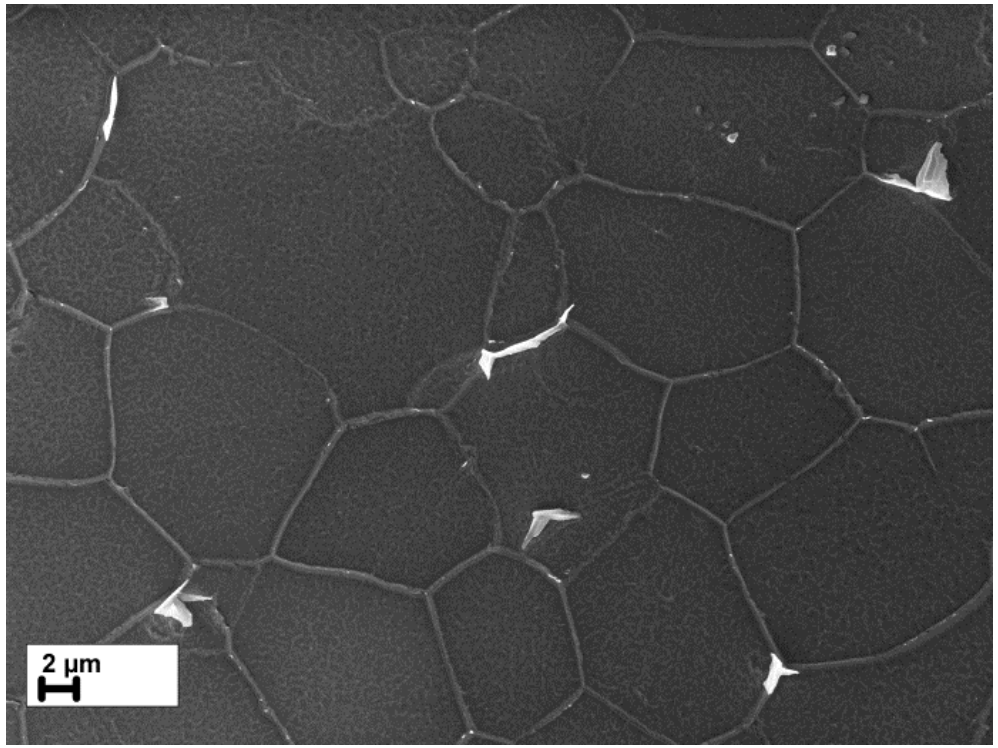


Confocal laser scanning microscopy (CLSM)

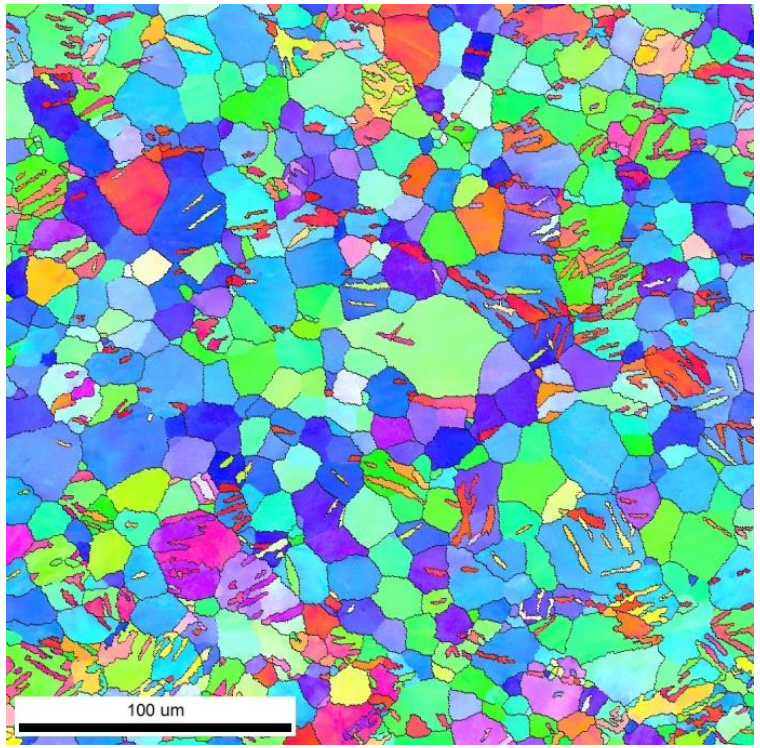
Real-time video-monitoring

Materials and sample preparation

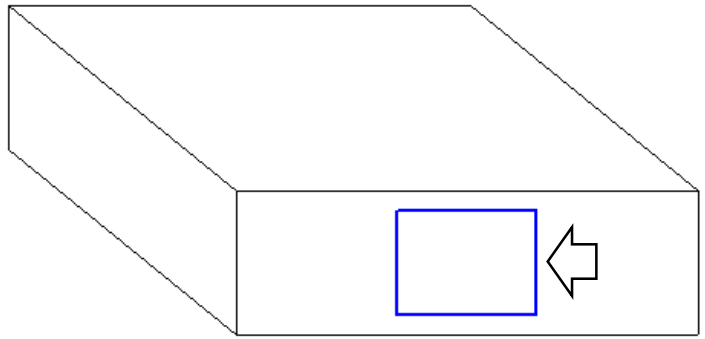
Hot-rolled AZ31 alloy:



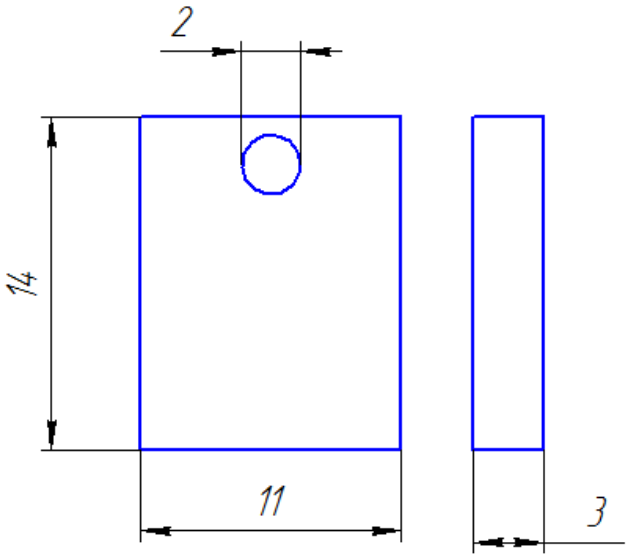
SEM



EBSD



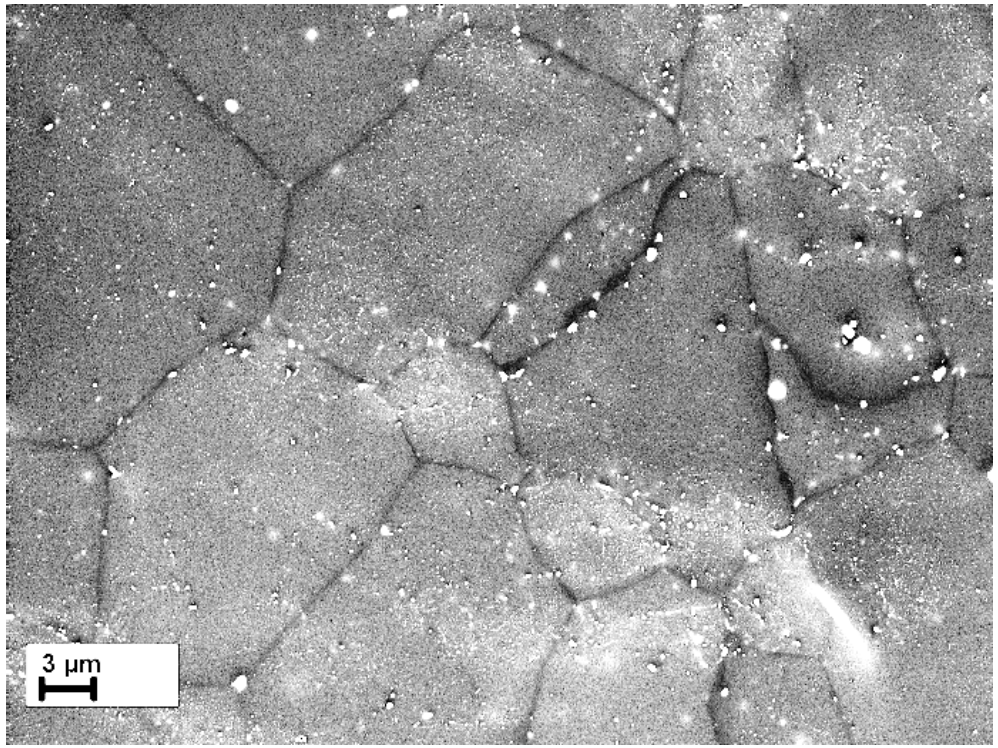
Cutting scheme



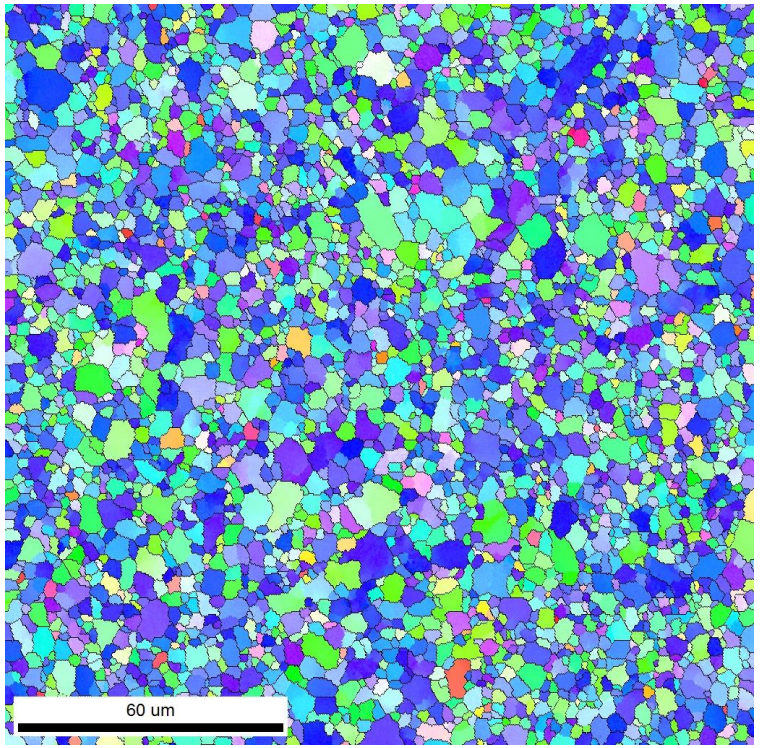
Sample geometry

Materials and sample preparation

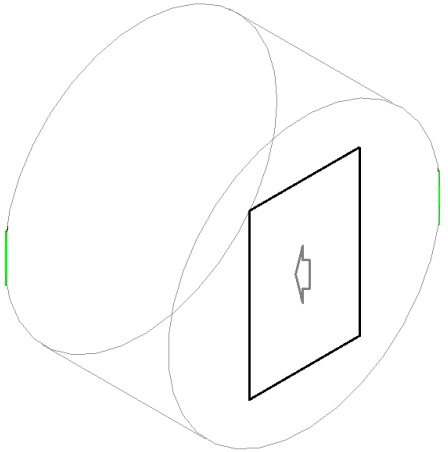
Extruded ZK60 alloy:



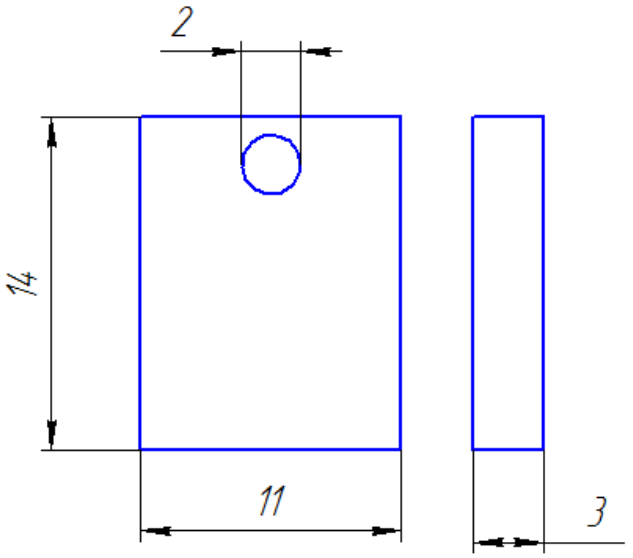
SEM



EBSD



Cutting scheme



Sample geometry

Experimental methodic

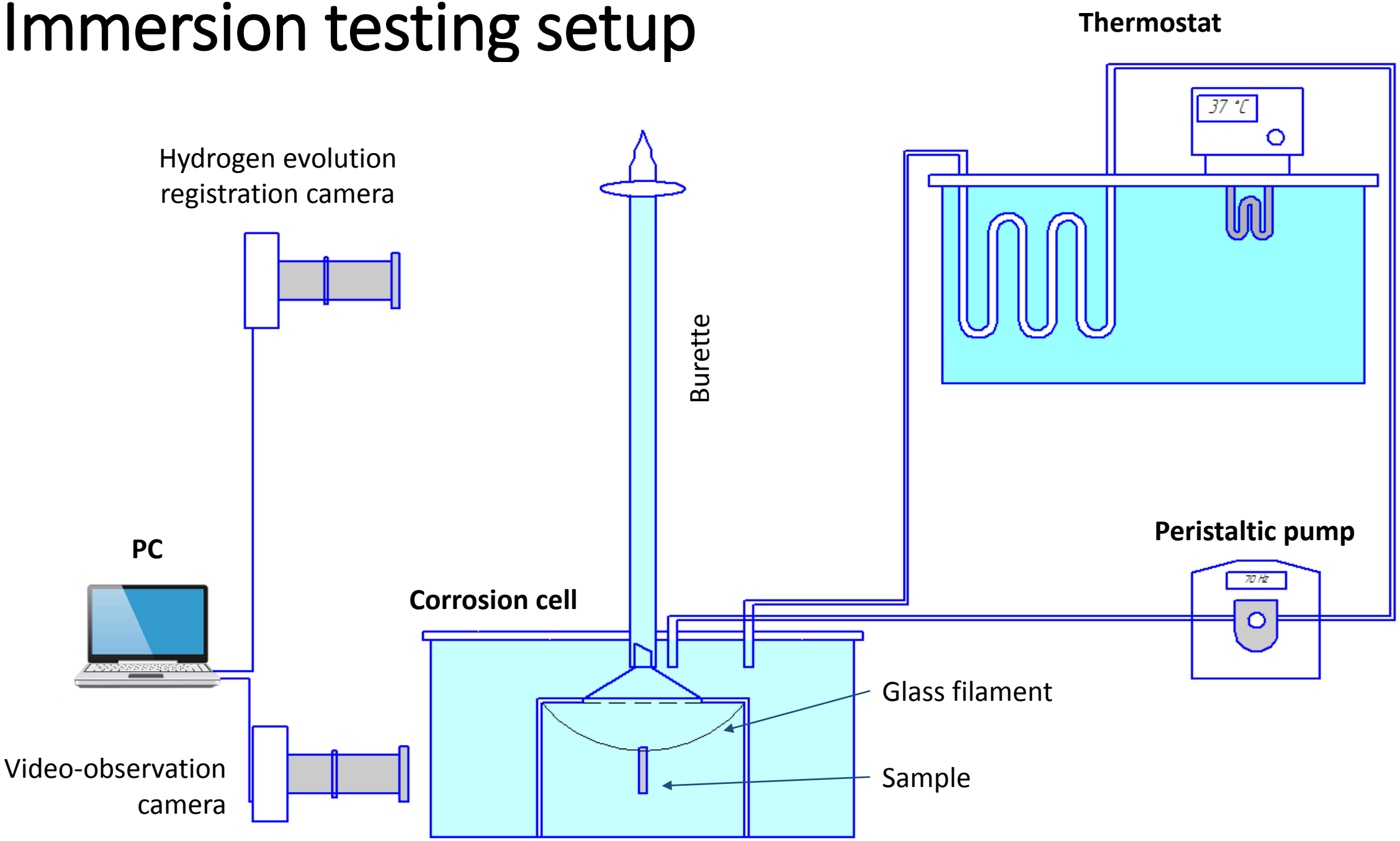
Immersion test

- 120 hours
- Temperature 37 °C
- In 0.9% NaCl aqueous solution
- Circulation of corrosion media
- Real-time video-observation
- Hydrogen evolution monitoring (every hour)
- pH measurement (twice per day)

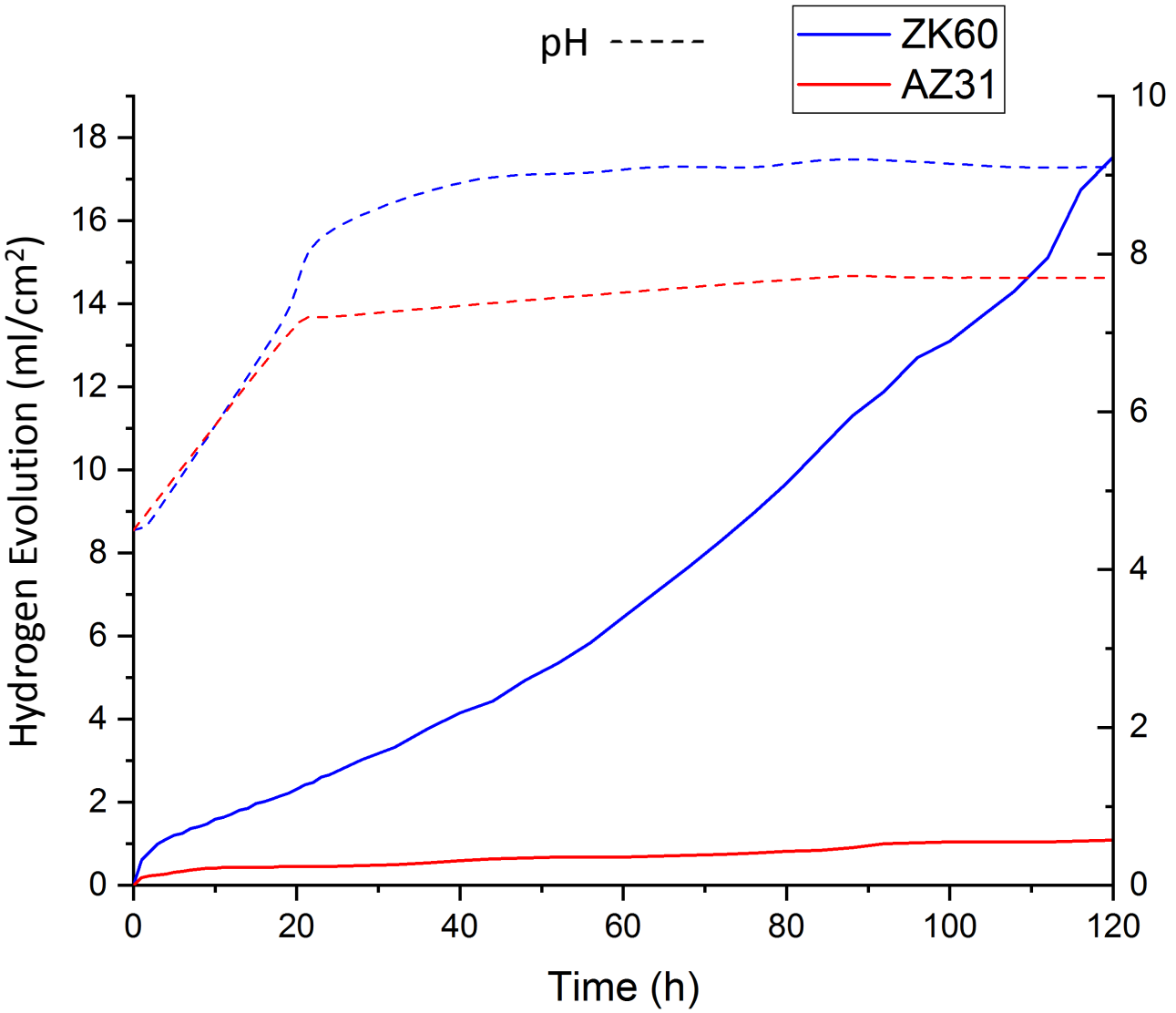
- Corrosion products removing in 20% CrO_3 + 1% $AgNO_3$ aqueous solution in ultrasonic bath
- Cleaning with ethanol
- Weight loss measurement

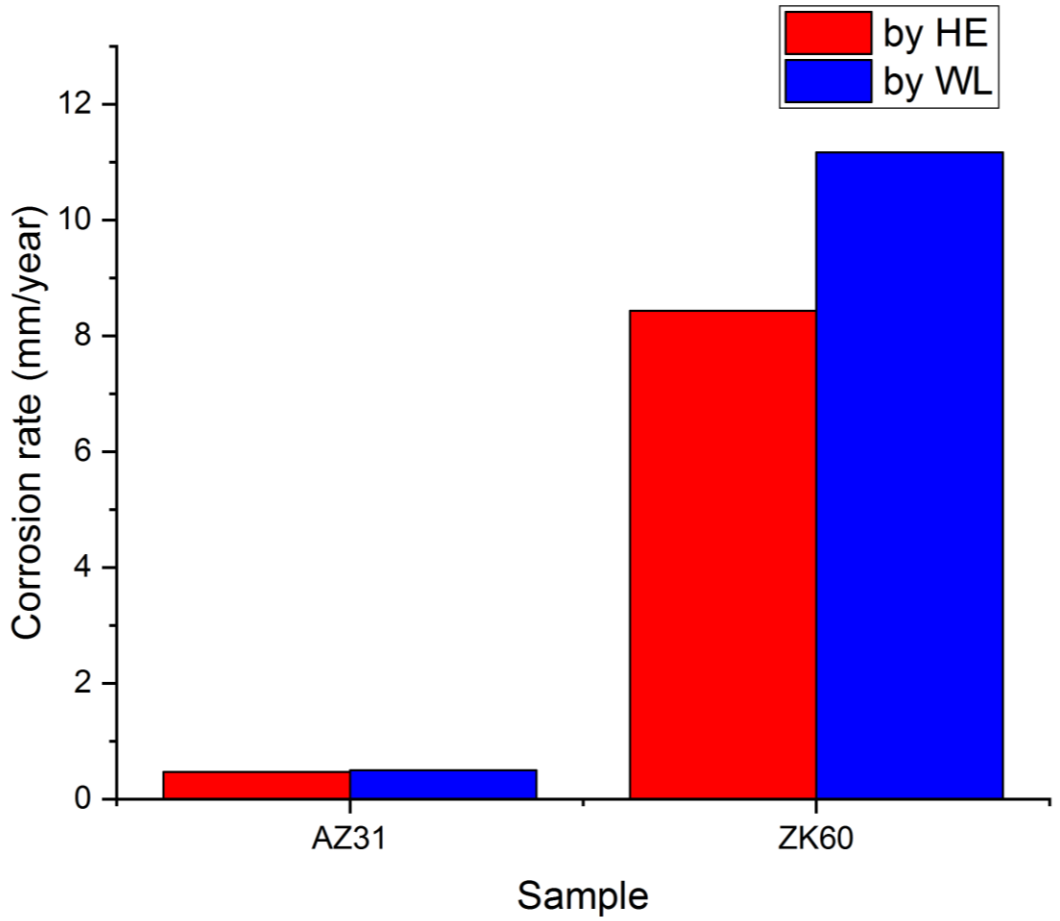
Surface topography examination by CLSM

Immersion testing setup

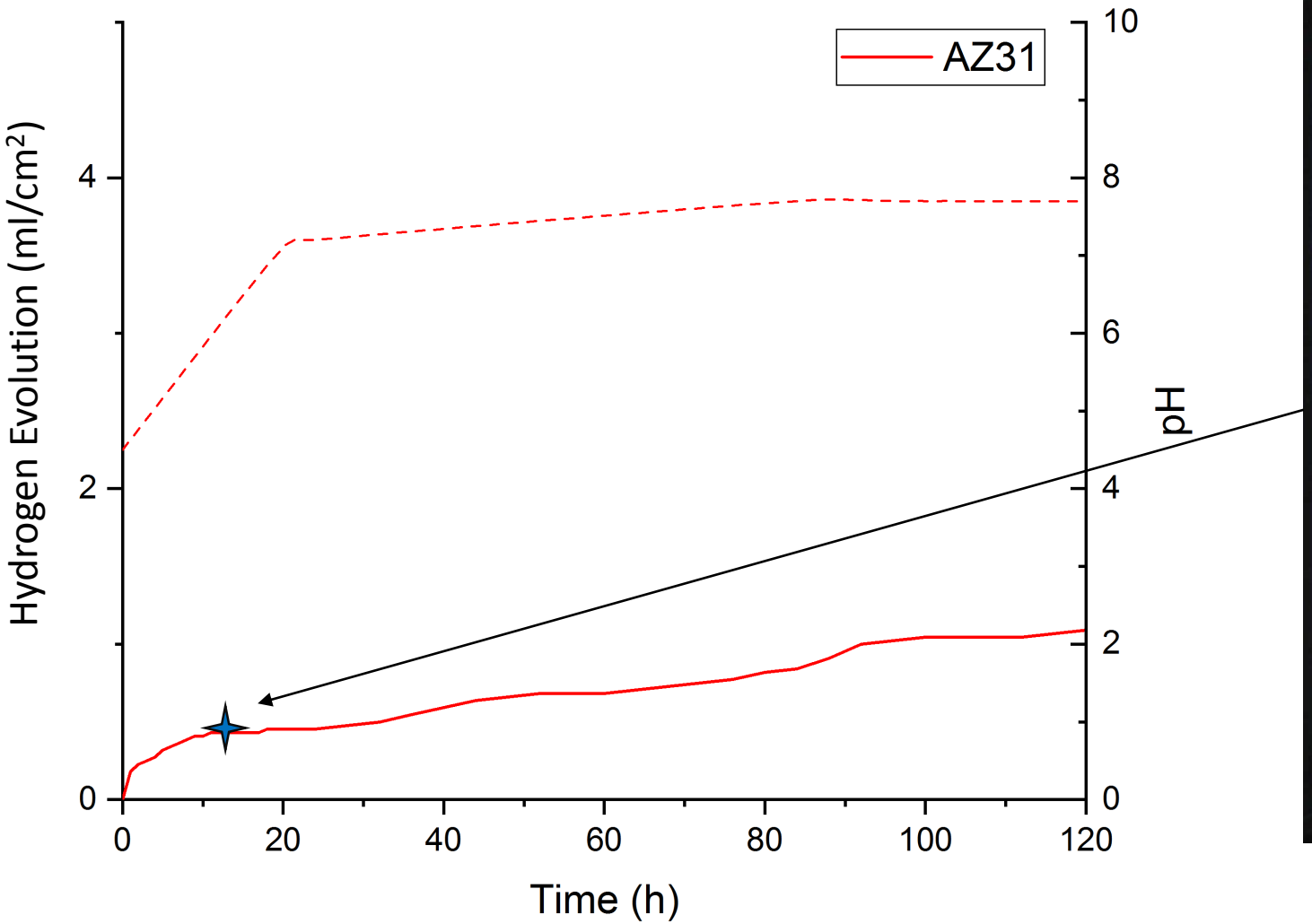


Results: corrosion rate



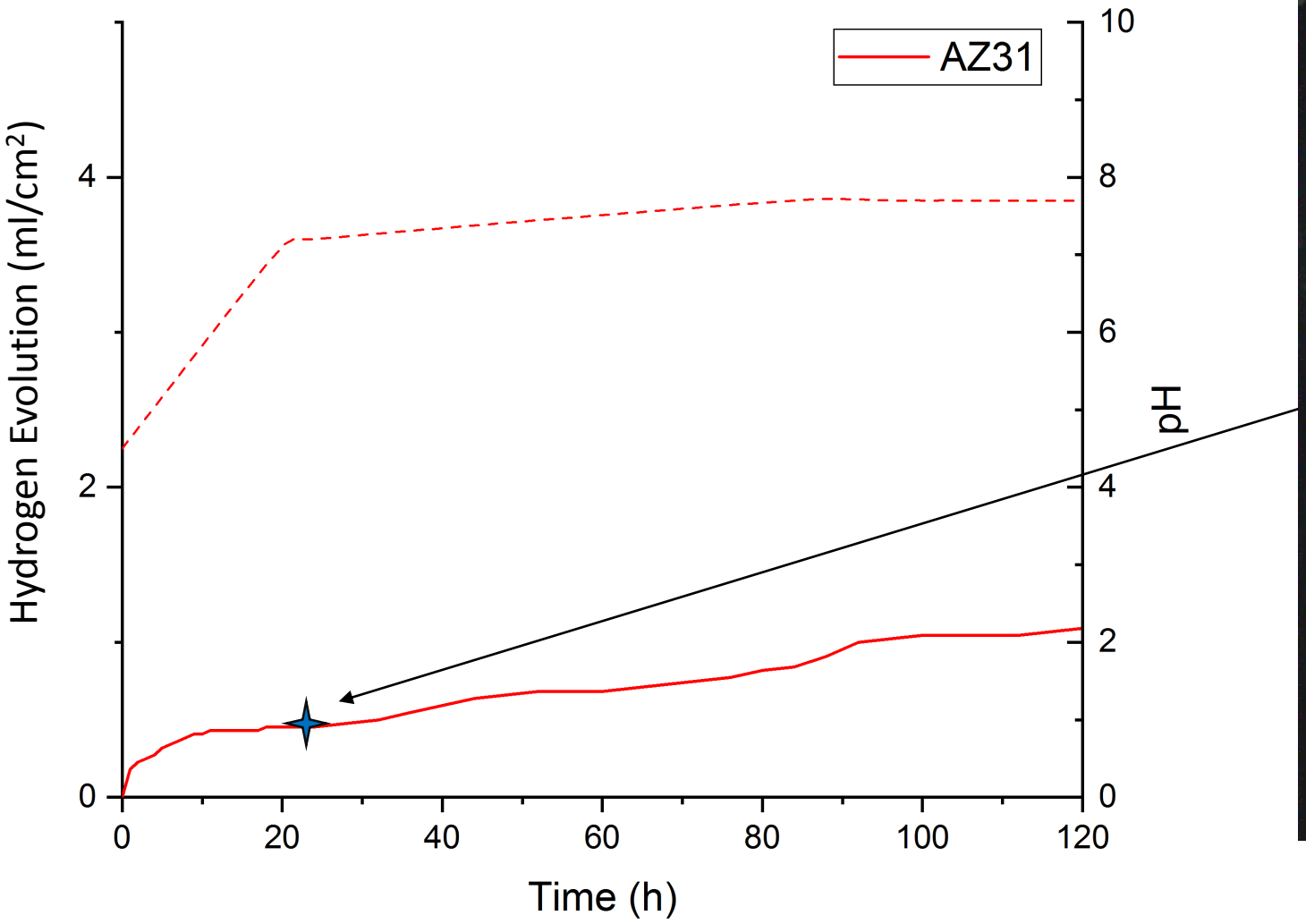


Results: surface morphology AZ31



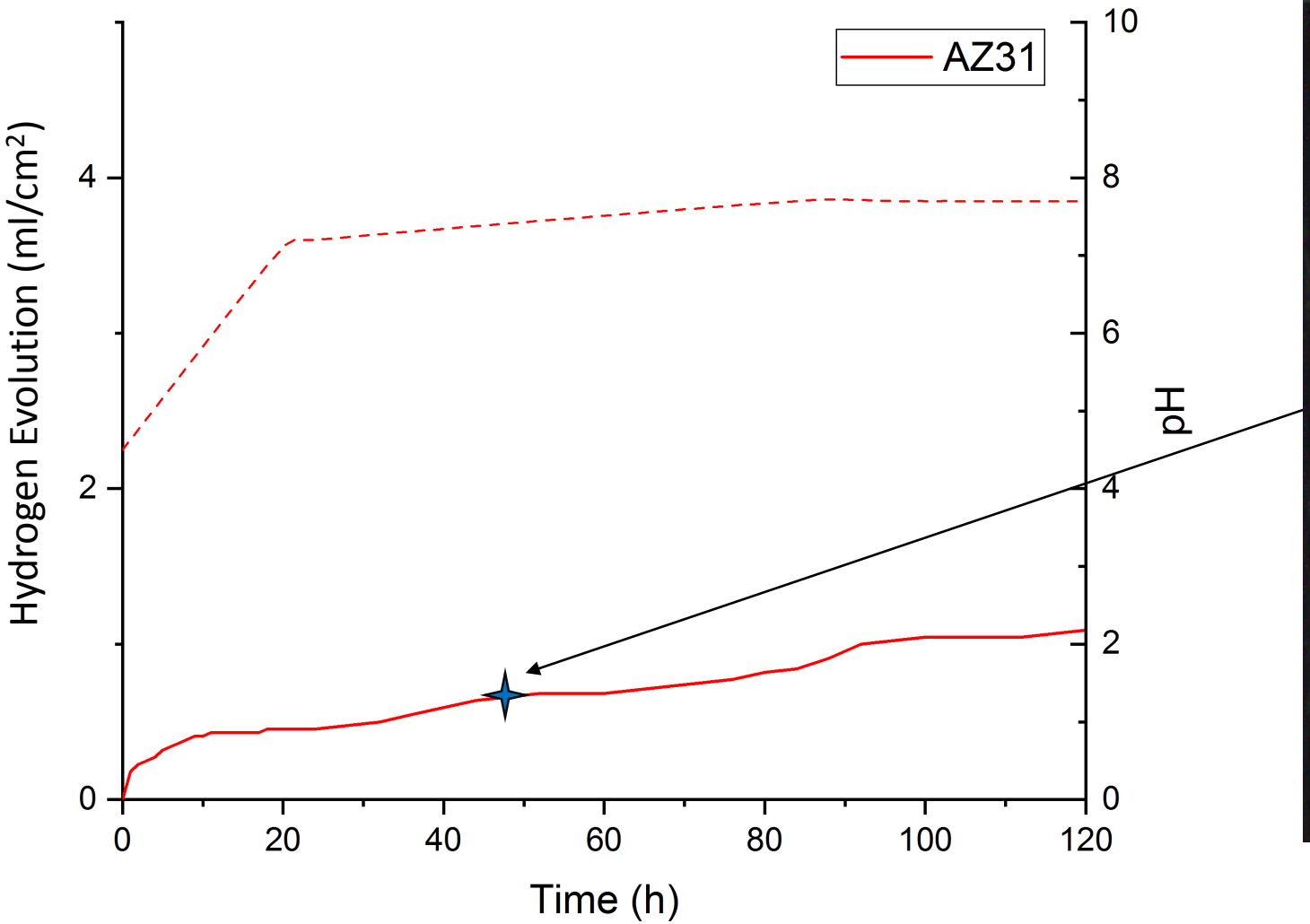
12 hours

Results: surface morphology AZ31



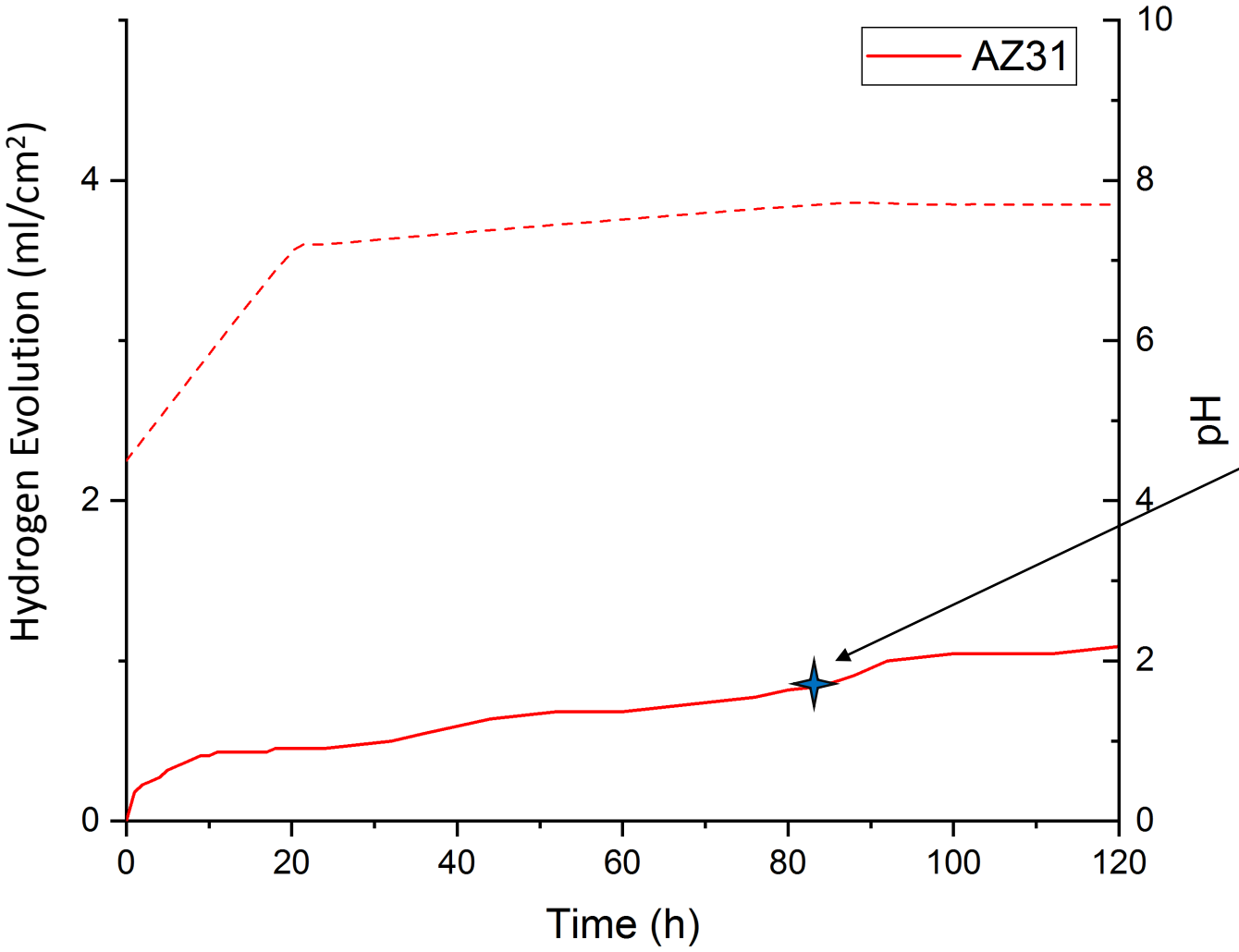
24 hours

Results: surface morphology AZ31



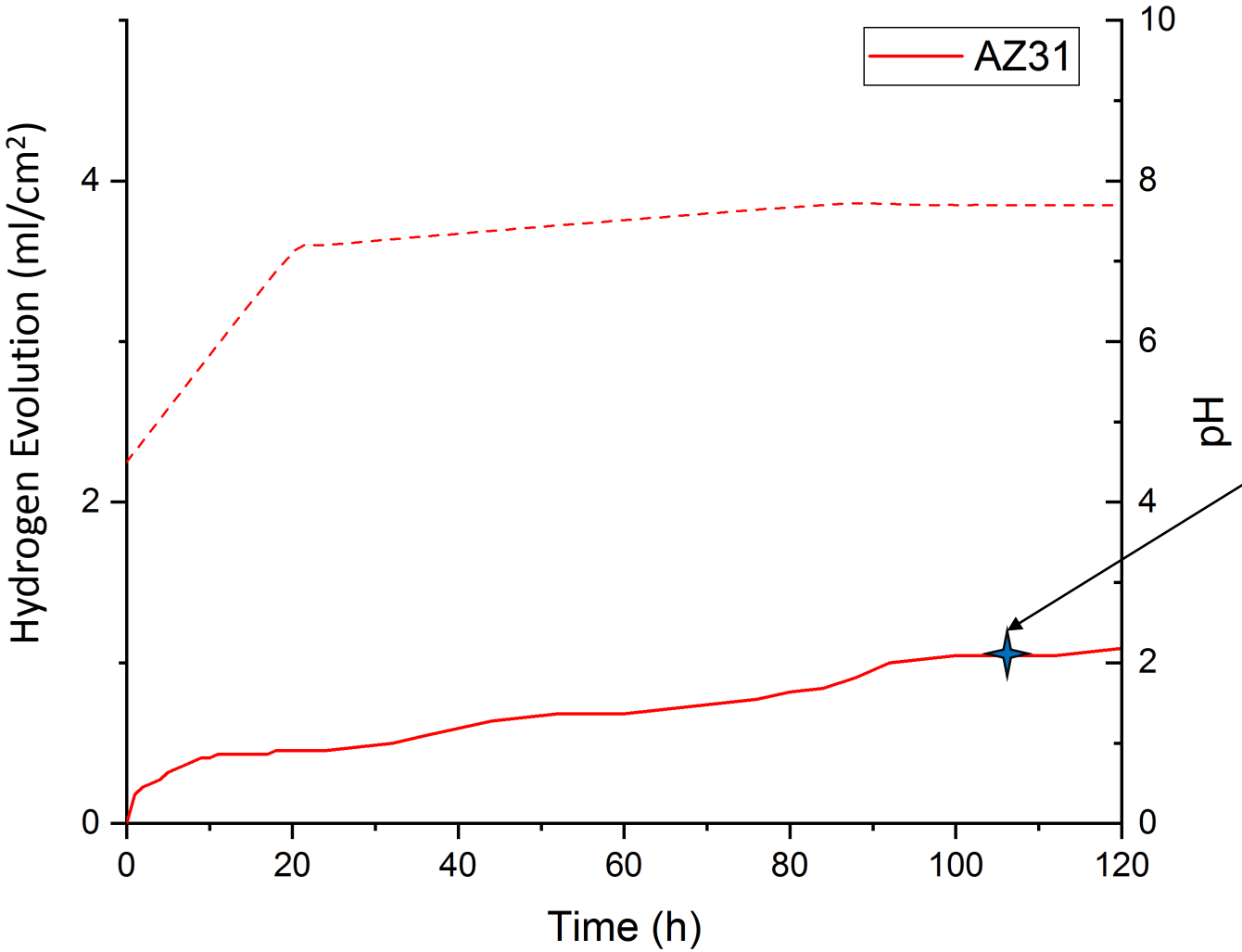
48 hours

Results: surface morphology AZ31



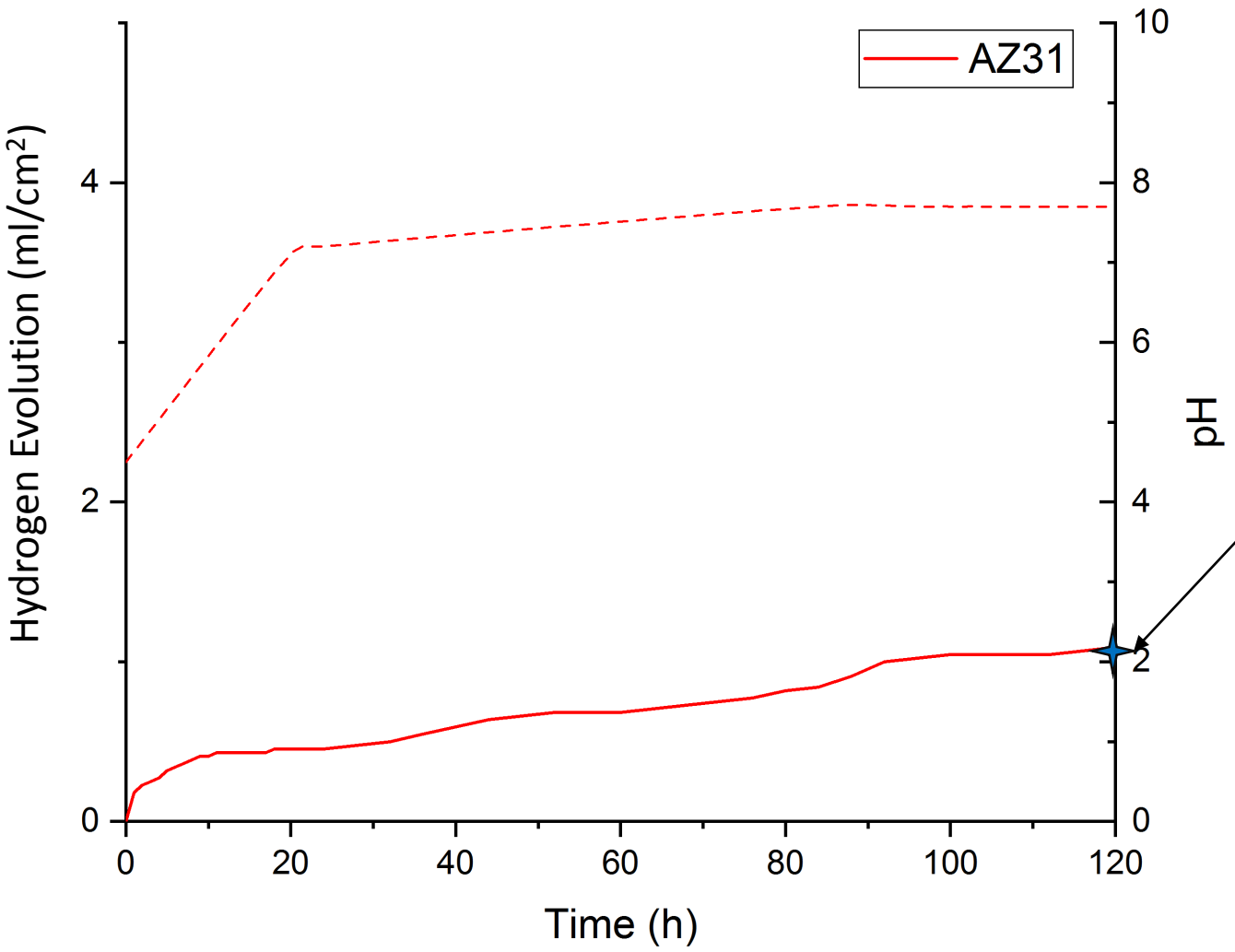
84 hours

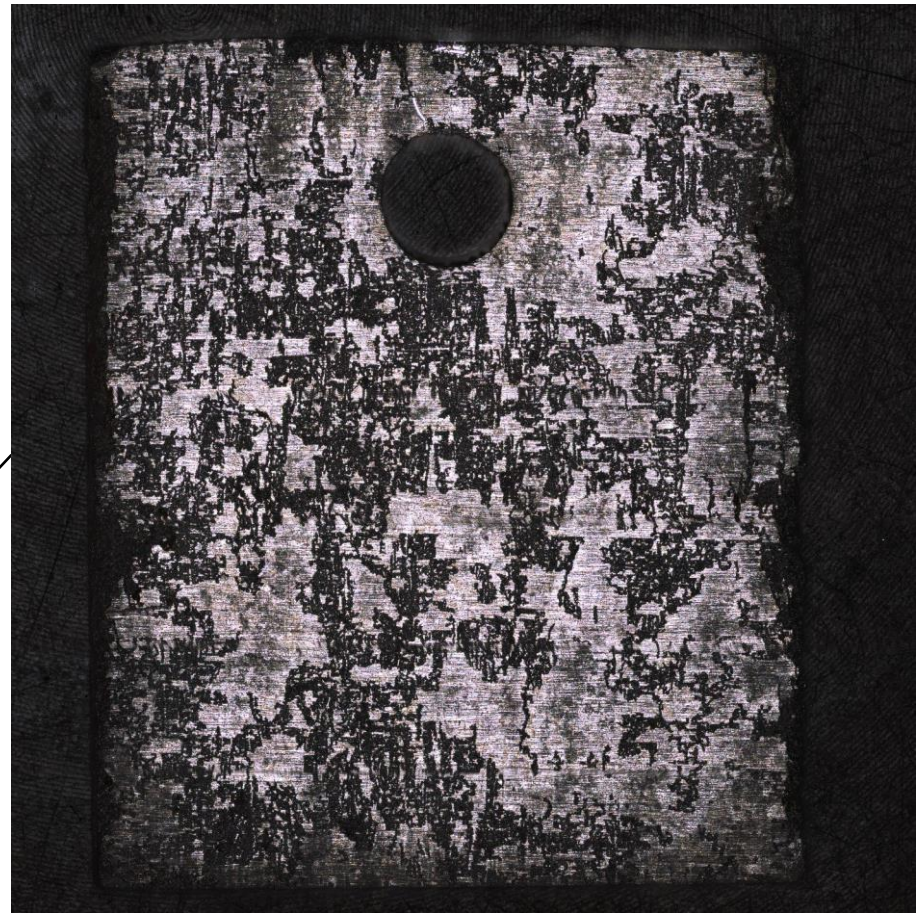
Results: surface morphology AZ31



108 hours

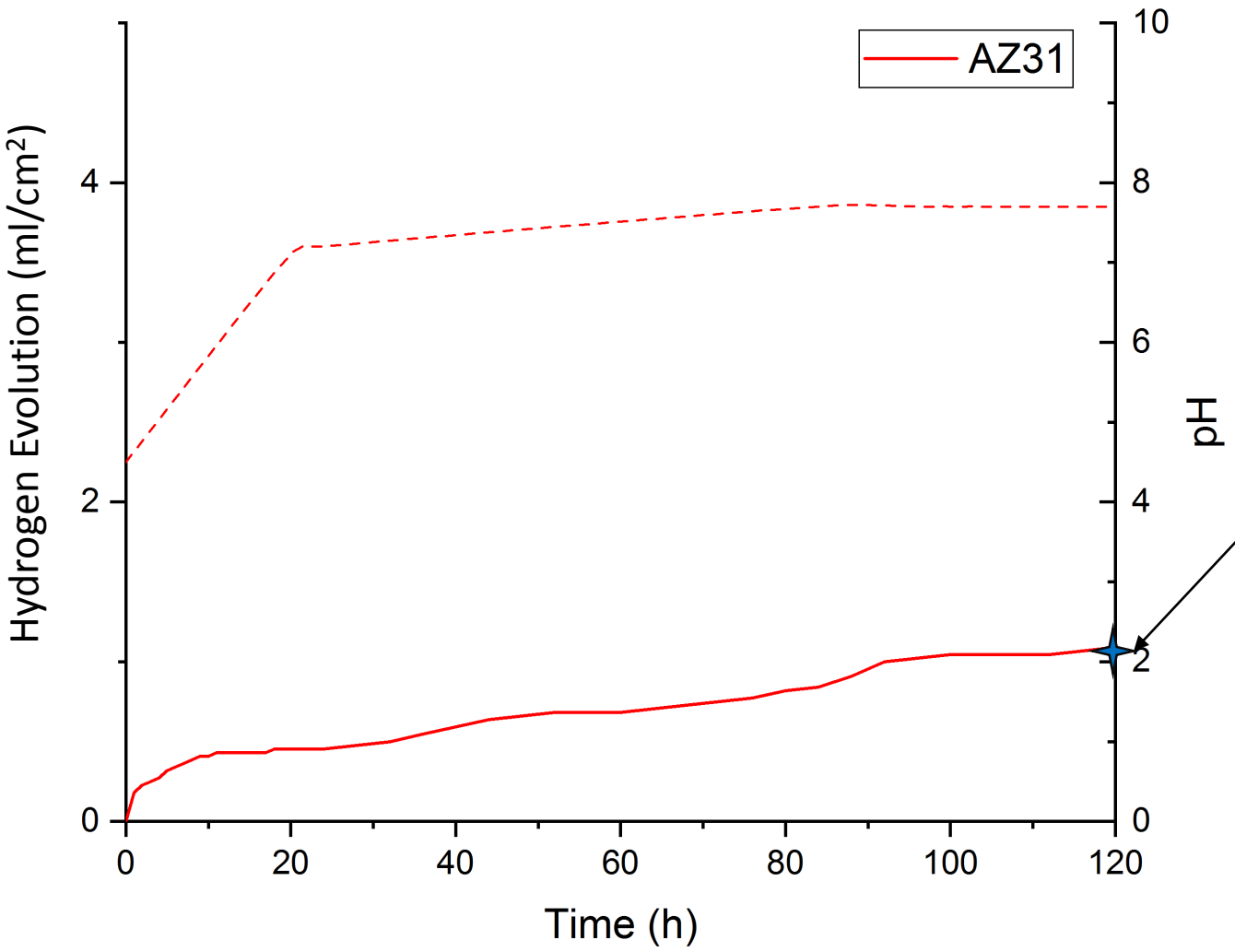
Results: surface morphology AZ31

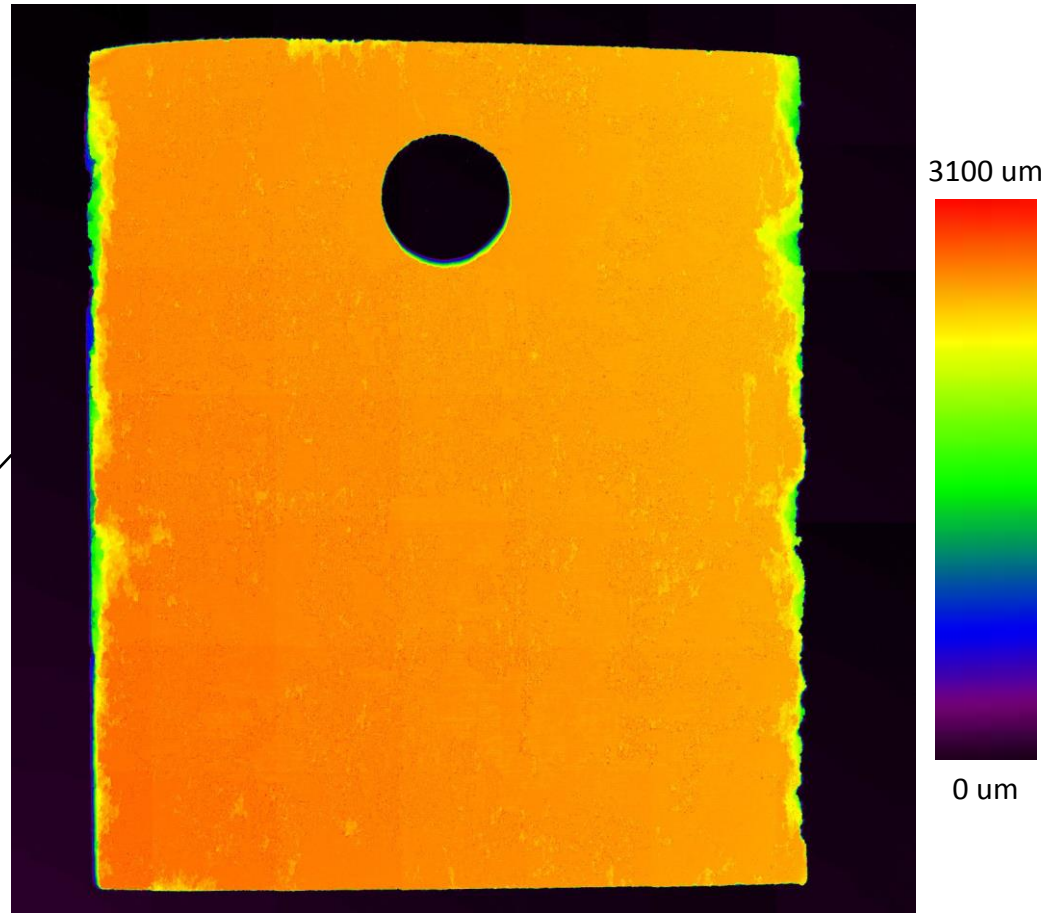




120 hours (without corrosion products)

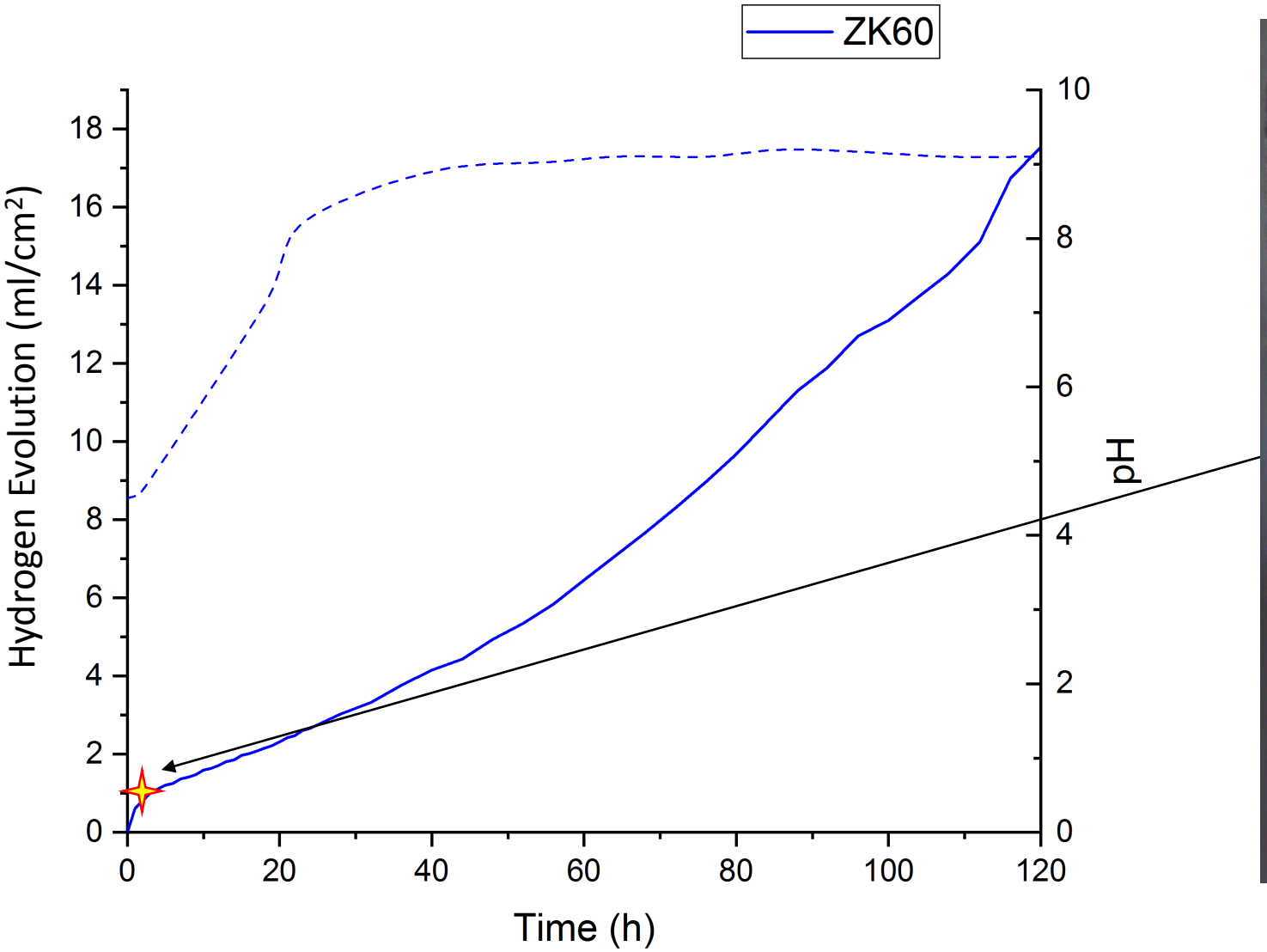
Results: surface morphology AZ31





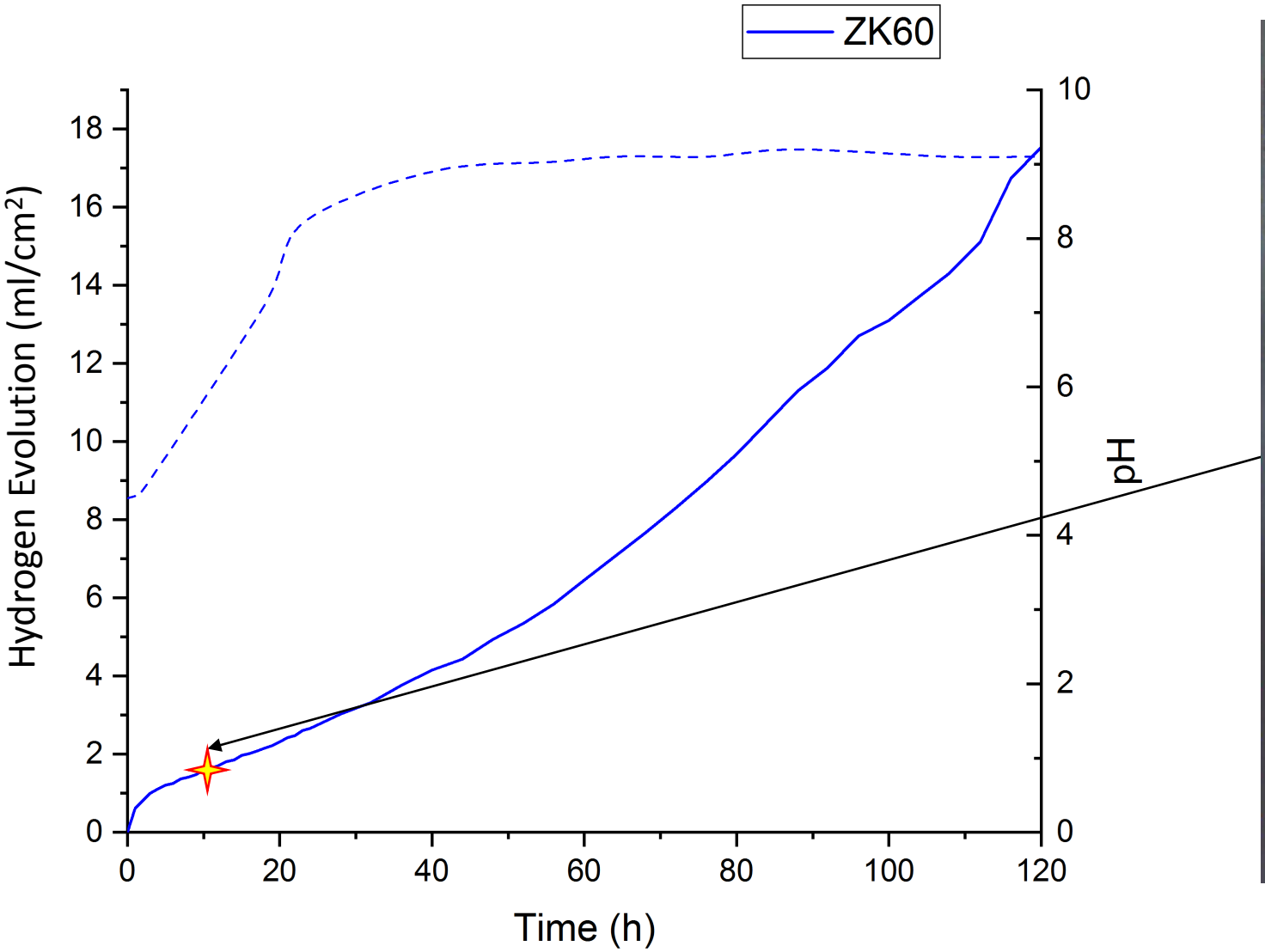
120 hours (height map, CLSM)

Results: surface morphology ZK60



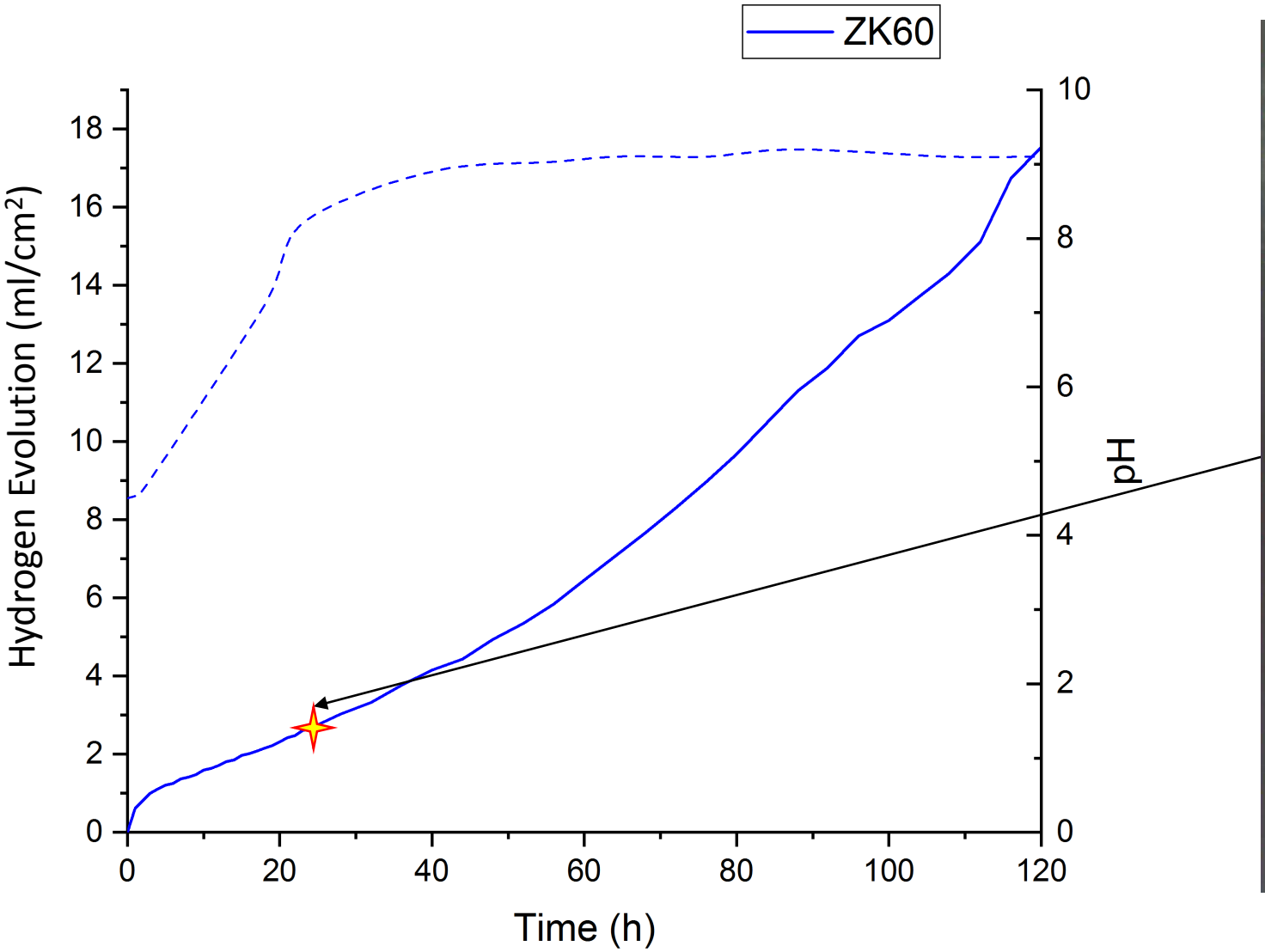
6 hours

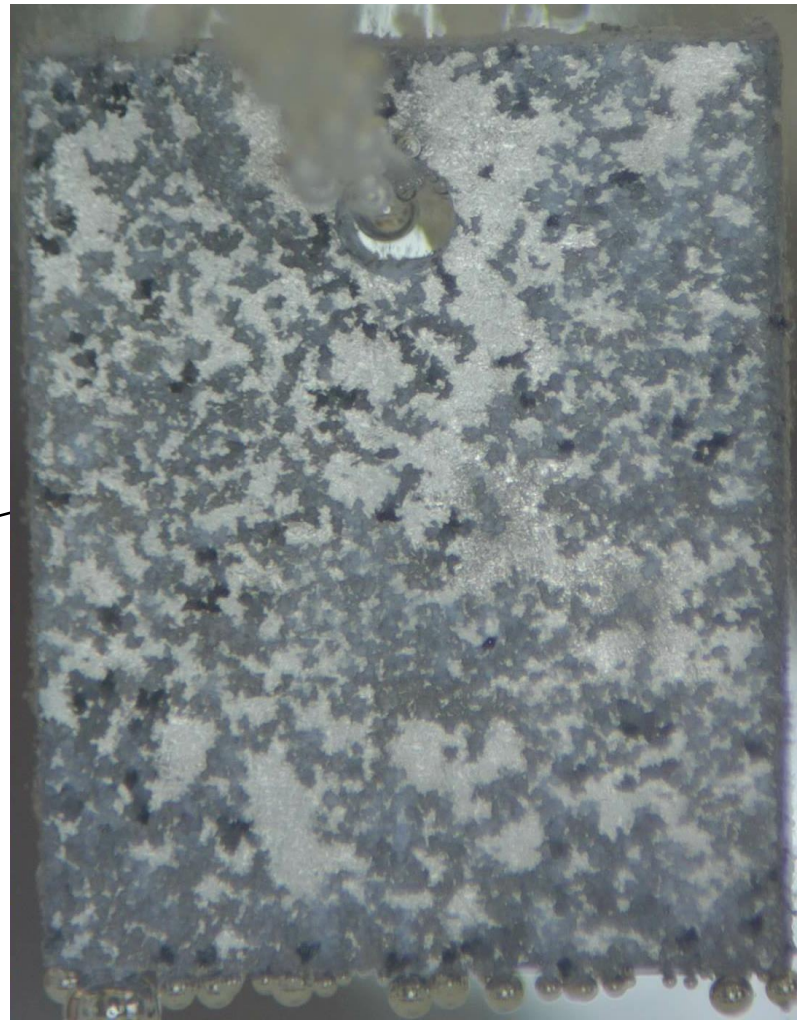
Results: surface morphology ZK60



12 hours

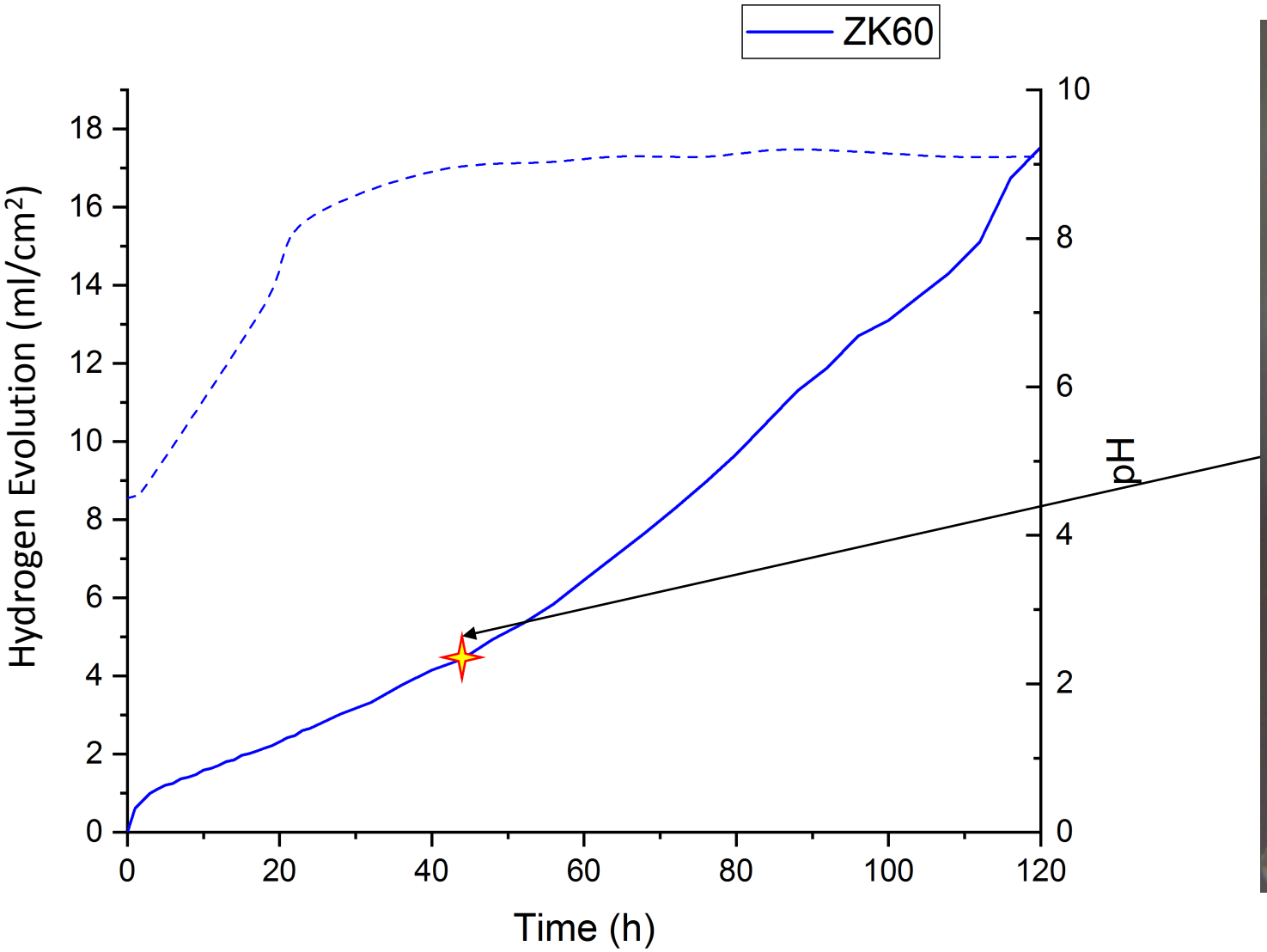
Results: surface morphology ZK60

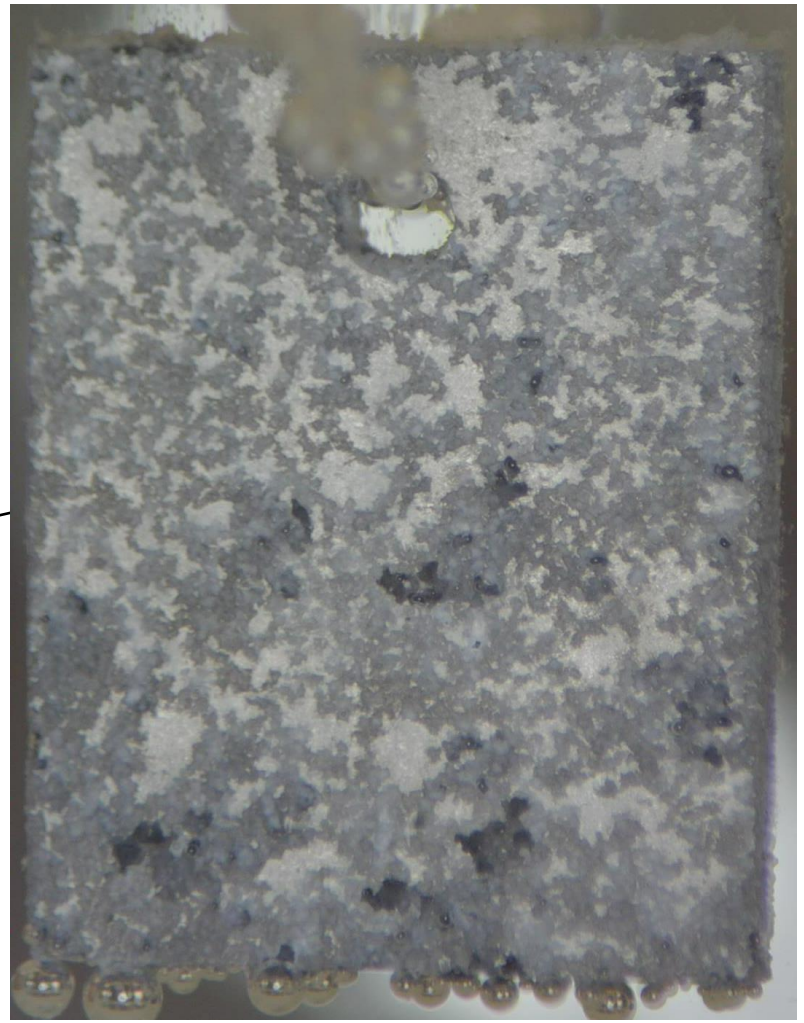




24 hours

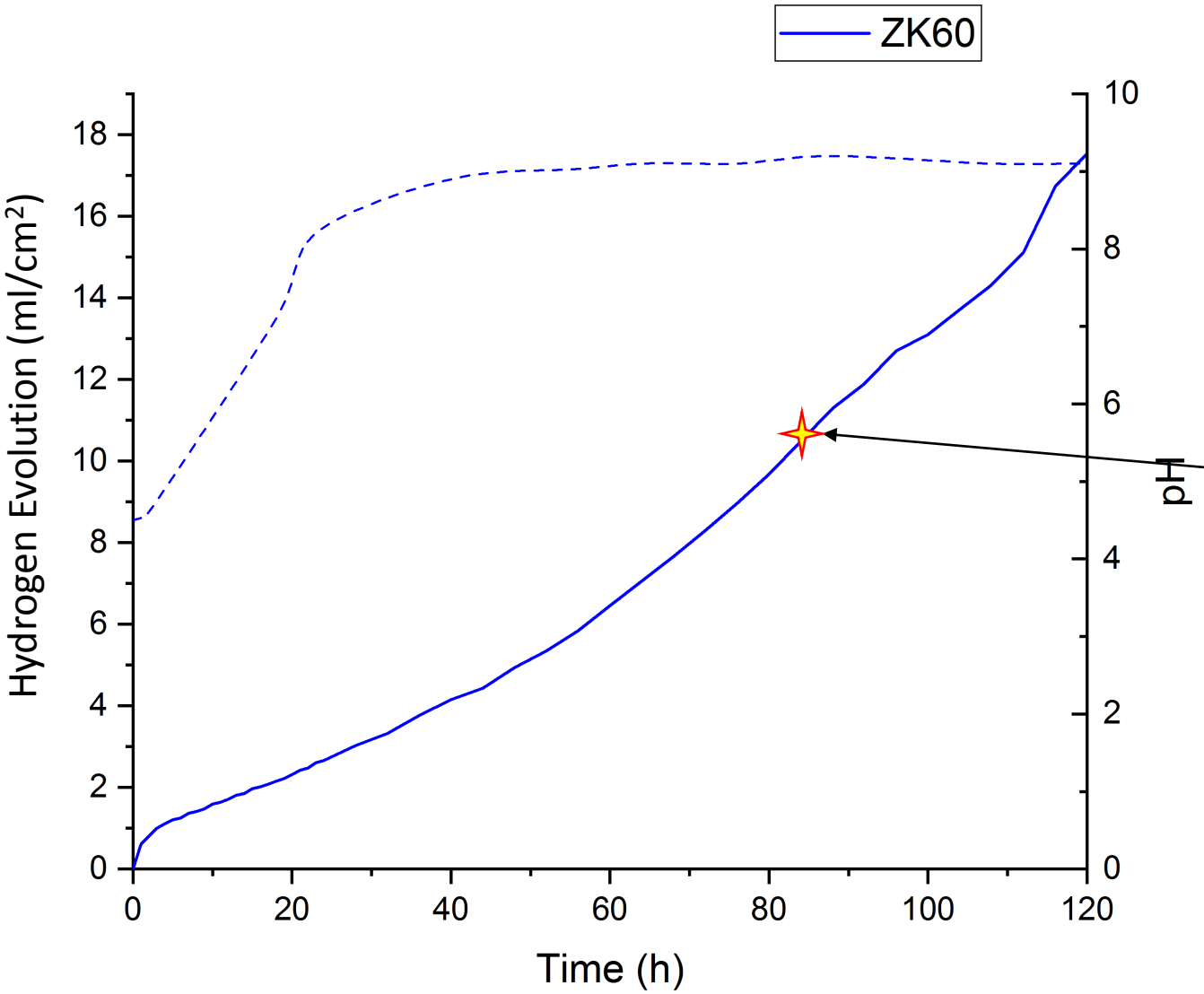
Results: surface morphology ZK60





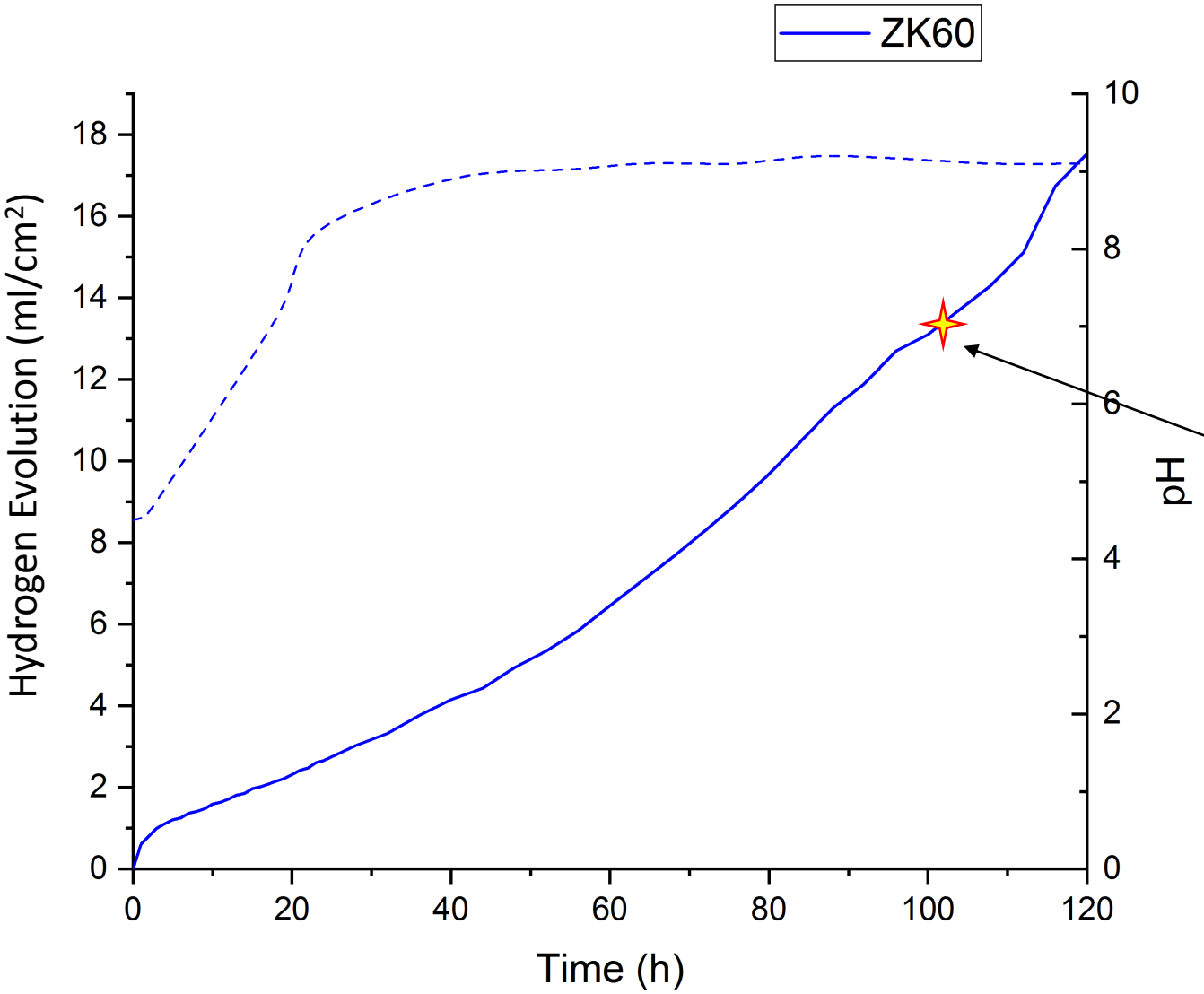
48 hours

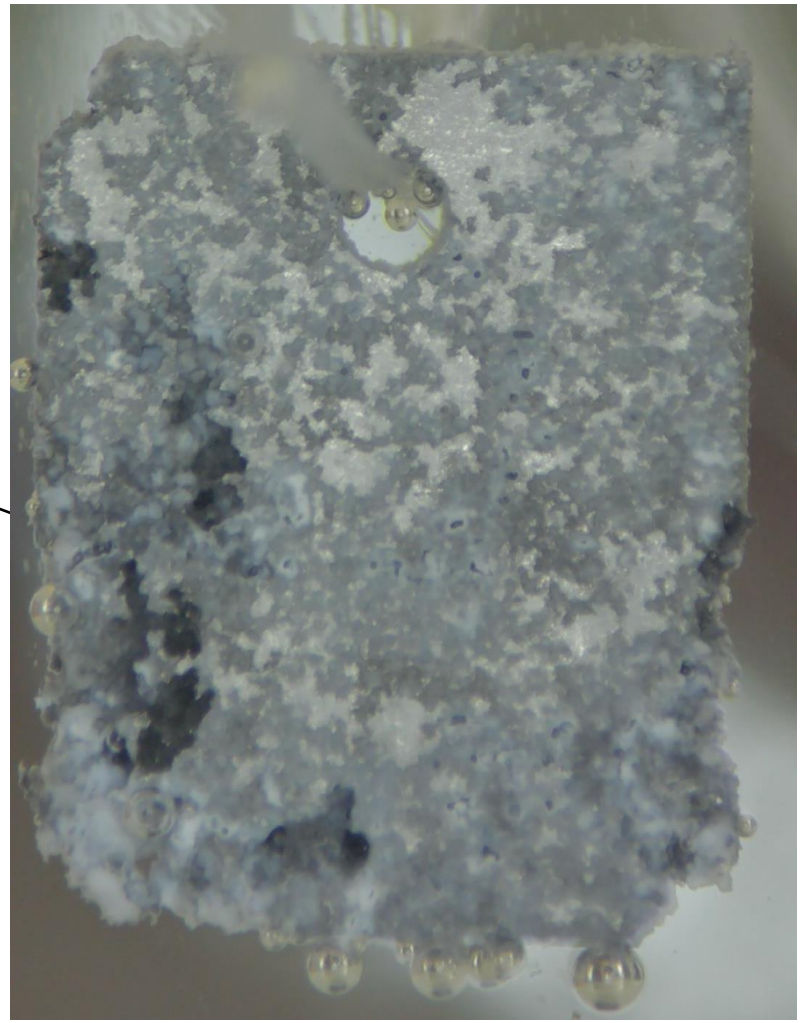
Results: surface morphology ZK60



84 hours

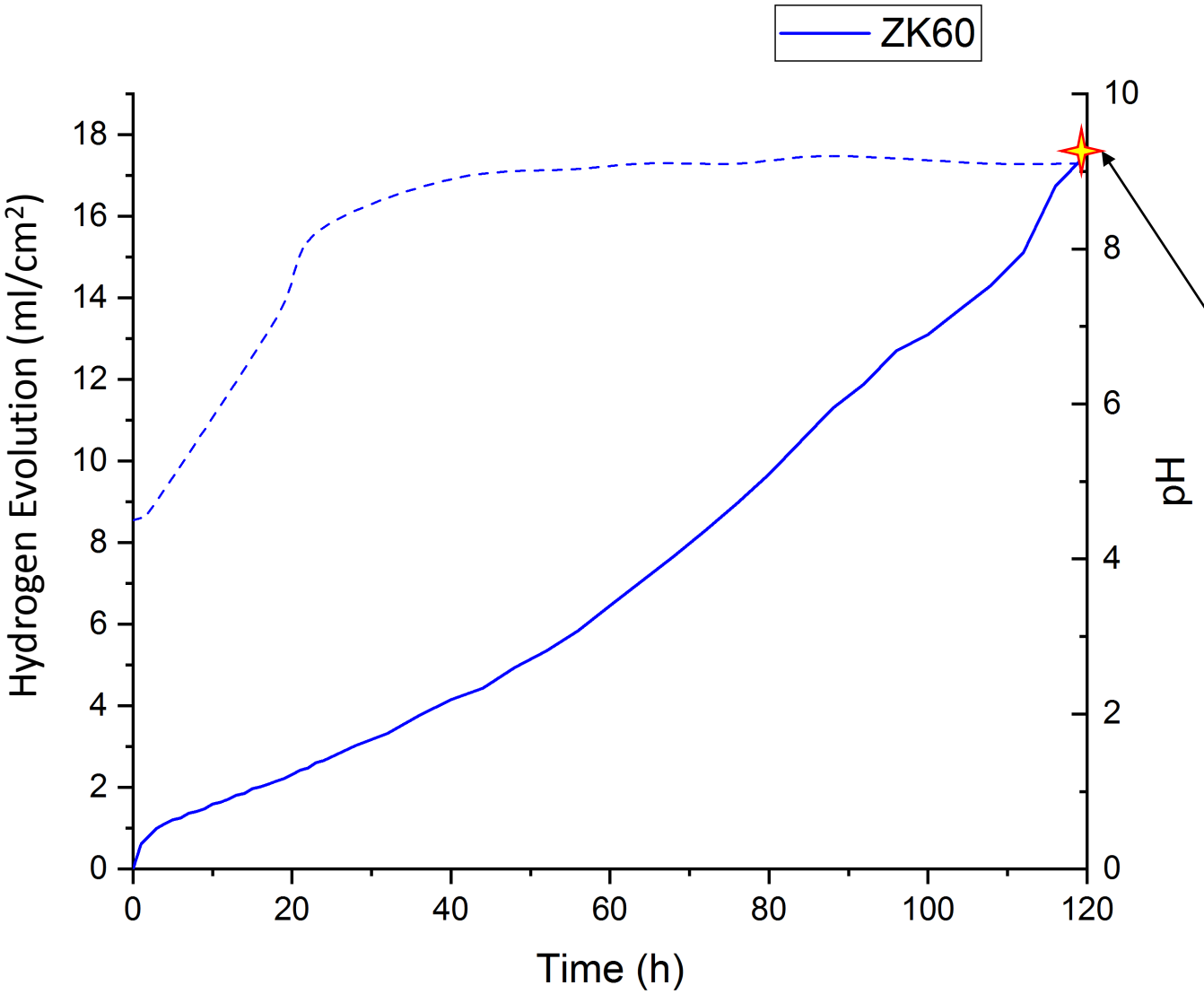
Results: surface morphology ZK60

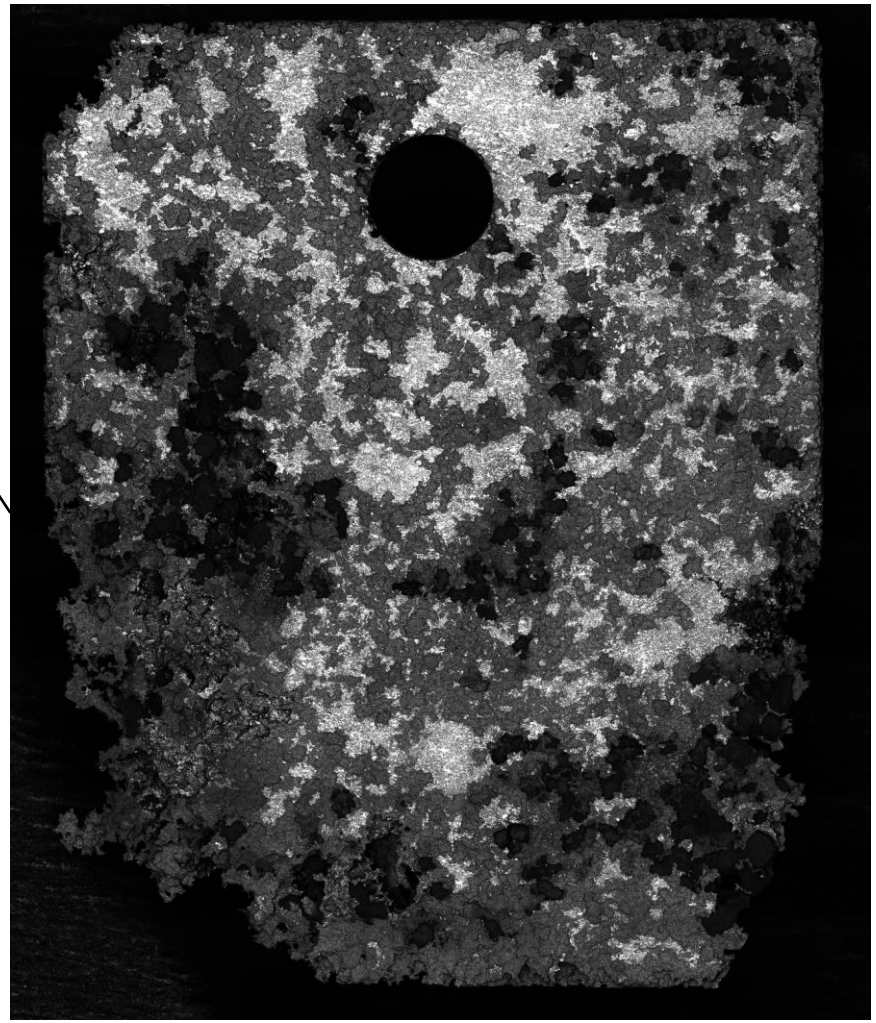




108 hours

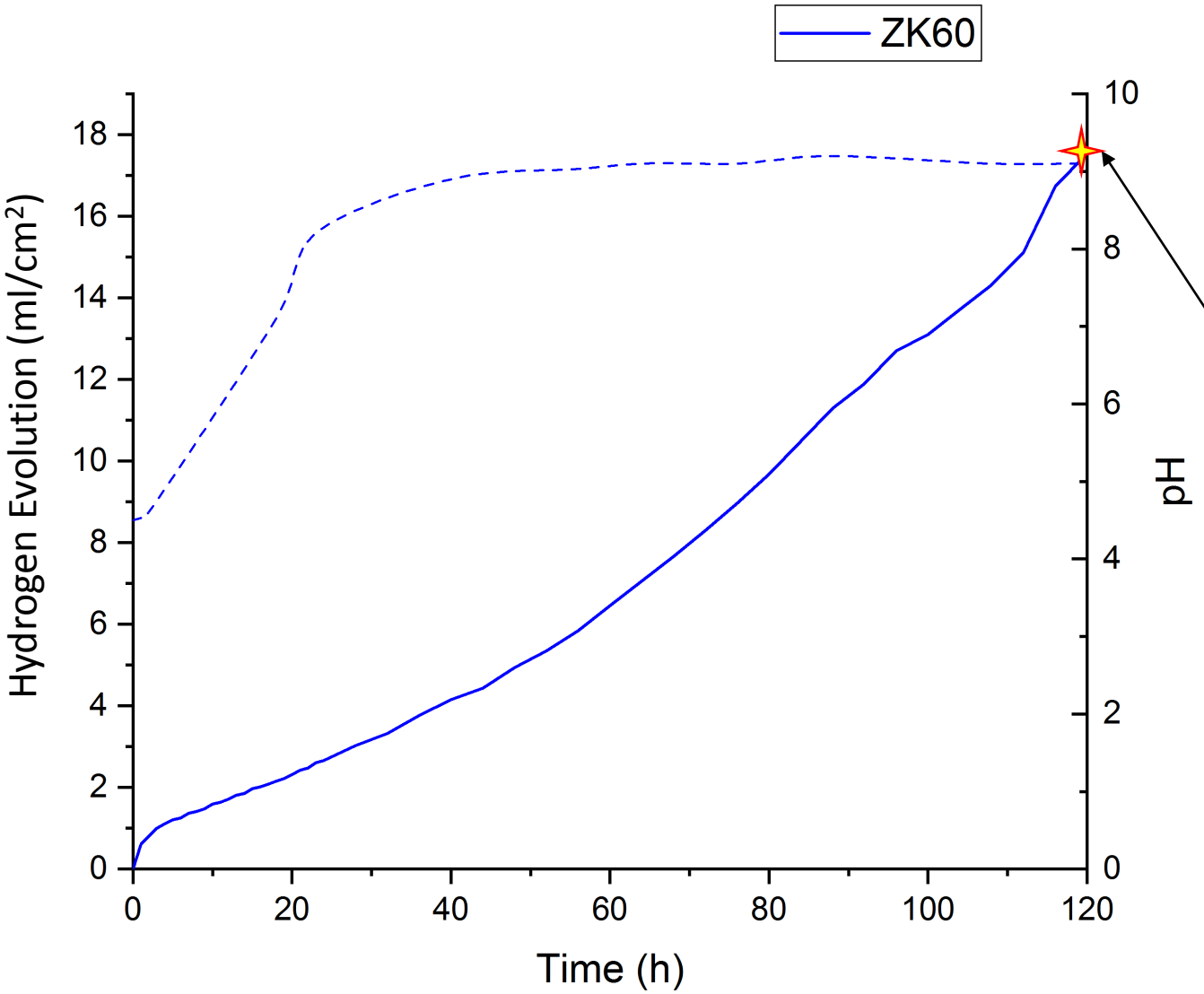
Results: surface morphology ZK60

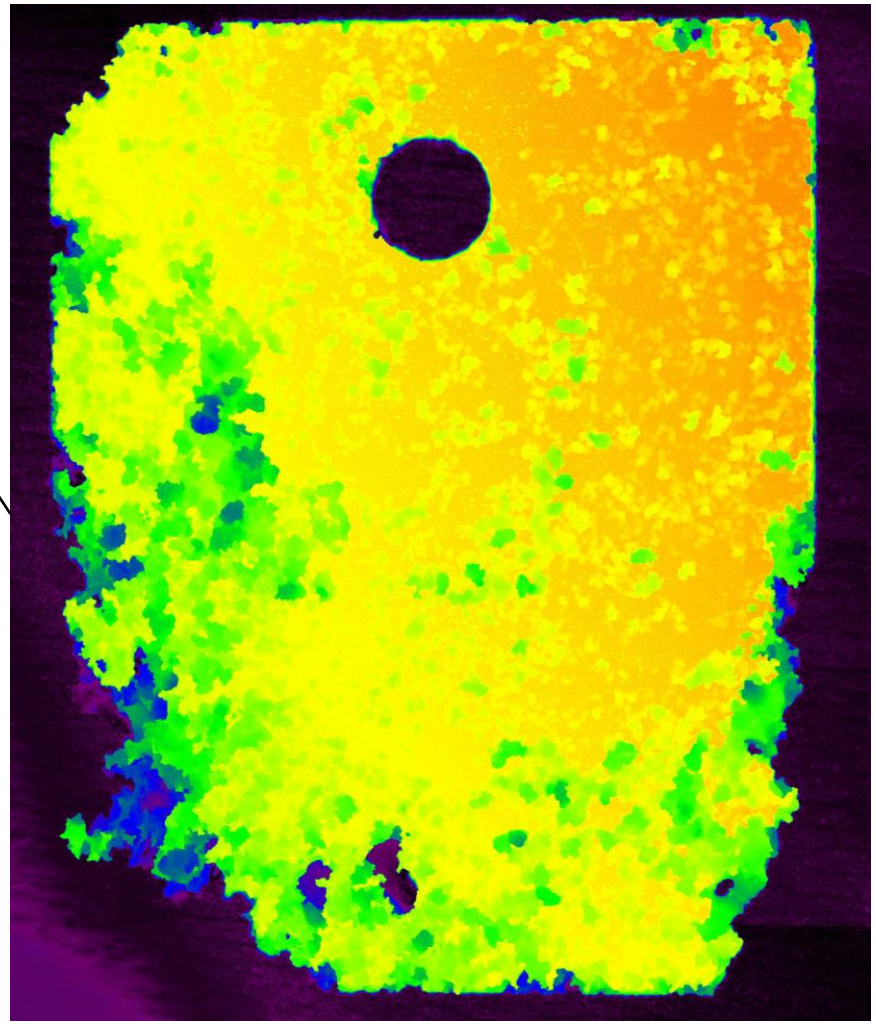




120 hours (without corrosion products)

Results: surface morphology ZK60





120 hours (height map, CLSM)

Summary

Corrosion rate

- Extruded ZK60 alloy possesses much less corrosion resistance in comparison with the hot-rolled AZ31 alloy.
- The corrosion rate of AZ31 alloy is nearly constant during the test, while ZK60 demonstrate increasing corrosion rate as is indicated by parabolic-like shape of hydrogen evolution curve.
- The corrosion rate of the both alloys is featured by the steep increase in the first 6 hours of immersion test. It is supposed to be due to formation of the magnesium hydroxide protection surface film.
- The discrepancy between the results of the hydrogen evolution and weight loss methods can arise due to fall off of the metal particles from the sample during corrosion process.

Surface morphology

- Extruded ZK60 alloy is prone to the severe pitting corrosion
- Metal particles fall off from the ZK60 sample during corrosion process
- Hot-rolled AZ31 exhibits increased susceptibility to the filiform corrosion
- In the both alloys, the samples' edges are damaged to the greater extent

Thanks for your attention!

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