

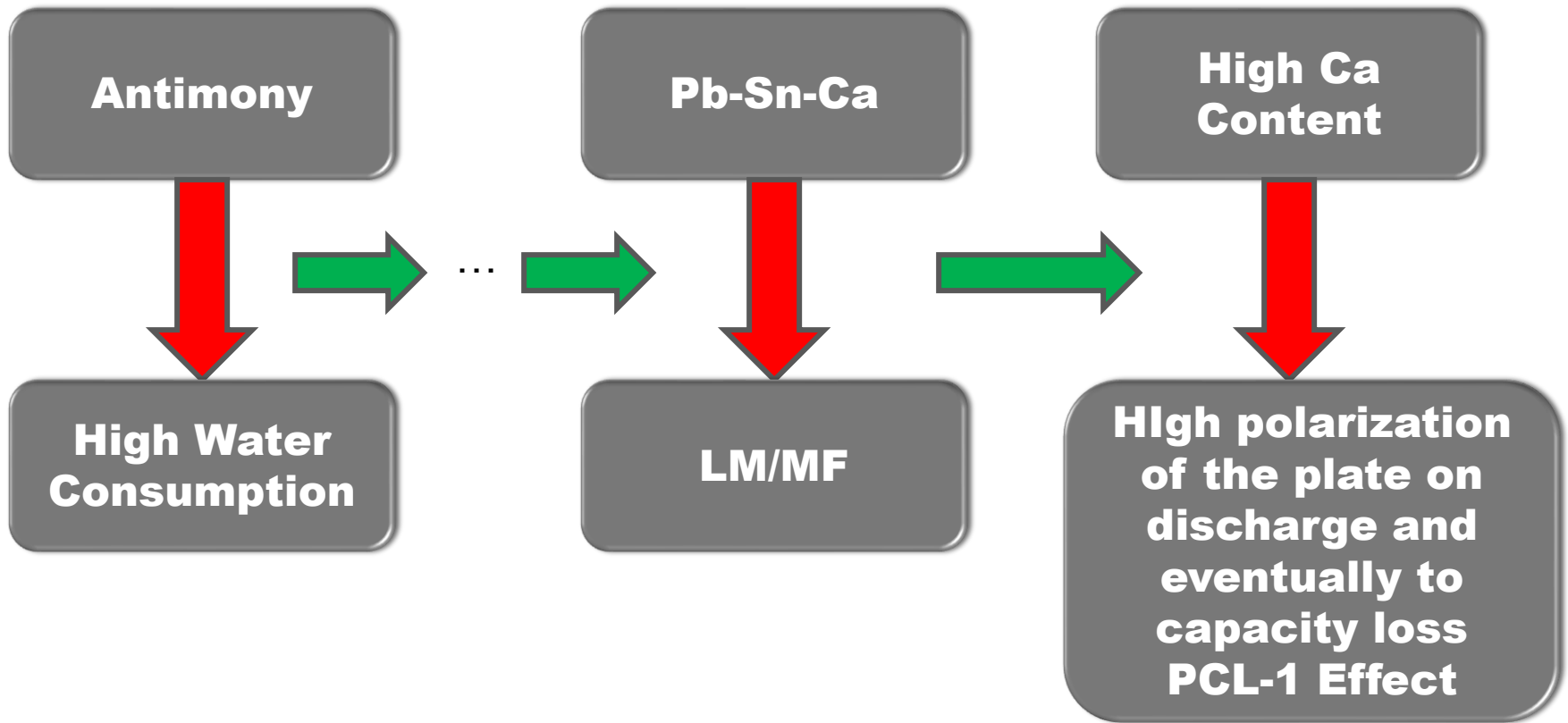


***Electrochemical Evaluation Of Pb-Ca-Sn-Sr Alloy
For Positive Grid Of SLI Lead Acid Battery***

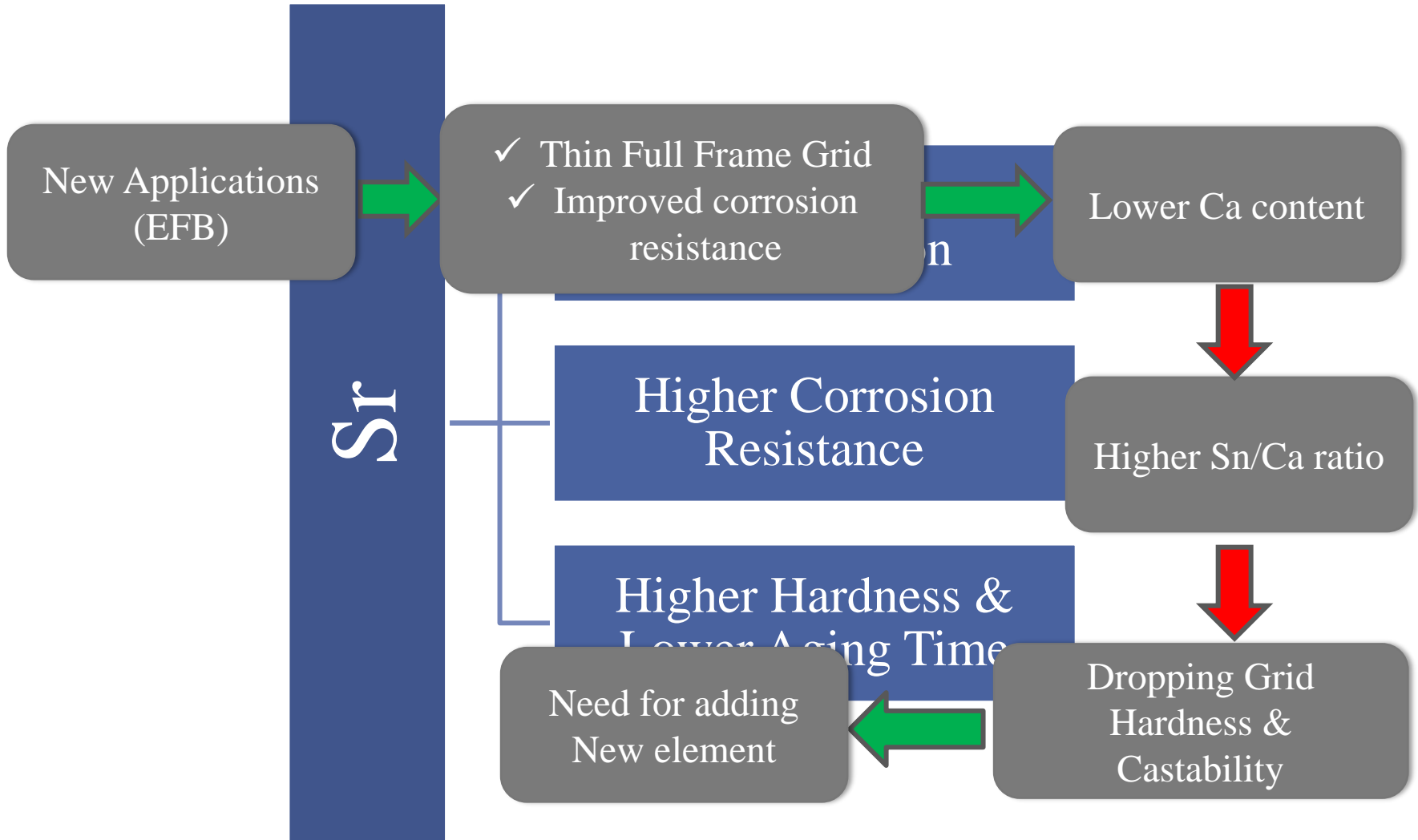
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A Brief History of Positive Grid Alloys



Introduction of New Element





Samples : In order to investigate mechanical and electrochemical behavior of Pb-Ca-Sn-Sr alloy Four different samples with constant ca content and various sr content were prepared and Sn and Al was so similar for all samples. . The samples were prepared from pure Pb (99.99%), pure Sn (99.99%) and the Al-Sr alloy by atmospheric casting.

NO	Composition (wt%)	
	Ca	Sr
Sample 1	0.04	0.012
Sample 2	0.04	0.020
Sample 3	0.04	0.040
Sample 4	0.04	0.060
Sample 5 (Ref)	0.09	---

It should be noted that the sample 5 is NGK conventional positive grid alloy and it was considered as reference sample .

Electrochemical properties including passive current density, PbO formation and oxygen evolution reaction were assessed using potentiostatic and cyclic voltammetry techniques. In addition, the hardness measurements were performed for various samples.

Potentiostatic tests

Constant Potential of
900 mV/SCE for 3600 s at
4.8M H₂SO₄ solution

Cyclic Voltammetry

samples polarized one cycle
from -2000 to 3000 mV/SCE
with the scan rate of 1500
mV/min

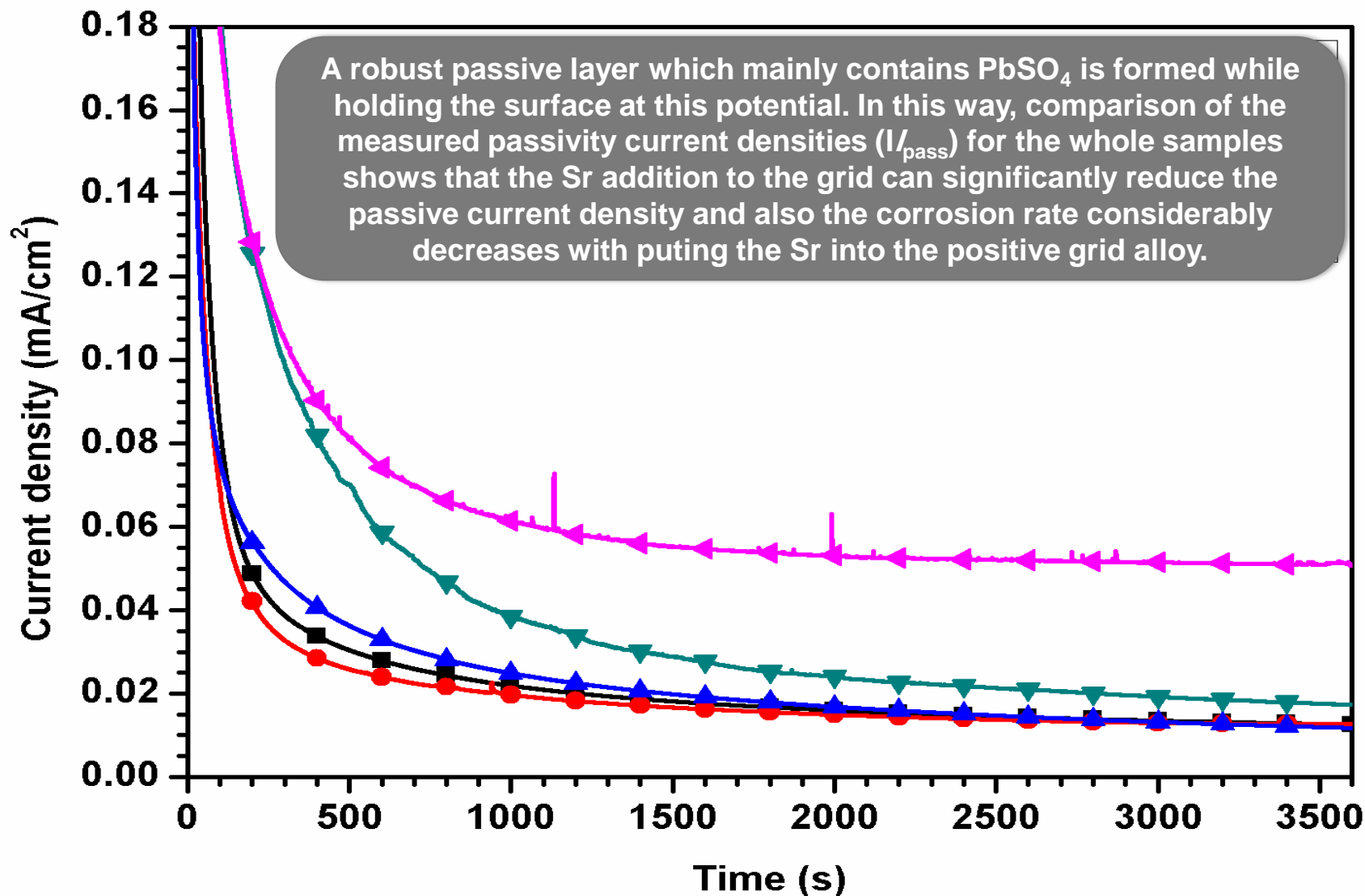
Cyclic Voltammetry

samples cyclically polarized
from 800 to 2800 mV/SCE with
scan rate of 1500 mV/min
for 50 times

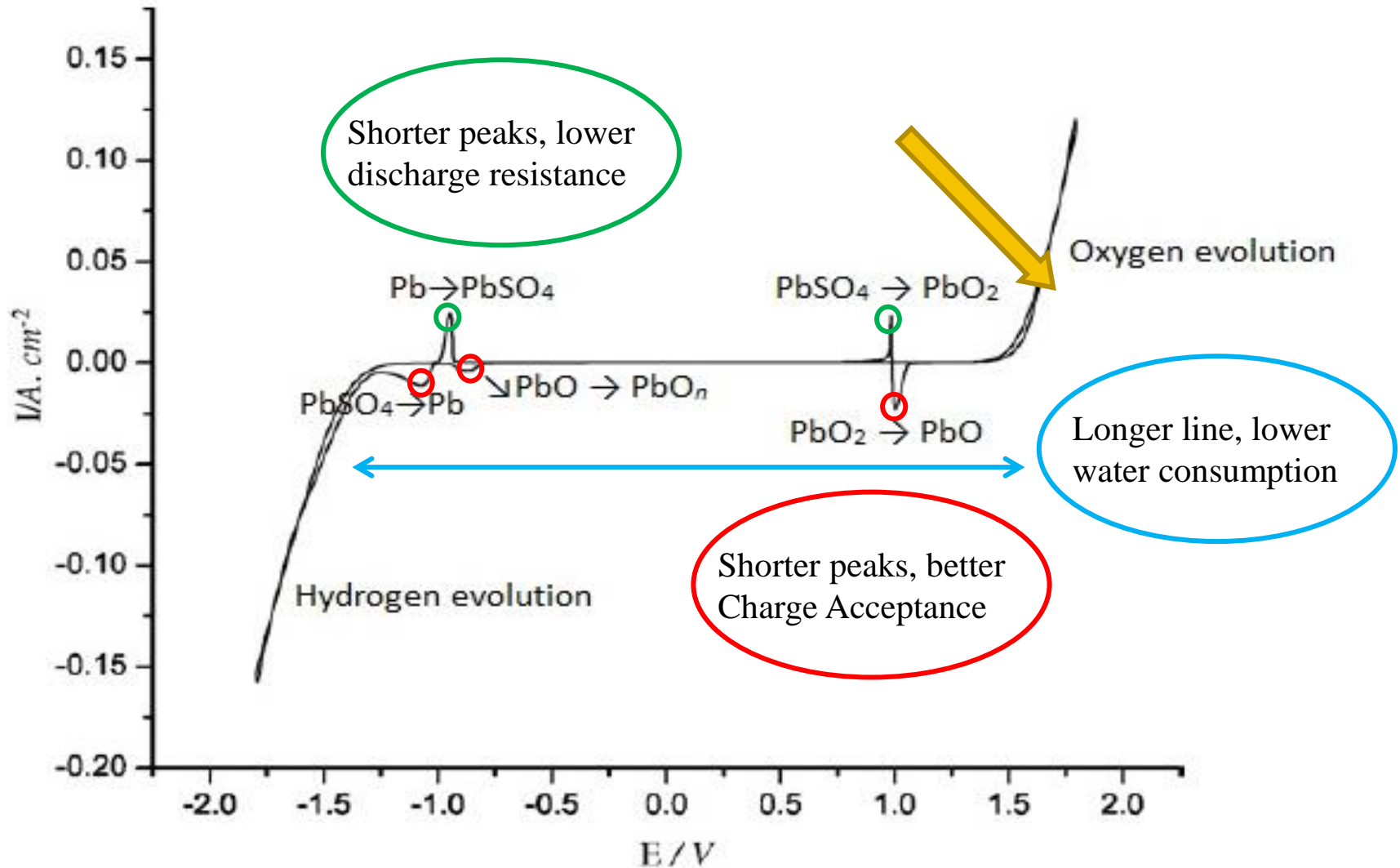
Hardness

Brinell Hardness (HB) after two-day
aging. The load of 1 kgf was applied
for 10 s with 1 mm diameter

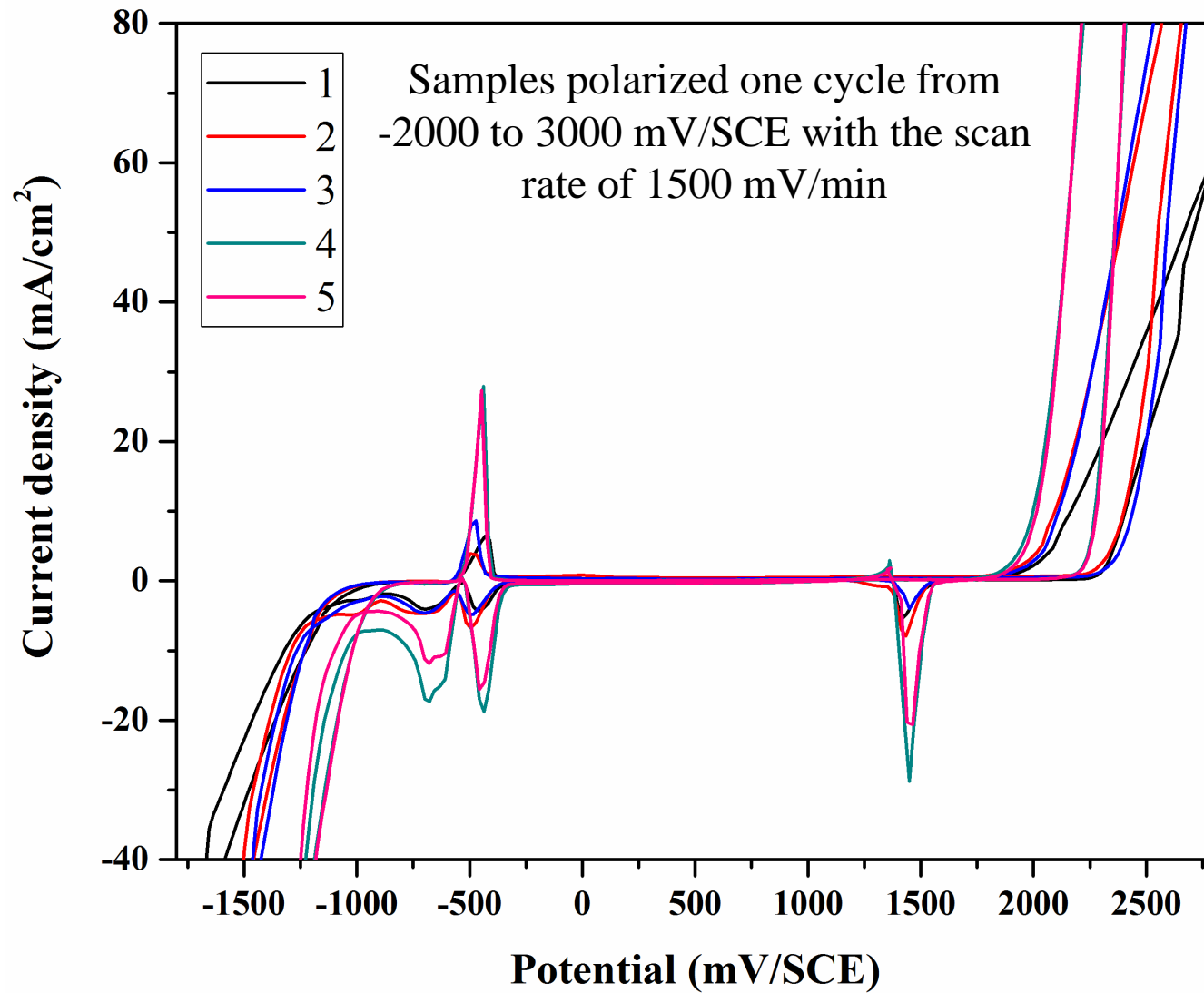
Potentiostatic tests : In order to access the effect of Sr addition to Pb-Ca-Sn grid alloy on corrosion resistance of the aged sample, the potentiostatic tests were run for different specimens after 10 days aging at room temperature.



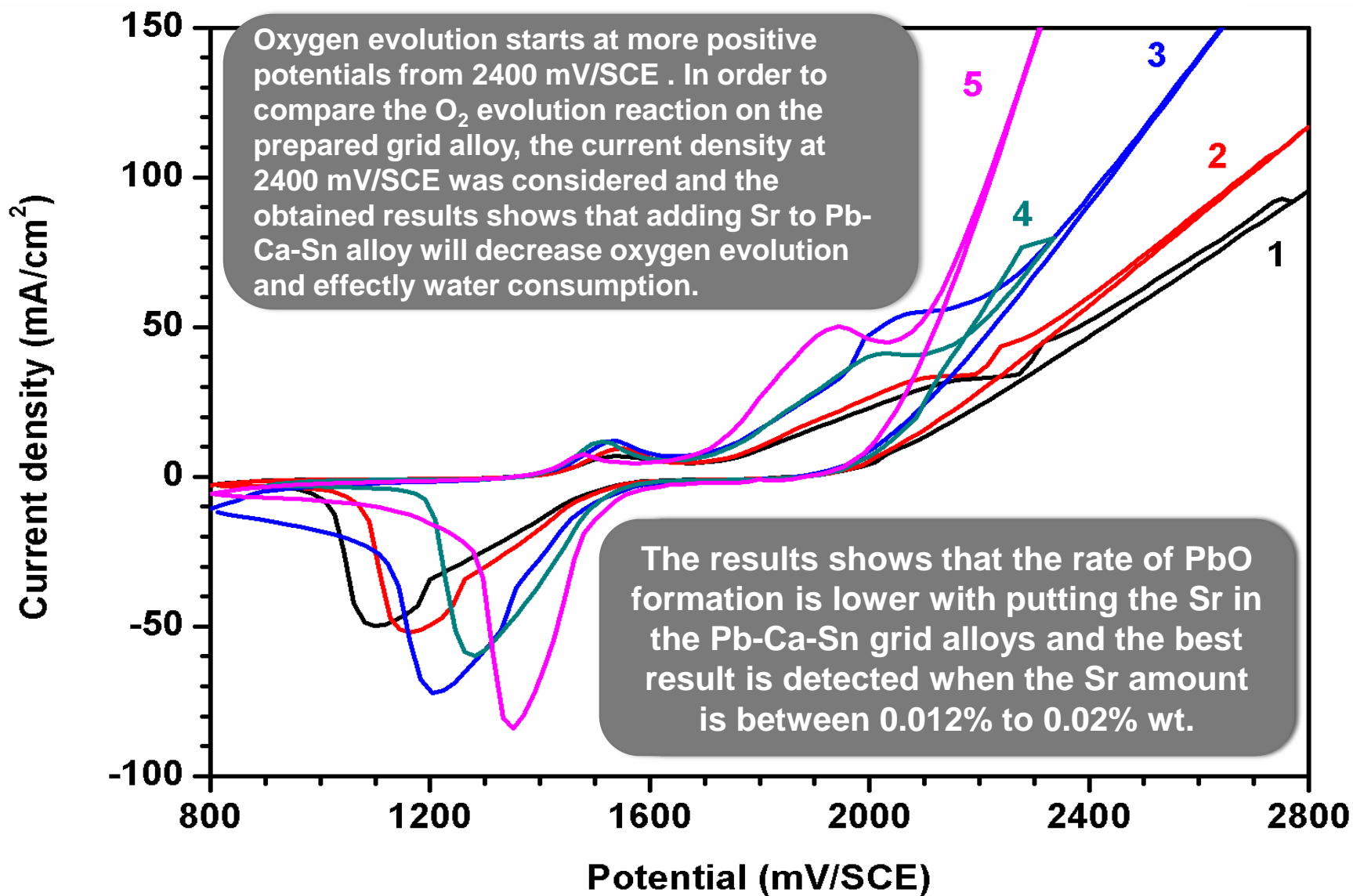
Cyclic Voltammetry Test : In order to access the effect of Sr addition to Pb-Ca-Sn grid alloy on PbO formation and oxygen evolution reaction of the aged sample, the cyclic voltammetry tests were run for different specimens after 10 days aging at room temperature.



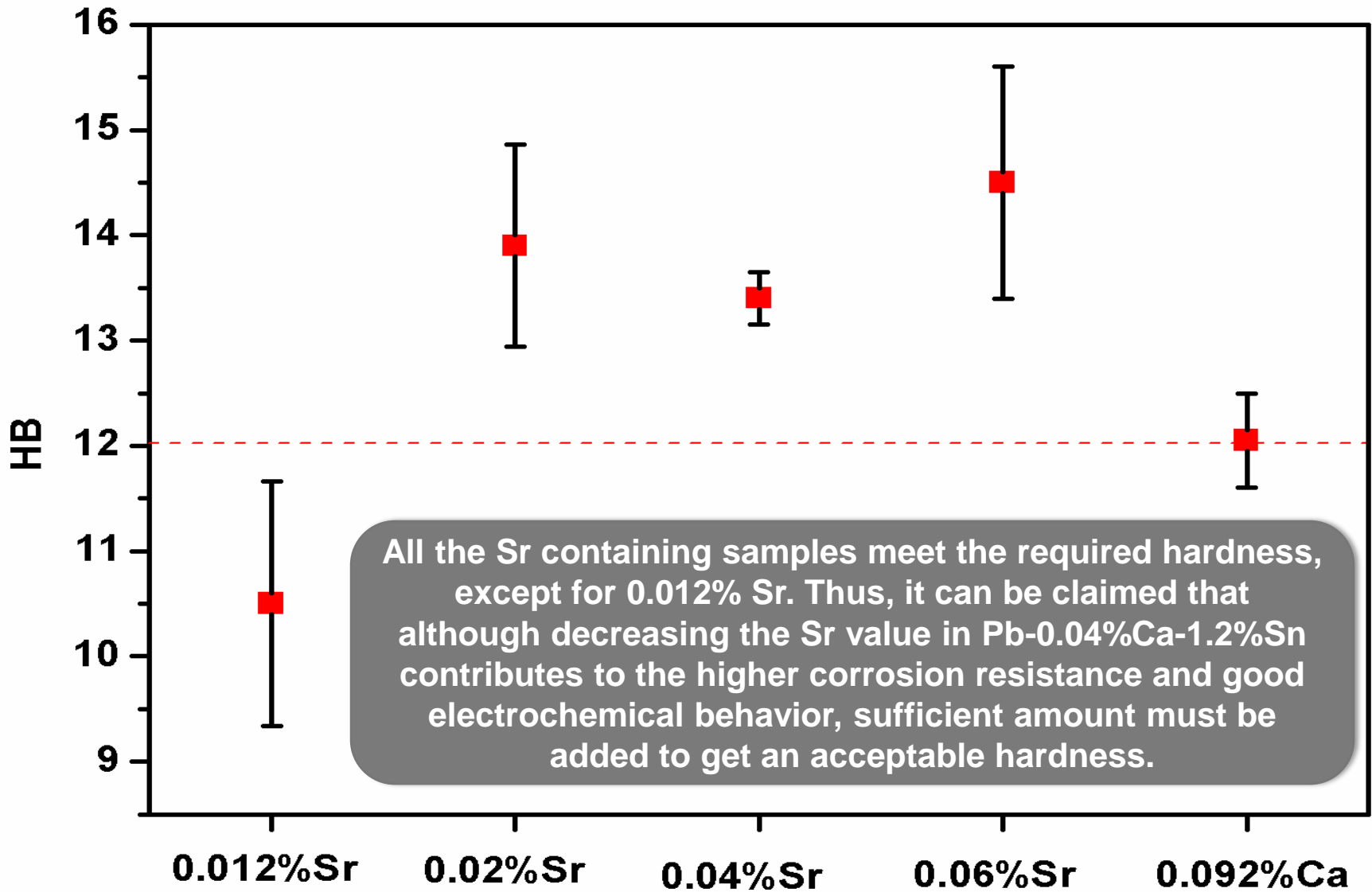
Cyclic Voltammetry (1st Cycle)



Cyclic Voltammetry (50th Cycle – Positive Electrode)

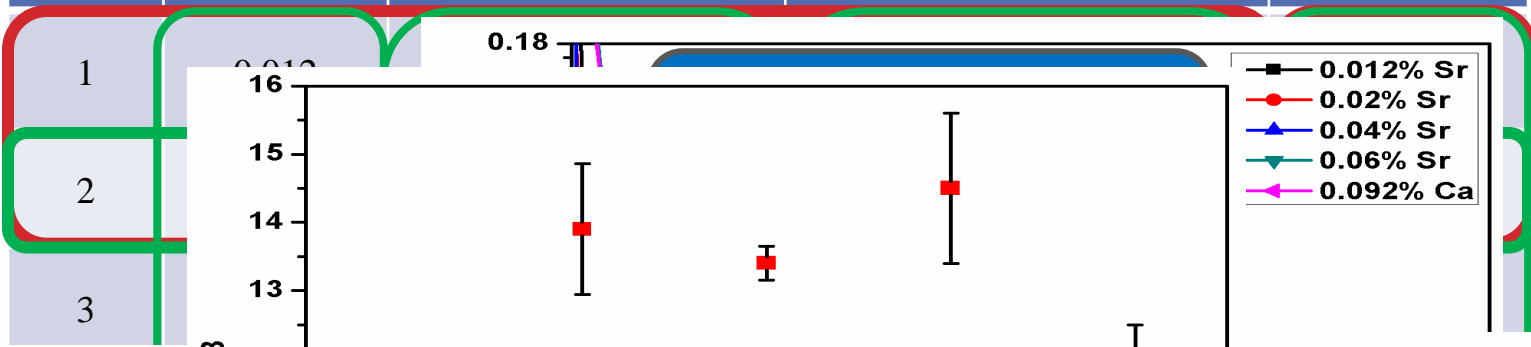


Hardness

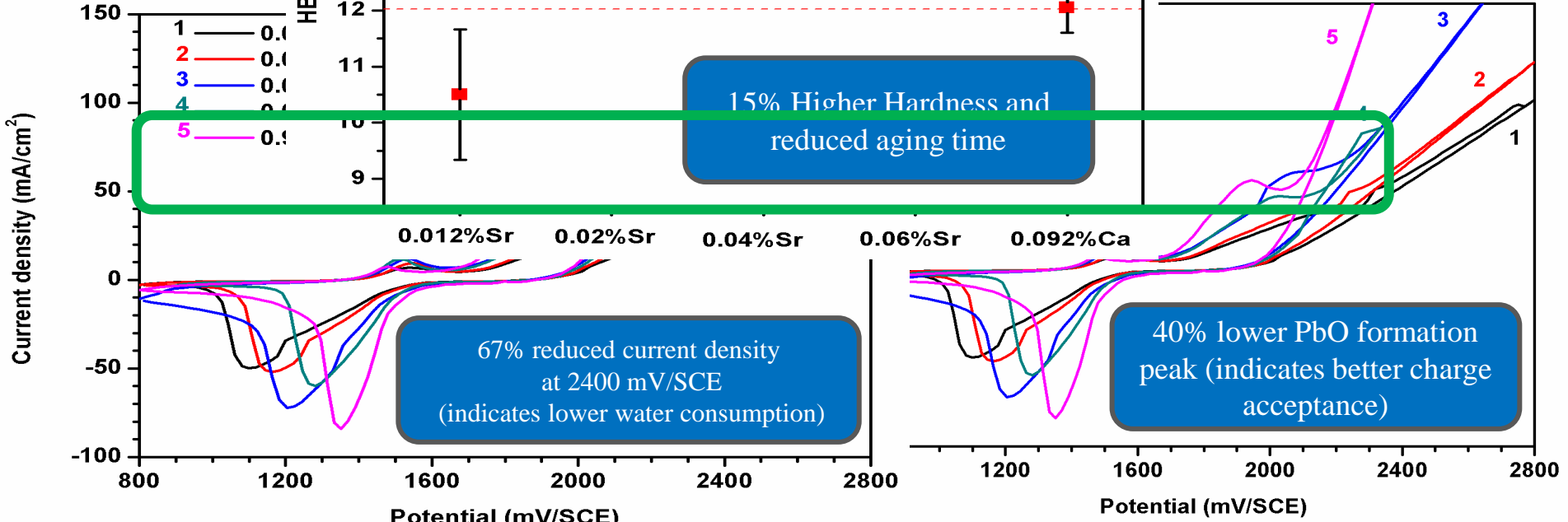


Summary of the Results

NO	I_{Pass} (mA/cm ²)	PbO formation pick (mA/cm ²)	Current at 2400 mV/SCE (mA/cm ²)	Hardness (HB)
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15% Higher Hardness and reduced aging time

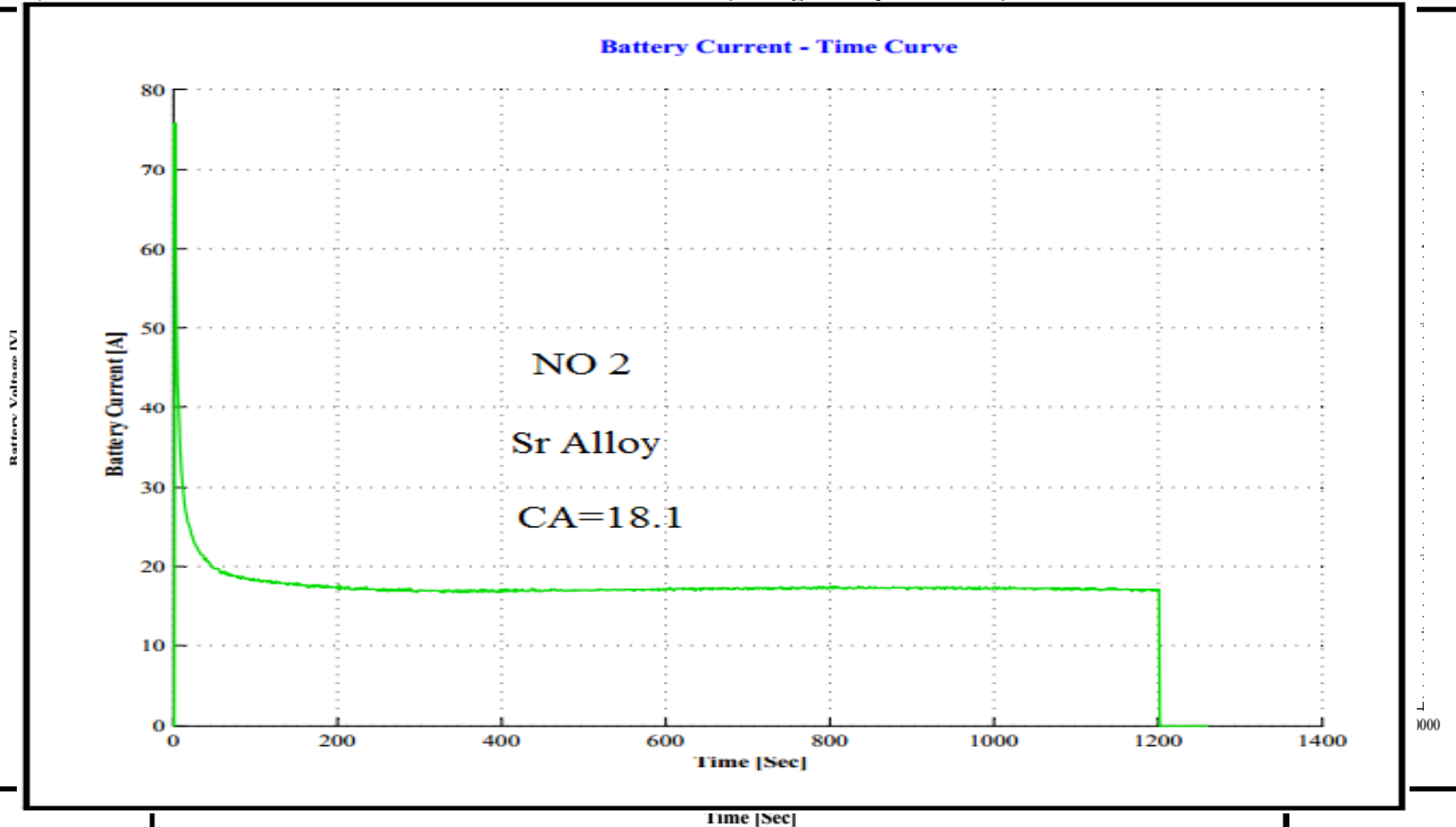


67% reduced current density at 2400 mV/SCE (indicates lower water consumption)

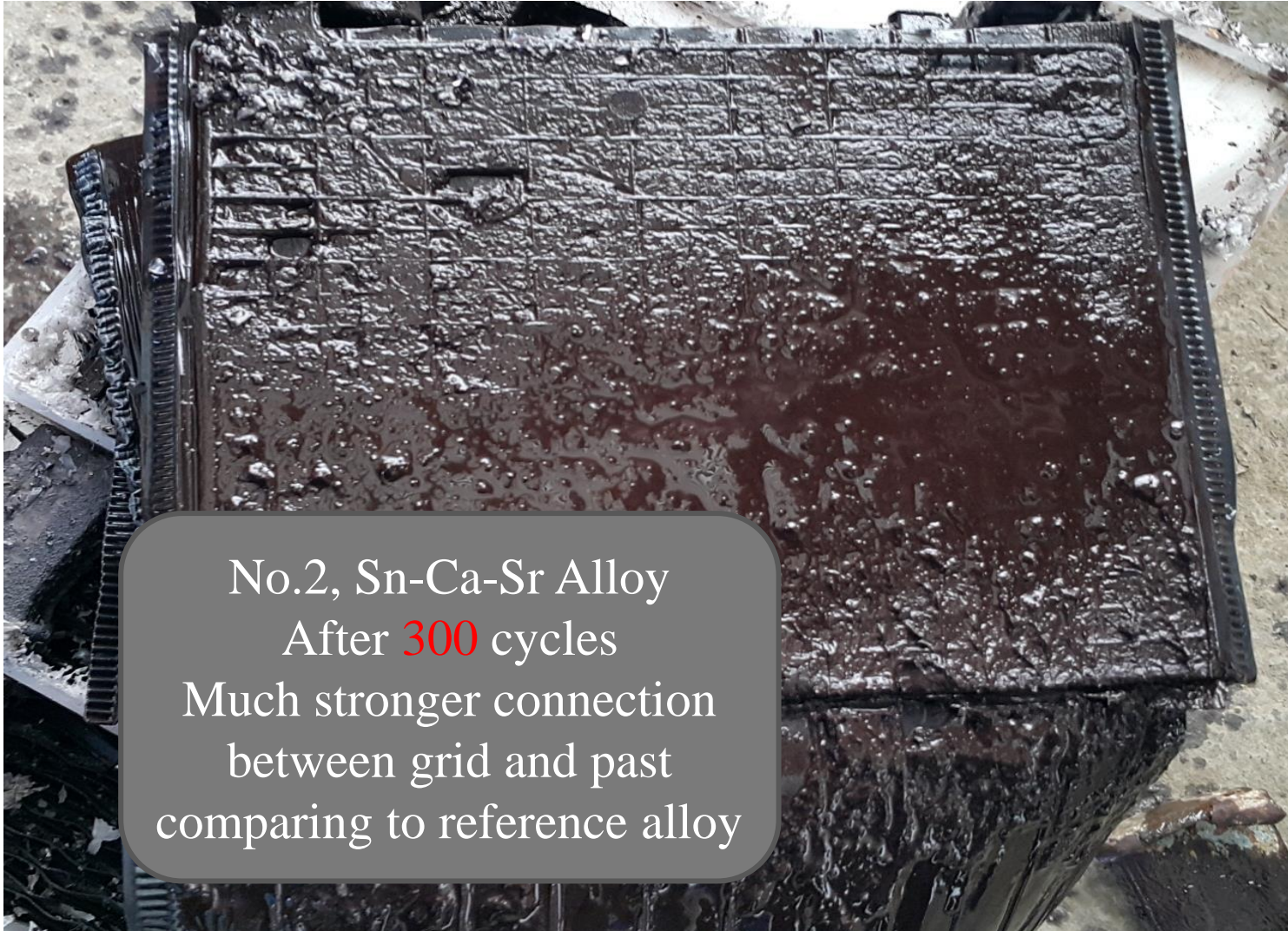
40% lower PbO formation peak (indicates better charge acceptance)

Battery Test Results According to B255210 –D Standard

Current vs Time Curve (Charge Acceptance Test)



Breakdown Pictures



No.2, Sn-Ca-Sr Alloy
After **300** cycles
Much stronger connection
between grid and paste
comparing to reference alloy



2nd Sample VS Reference Sample

✓ Electrochemical Tests Summary:

- ✓ more than four times lower passive current density
- ✓ 40% lower PbO formation peak
- ✓ 67% reduced current density at 2400 mV/SCE
- ✓ 15% Higher Hardness
- ✓ More than two times increased corrosion resistance

Battery Tests Summary:

- ✓ Equal Battery Capacities
- ✓ 6% improved cold cranking ability
- ✓ 37% increased charge acceptance
- ✓ 44% improved cycle life
- ✓ 45% lower capacity loss after cycle life test



Thank You

Any Questions?

