# Corrosion Study of Current Collectors for Magnesium Batteries

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## Introduction

Magnesium (Mg) is an abundant and safer raw material than lithium for electrochemical energy storage systems such as batteries, due to its reduced sensitivity to air. For an improved electrochemical reaction kinetic and reduction of overpotentials in the anode, chlorine has a crucial role in the electrolyte. Chlorine also reduces the activation energy of interfacial charge transfer in intercalation cathodes such as the Chevrel phase $Mo_6S_8$. However chlorine containing electrolytes cause severe corrosion of the current collector. This study utilizes linear sweep voltammetry (LSV), chronoamperometry (CA), and electrochemical impedance spectroscopy (EIS) to identify suitable materials for current collectors which withstand a polarization potential of 2 V vs. $Mg/Mg^{2+}$ in the APC electrolyte. In addition tests in a Magnesium perchlorate based electrolyte were carried out.

## Methodology

### Materials

- Metal foils 15-100 µm
- Graphitic foil (Gr)
- Gold covered aluminium foil (Au-Al)
- Gold covered graphite foil (Au-Gr)
- Carbon coated Aluminium foils (C-Al: AlGA, AlH, AlHC)
- Carbon coated Ni (CNi)

### Cell Setup

- EL-CELL® 3 electrodes setup
- WE: 18 mm diameter
- Measurements in different electrolytes

**APC 0.25M $AlCl_3$ 0.5M PhMgCl in THF**
- CE: Mg foil 100 µm
- RE: Mg foil 100 µm

LSV
- 100 µl Electrolyte
- 1 layer of Whatman GF/C

CA
- 200 µl Electrolyte
- 2 layers of Whatman GF/C

**Perchlorate 0.25M $MgClO_4$ in ACN**
- CE: ACC Kynol ®
- RE: Ag foil 100 µm

LSV + CA
- 180 µl Electrolyte
- 1 layer of Whatman GF/C

### Linear-Sweep-Voltammetry (LSV)

- Scan Rate: 1 mV/s
- Start Point: OCV
- End Point: current limited to 500 µA/cm²
- LSV onset potential: current density exceeds 10 µA/cm²

### Chronoamperometry (CA)

**APC 0.25M $AlCl_3$ 0.5M PhMgCl in THF**
- Polarization potential: 2 V
- Time: 100 h

**Perchlorate 0.25M $MgClO_4$ in ACN**
- Plarisation at different potentials
- Starting OCV
- Increment by 50 mV
- Termination: 500 µA/cm2
- Time: 1000 s

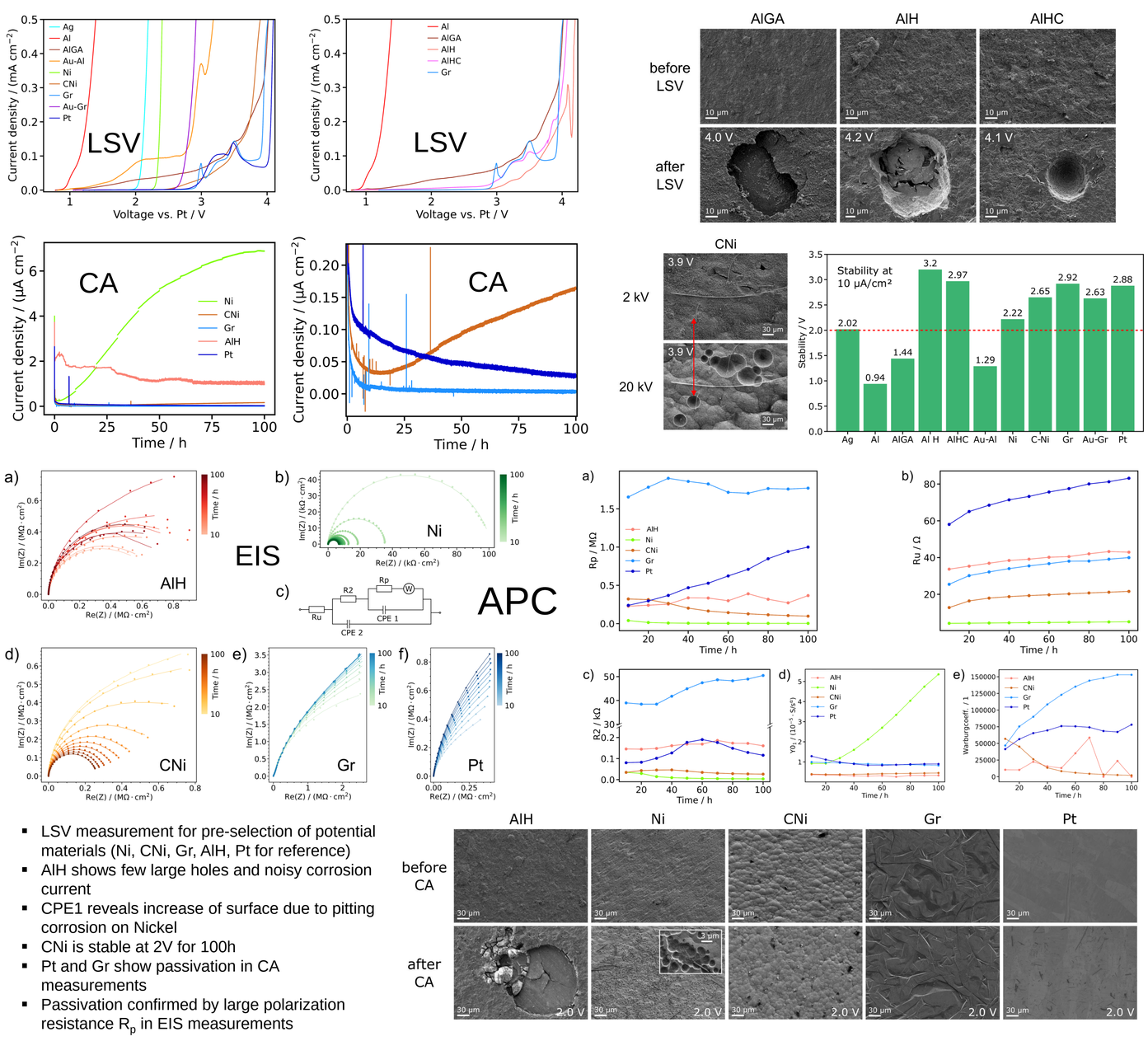
### Electrochemical Impedance Spectroscopy (EIS)

- 20 mHz – 300 kHz
- AC: 5 mV
- EIS during CA measurement every 10 h
- Potentiostatic EIS @ 2 V
- Interpretation with equivalent circuit modes (ECM)

### Post mortem characterization/morphology

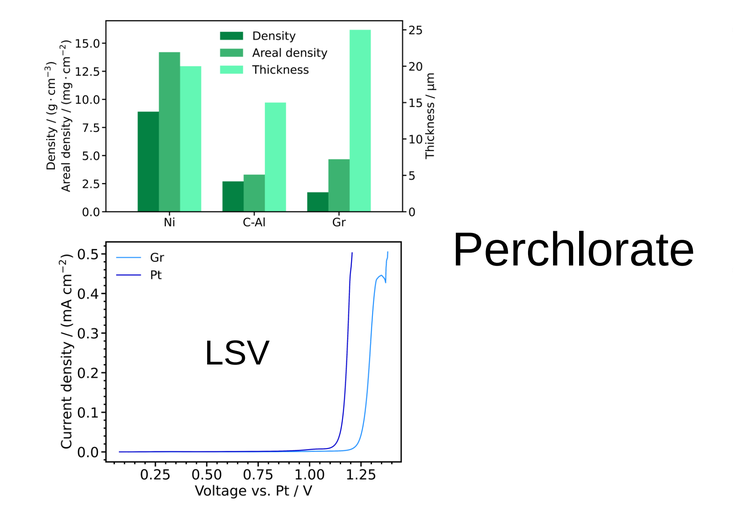
- scanning electron microscopy (SEM)

## Experimental results

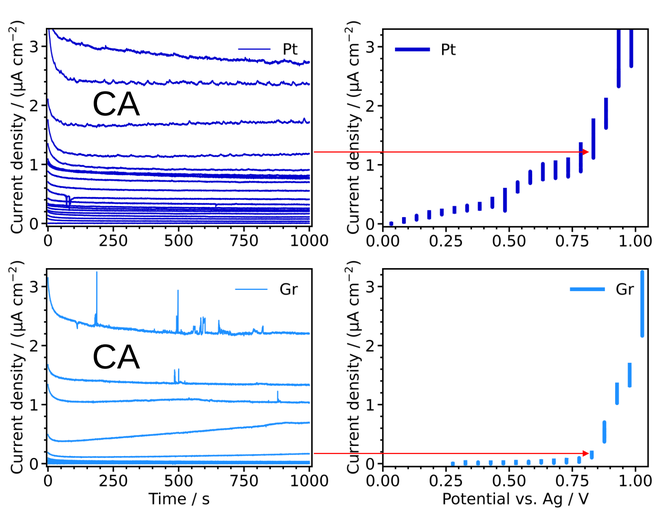



- LSV measurement for pre-selection of potential materials (Ni, CNi, Gr, AlH, Pt for reference)
- AlH shows few large holes and noisy corrosion current
- CPE1 reveals increase of surface due to pitting corrosion on Nickel
- CNi is stable at 2V for 100h
- Pt and Gr show passivation in CA measurements
- Passivation confirmed by large polarization resistance $R_p$ in EIS measurements




## Perchlorate




## Conclusion

- LSV, CA and EIS were used to study the corrosion behavior of current collectos for Mg batteries
- Graphitic current collector shows a large LSV onset potential of 2.9 V in APC and a large polarization resistance comparable to platinum
- Gr shows a passivating behaviour during CA experiment with a corrosion current of only 3 nA/cm² after 100 h and is confirmed by EIS and SEM measurements
- Gr and Pt show passivation in perchlorate electrolyte up to 0.78 V vs. Ag
- Due to its low areal density it is well suited for high energy Magnesium batteries

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**This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 824066**