Forensic Analysis of Water Damaged Mobile Devices

By

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Forensic Analysis of Water Damaged Mobile Devices

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Data Recovery from Damaged Devices

- Physical damage
- Fire damage
- Water damage

Data recovery is possible through *chip transplant* as long as the key components are undamaged
How We Receive Water Damaged Devices (In reality)

- Transported in liquid or in a dried state
  (after being left at a police station for a few days ...)
- Disassembling
- PCB cleaning
- Drying

What are those white contaminants?
Chip transplants really necessary?
Brief Summary of the Paper

• **Our Goal:**
  • Understand the board level reaction when a mobile device contacts with liquid
  • Update the forensic handling method for water damaged devices to improve successful data recovery

• **Our findings:**
  • *Metal corrosion* is the key about water damaged devices
  • Longer submersion time leads to more severe corrosion
Talk Outline

• Metal corrosion under humid environment
  • Electrochemical migration (ECM)
  • Galvanic corrosion

• Testing water damage to smartphones
  • Observing system failure of water-submerged smartphones
  • Repairing water damaged smartphones

• Conclusion
Smartphone Main Board
Metal Corrosion by Electrochemical Migration

**Anodic reaction**

- Metal ionization
  \[ Cu \rightarrow Cu^{2+} + 2e^- \]

- Water
  \[ H_2O \rightarrow H^+ + OH^- \]

- Precipitation of Copper hydroxides
  \[ Cu^{2+} + 2OH^- \rightarrow Cu(OH)_2 \]

**Cathodic reaction**

- Copper deposition
  \[ Cu^{2+} + 2e^- \rightarrow Cu \]

- Hydrogen production
  \[ 2H^+ + 2e^- \rightarrow H_2 \]

**Inter-electrode reaction**

\[ Cu(OH)_2 \rightleftharpoons CuO + H_2O \rightleftharpoons Cu^{2+} + 2OH^- \]
Electrochemical Migration (ECM)

R: 330Ω

3.7V
Experiment (video - 2)
Before applying voltage ~7 minutes 8 minutes
Metal Corrosion by ECM

Open circuit

Short circuit
Galvanic Corrosion

Less noble metal
(i.e., Aluminum) Low potential

Al → Al^{3+} + 3e^-

Noble metal
(i.e., Copper) High potential

\[ \frac{1}{2}O_2 + H_2O + 2e^- \rightarrow 2OH^- \]
Galvanic Corrosion - Example
Talk Outline

- Metal corrosion under humid environment
  - Electrochemical migration (ECM)
  - Galvanic corrosion
- Testing water damage to smartphones
  - Observing system failure of water-submerged smartphones
  - Repairing water damaged smartphones
- Conclusion
Testing water damage on Smartphones

• Samsung Galaxy 6s Edge & LG Nexus 5X
  • Two each, one submerged while running, another while turned off
  • Battery fully charged
  • Left in tap water for three days
## Results

After being dried and PCB cleaned

<table>
<thead>
<tr>
<th></th>
<th>Samsung S6 edge</th>
<th>LG Nexus 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turned on</td>
<td>PMIC damaged, swap needed</td>
<td>Display connector corroded</td>
</tr>
<tr>
<td>Turned off</td>
<td>PMIC short circuited, no swap needed</td>
<td>No repair needed after cleaning</td>
</tr>
</tbody>
</table>
Results
LG display connector
~20V applied when display is working
LG Devices: Underfill protected

Samsung: no underfill

LG: Underfill protected
Metal Corrosion and Missing Components by Galvanic corrosion

Longer submersion time = severe corrosion = detachment of components
Conclusions

• Water damage = Metal corrosion (ECM/Galvanic) = System failure

• Corrosion severity factors
  • Liquid conductivity
  • Submersion time
  • Exposure of metal
  • State of the device
  • Voltage level

• Proper knowledge about water damage helps successful data retrieval
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