



Lithium-Ion Batteries

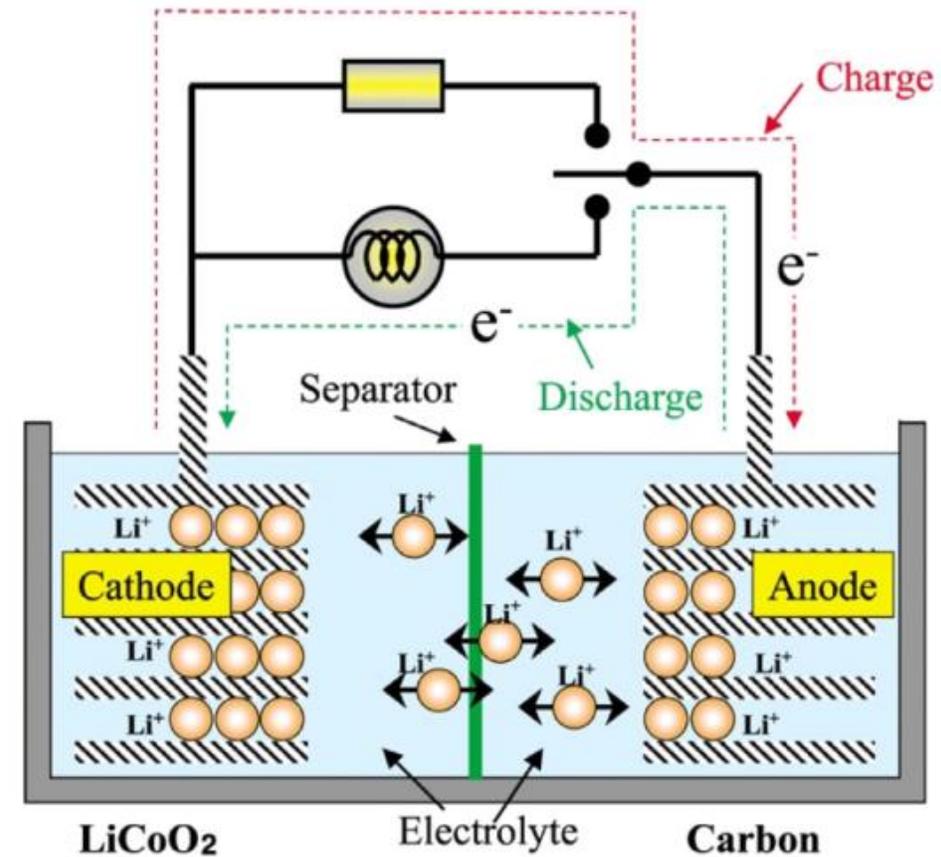


Usage

- Lithium-ion batteries (LIBs) are the dominant power source for several reasons:
 - High specific energy (Wh/kg)
 - High energy density (Wh/L)
- Shortcomings:
 - Narrow operational temperature range
 - Narrow charge/discharge rates
 - Can fail in an uncontrollable manner

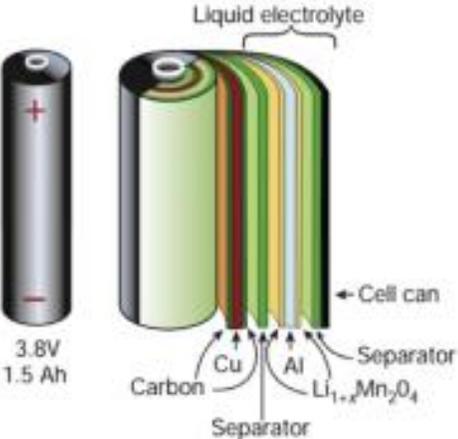
Primary Components

- The primary components of Lithium-ion Batteries are:
 - Anode (Negative Electrode)
 - Cathode (Positive Electrode)
 - Separator
 - Electrolyte
 - Current Collector

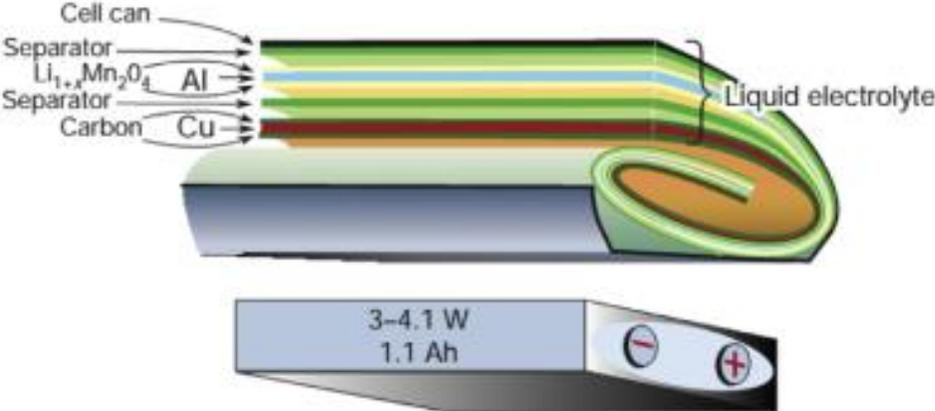


Internal Structure

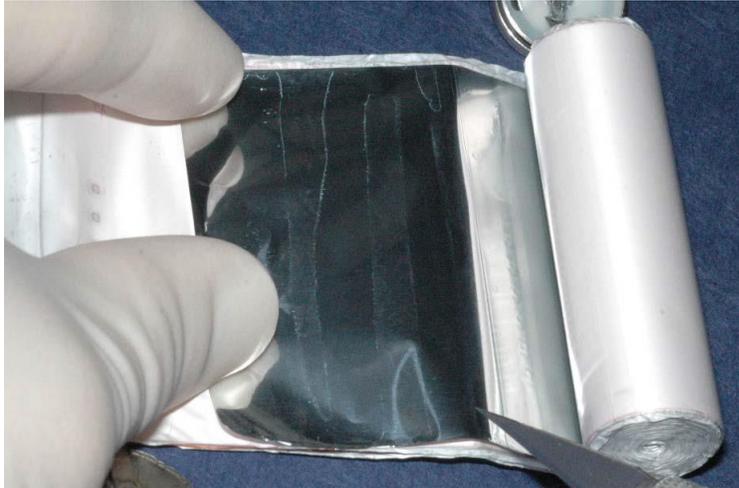
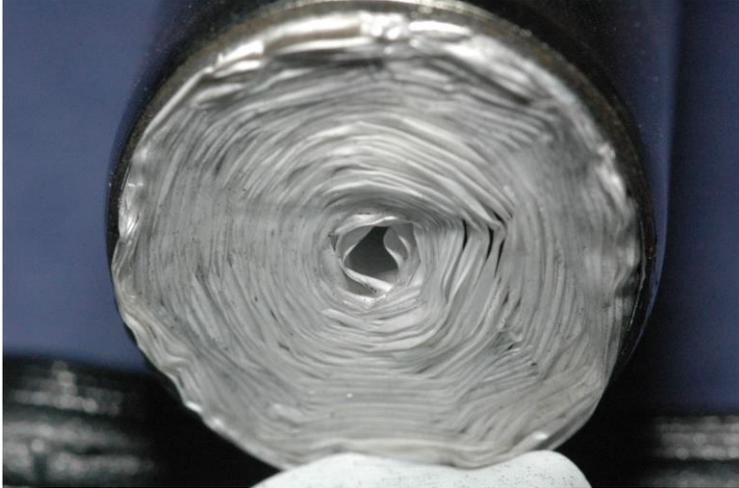
- Stacked or “jelly roll” configuration



(a) cylindrical

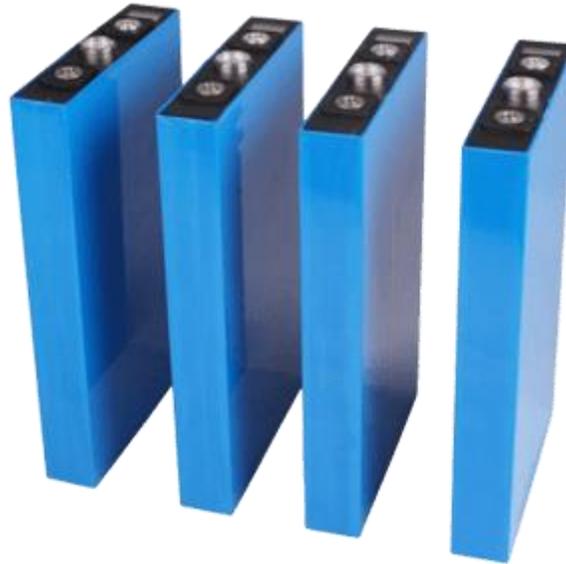


(b) prismatic

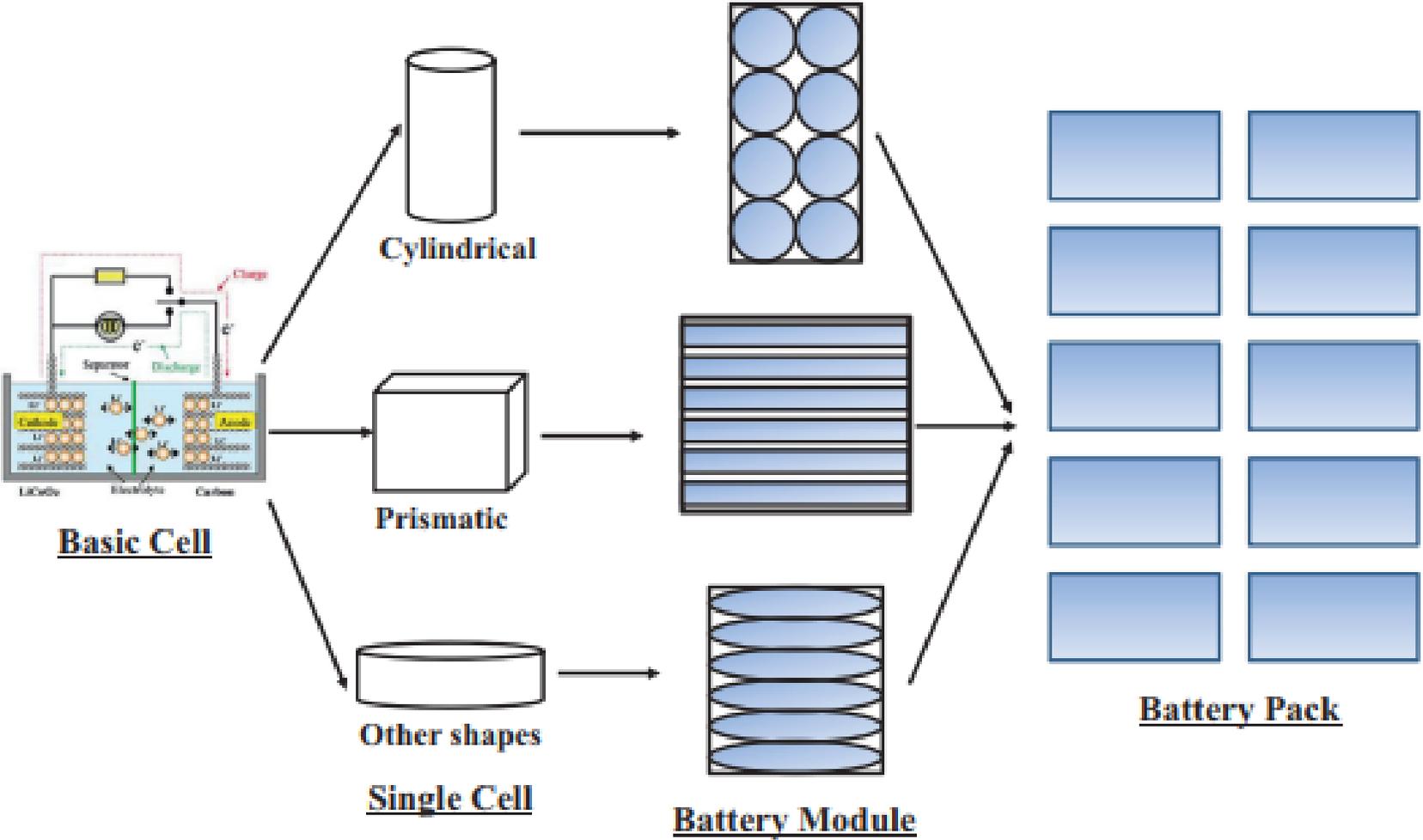


External Structure

- Cylindrical, prismatic, or pouch cells



Battery Pack Structure



Failure Modes

- Non-Energetic Failures
 - Loss of capacity
 - Internal impedance increase
 - Activation of permanent disabling mechanism
 - Electrolyte leakage
 - Cell swelling
- Energetic Failures
 - Thermal Runaway



Root Causes of Energetic Cell Failures

- Thermal abuse
- Mechanical abuse
- Electrical abuse
- Poor cell design



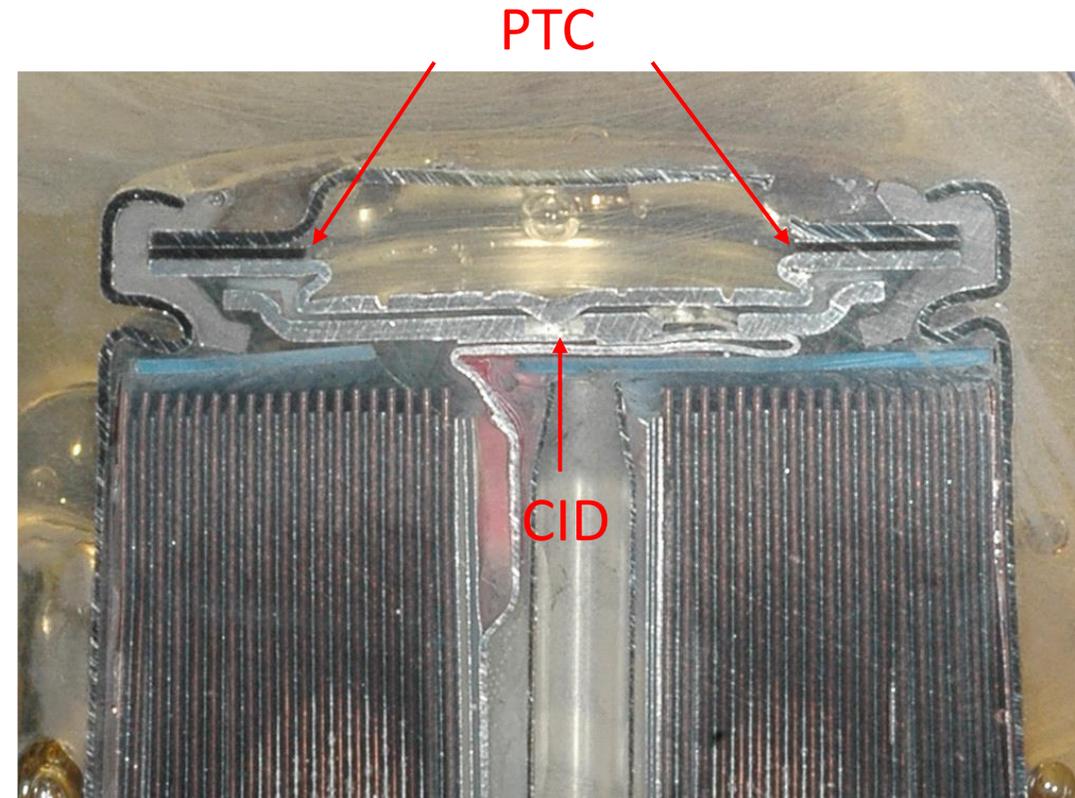
Root Causes of Energetic Cell Failures

- Internal cell faults associated with manufacturing defects
 - Defects in raw materials
 - Defects in electrode coating
 - Contaminants
 - Misplaced, misapplied, or damaged components



Safety Mechanisms

- Battery Pack Protection Electronics (BMU)
 - Protects against most electrical abuse scenarios
- Charge interrupt devices (CID)
 - Prevents overcharge in cylindrical cells
- Positive Temperature Coefficient (PTC) switches
 - Reduces excessive current



Well Known Examples

- Samsung Galaxy Note 7
- Apple MacBook Pro laptop
- Hoverboards

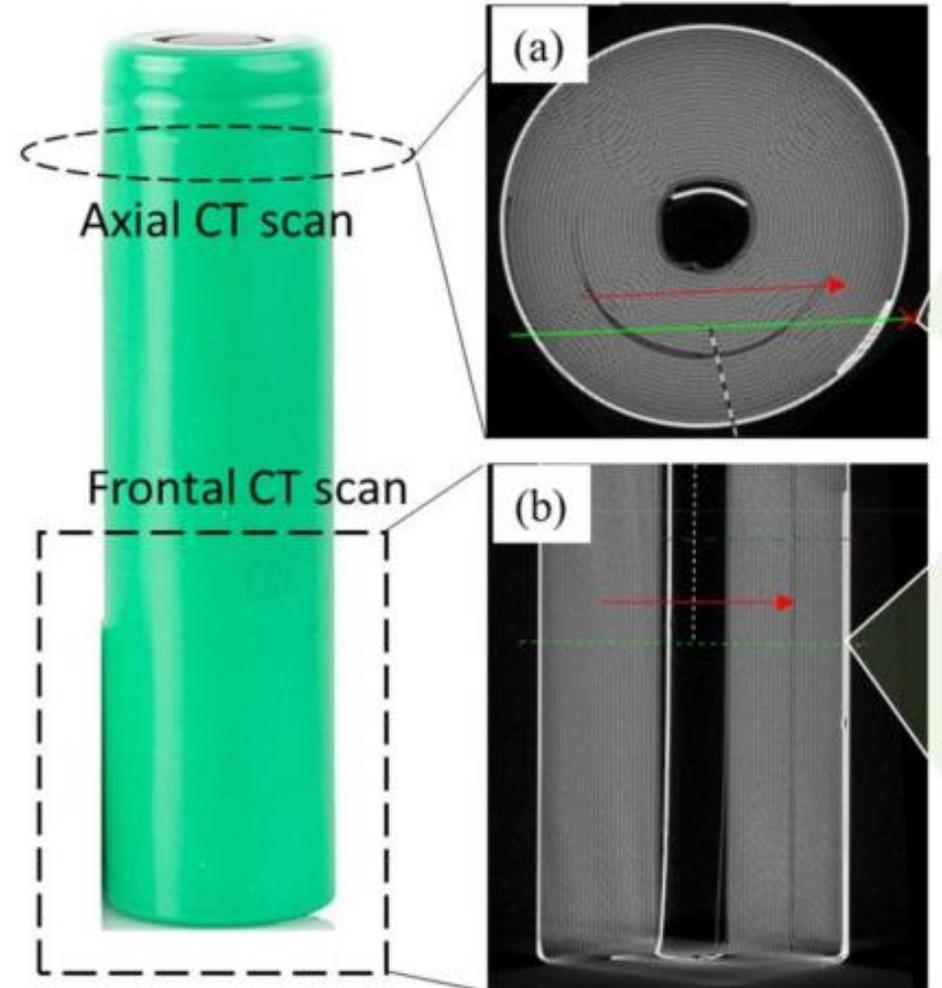




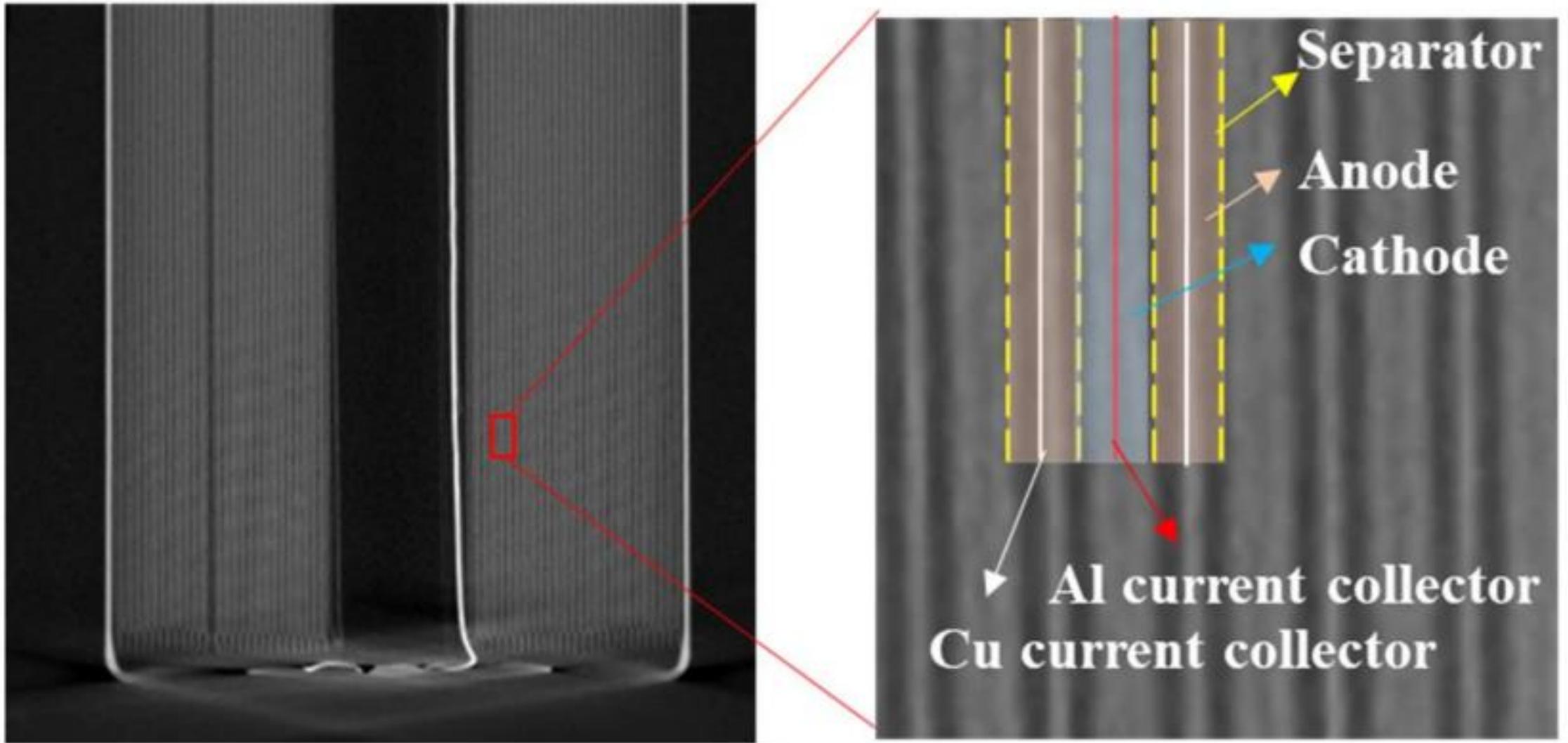
Computer Tomography (CT) Scans

CT Scans

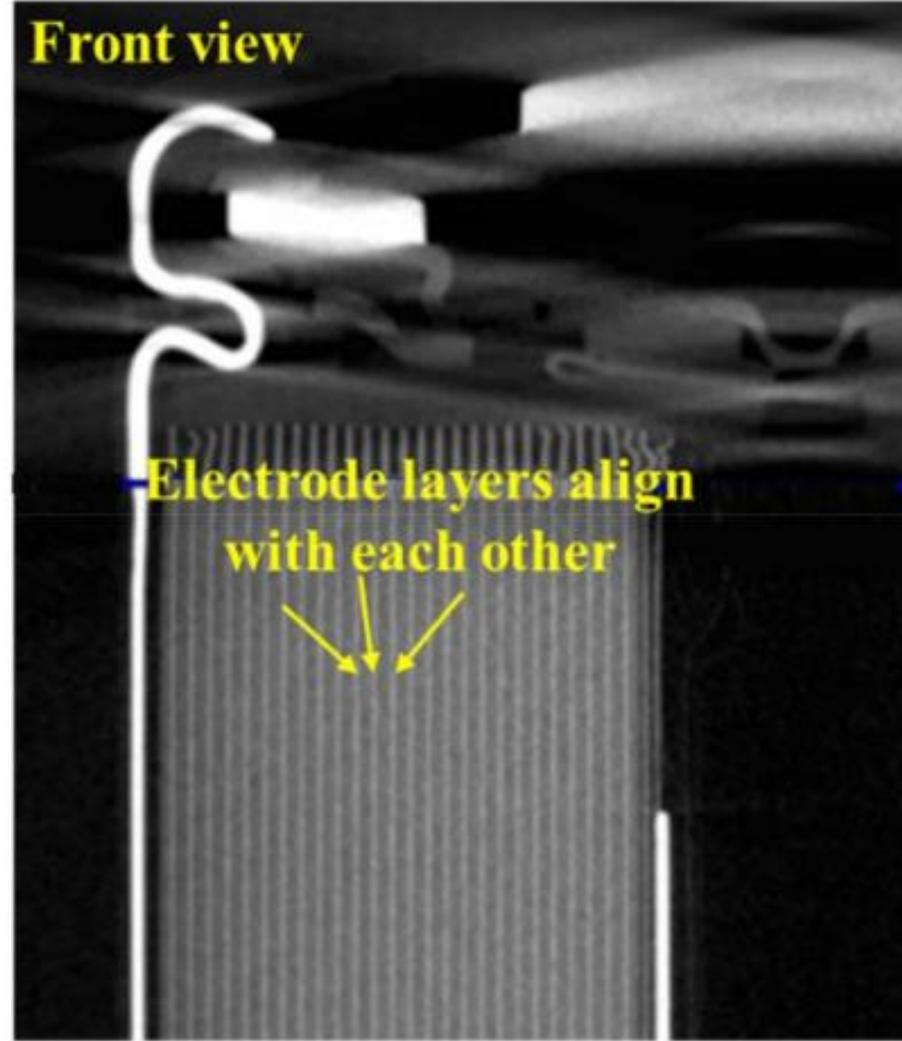
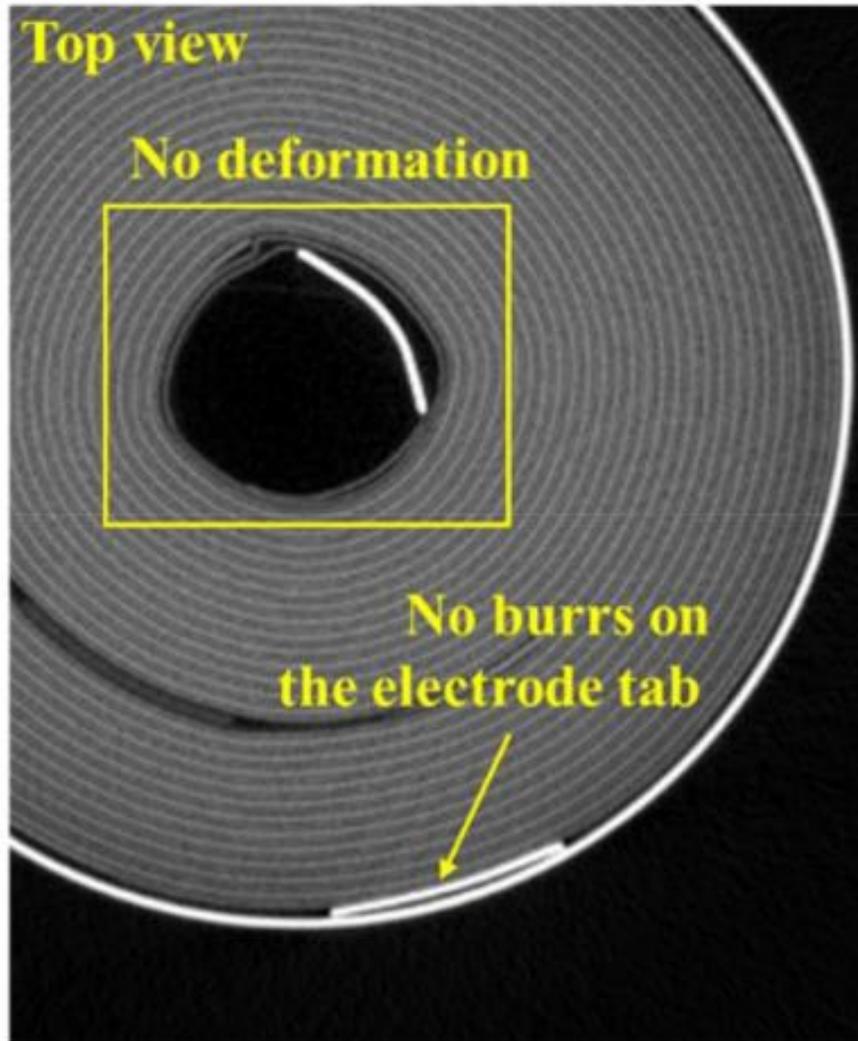
- Uses X-rays to produce 3D representations of a scanned object
- The 3D image is composed of slices



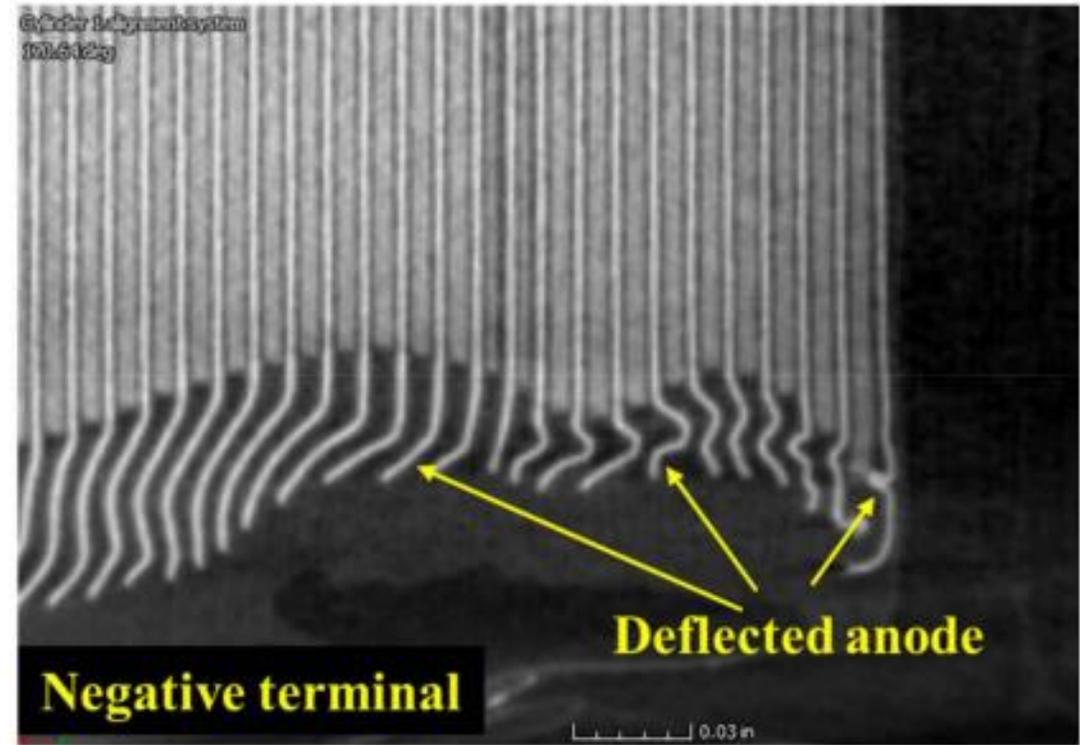
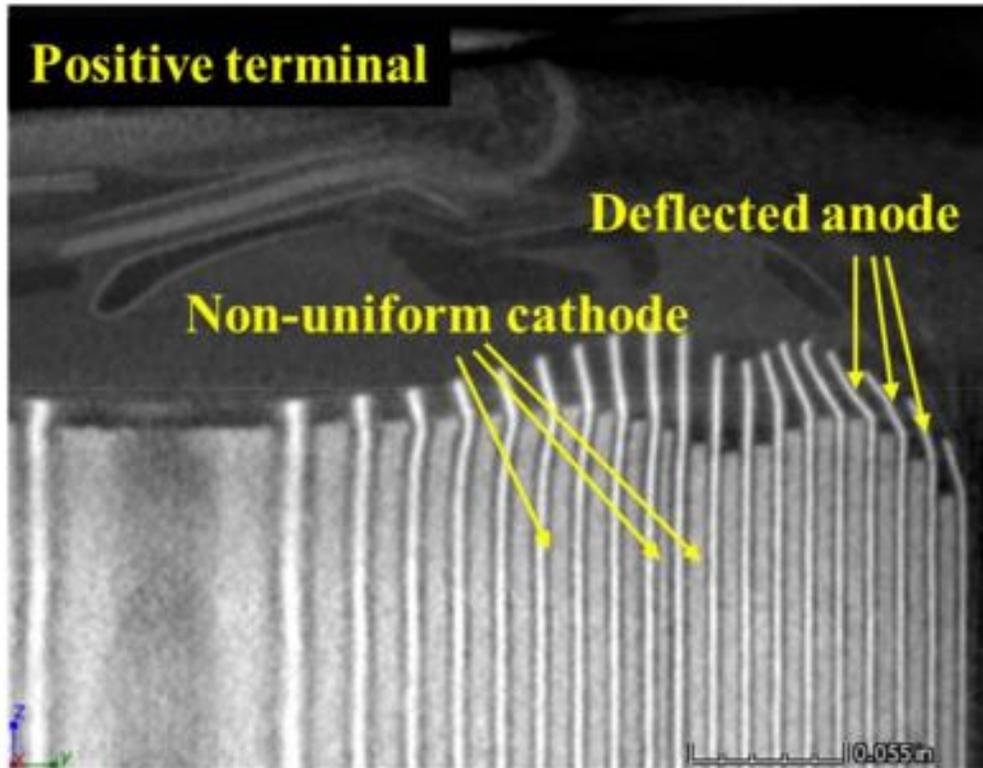
CT Scans



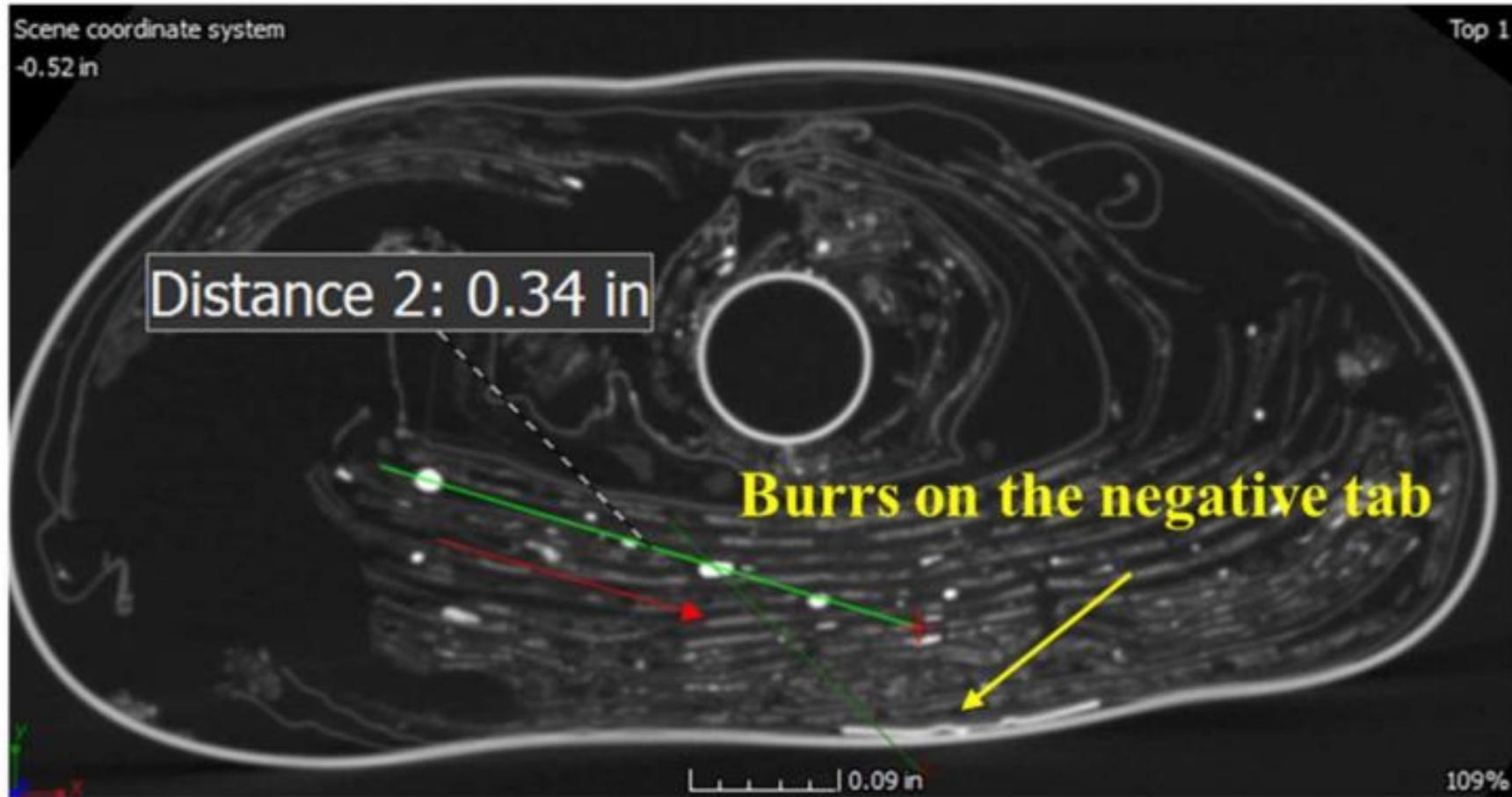
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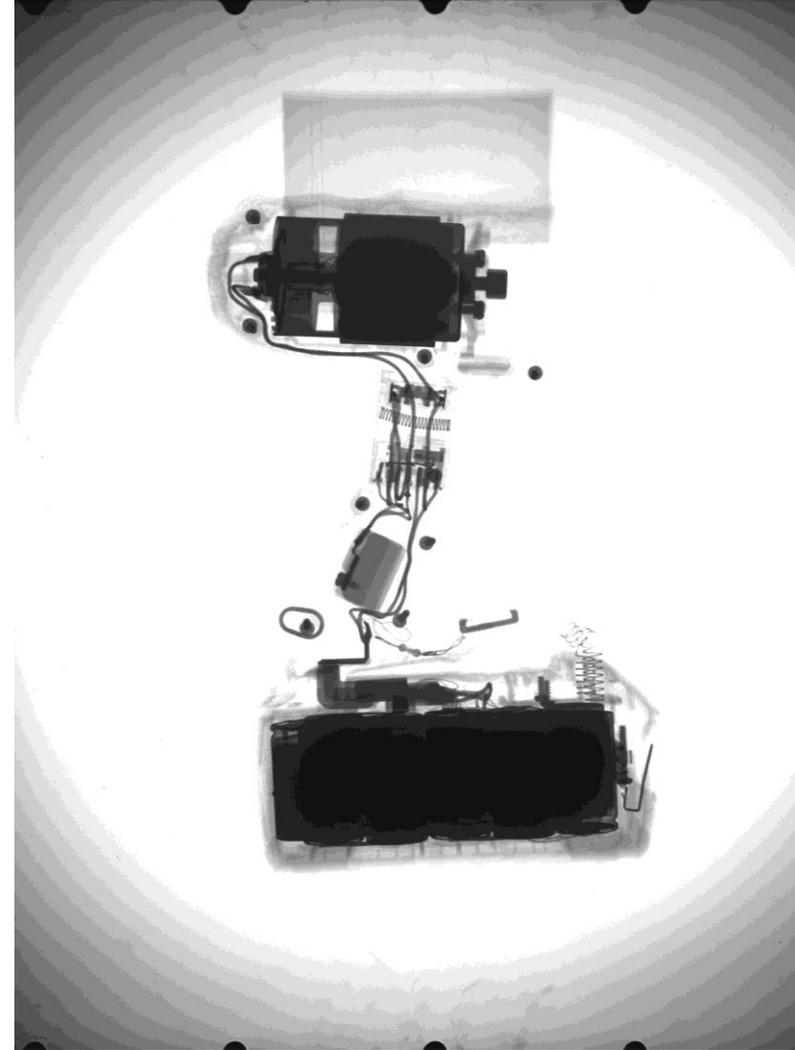
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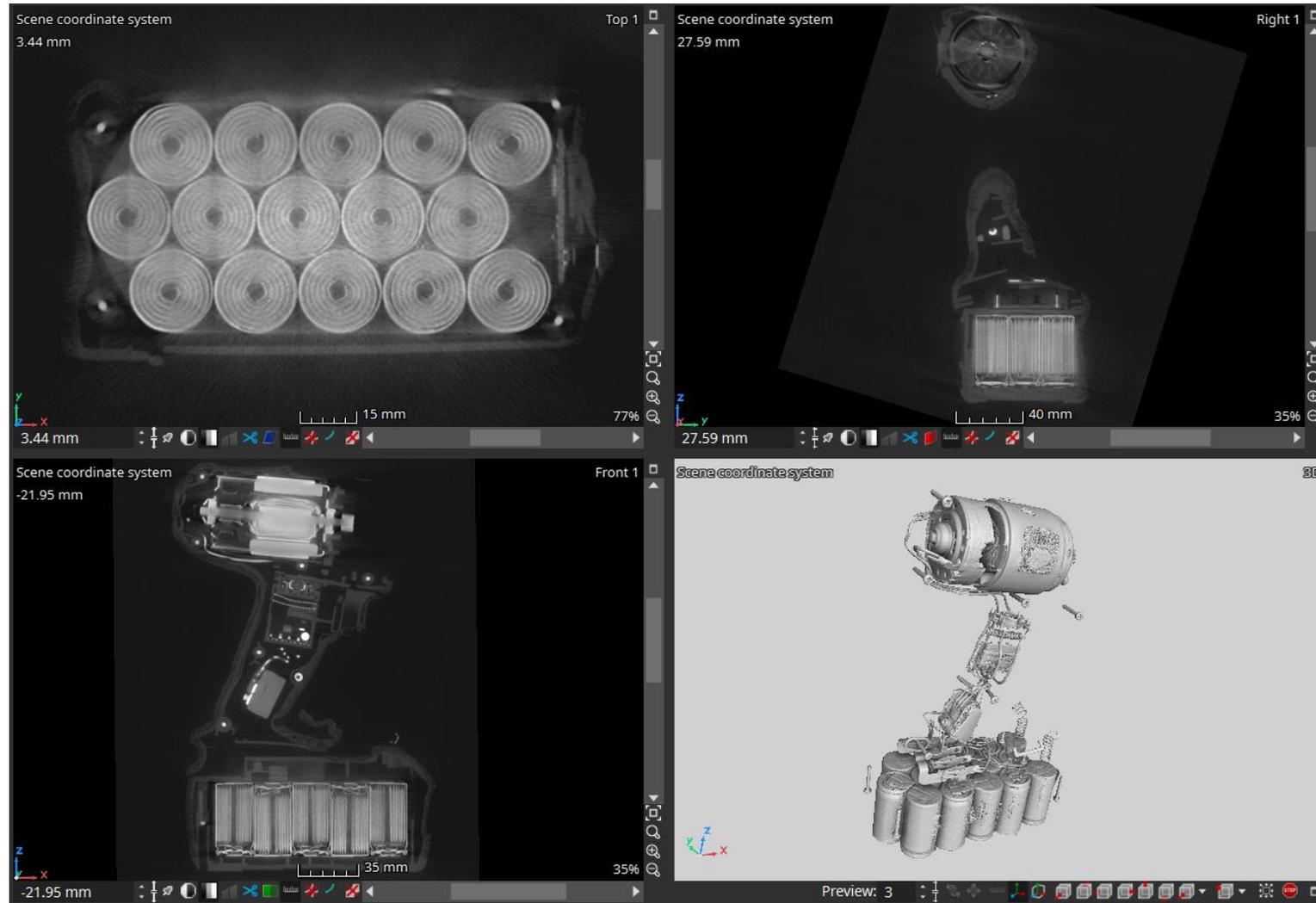
CT Scans



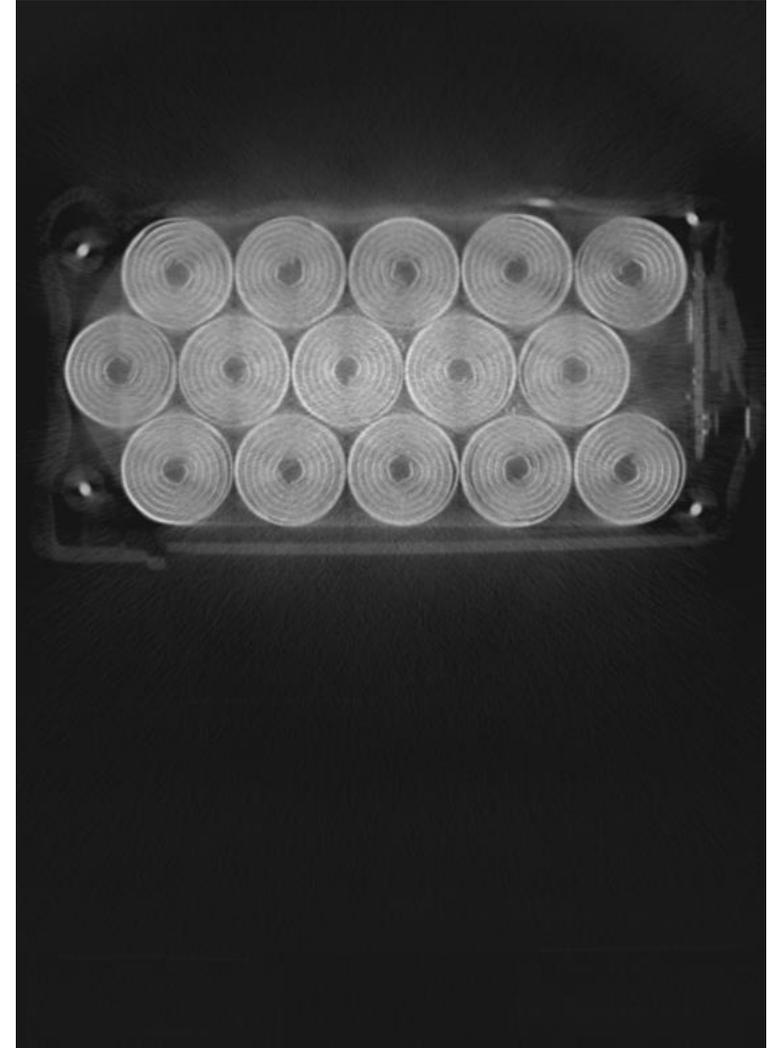
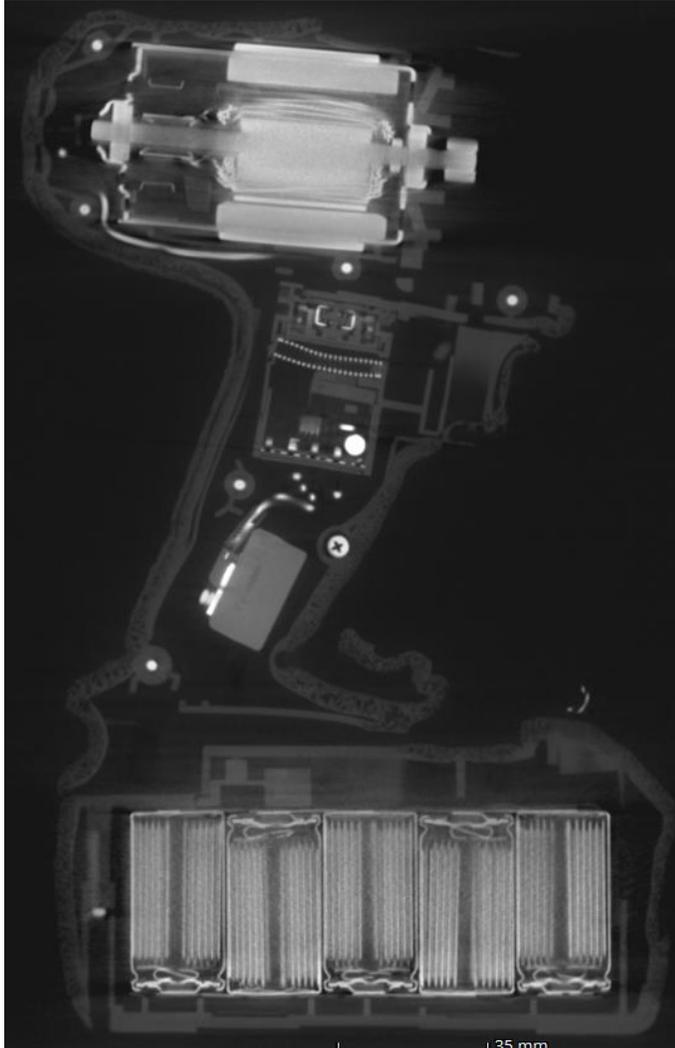
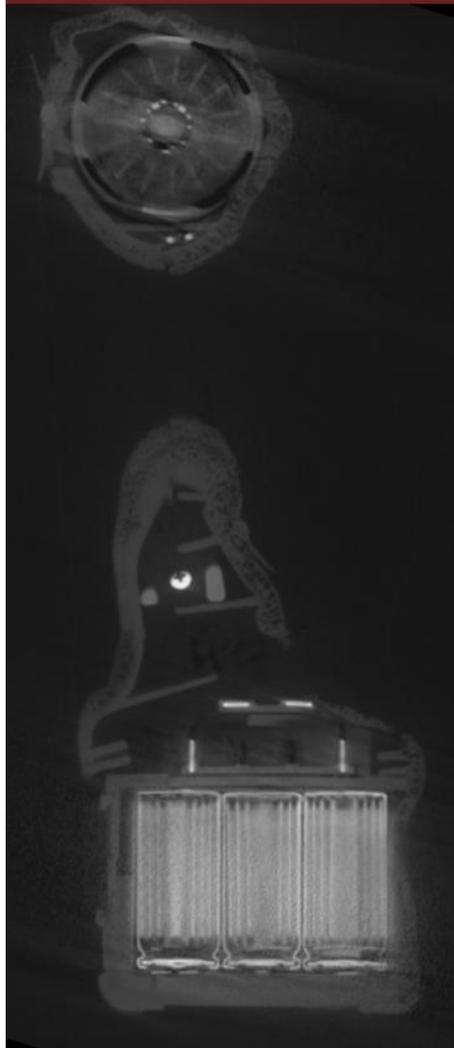
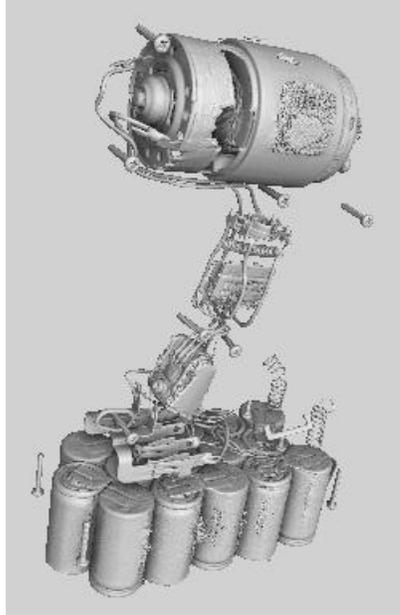
CT Scan – Ni-Cd



CT Scan – Ni-Cd



CT Scan – Ni-Cd





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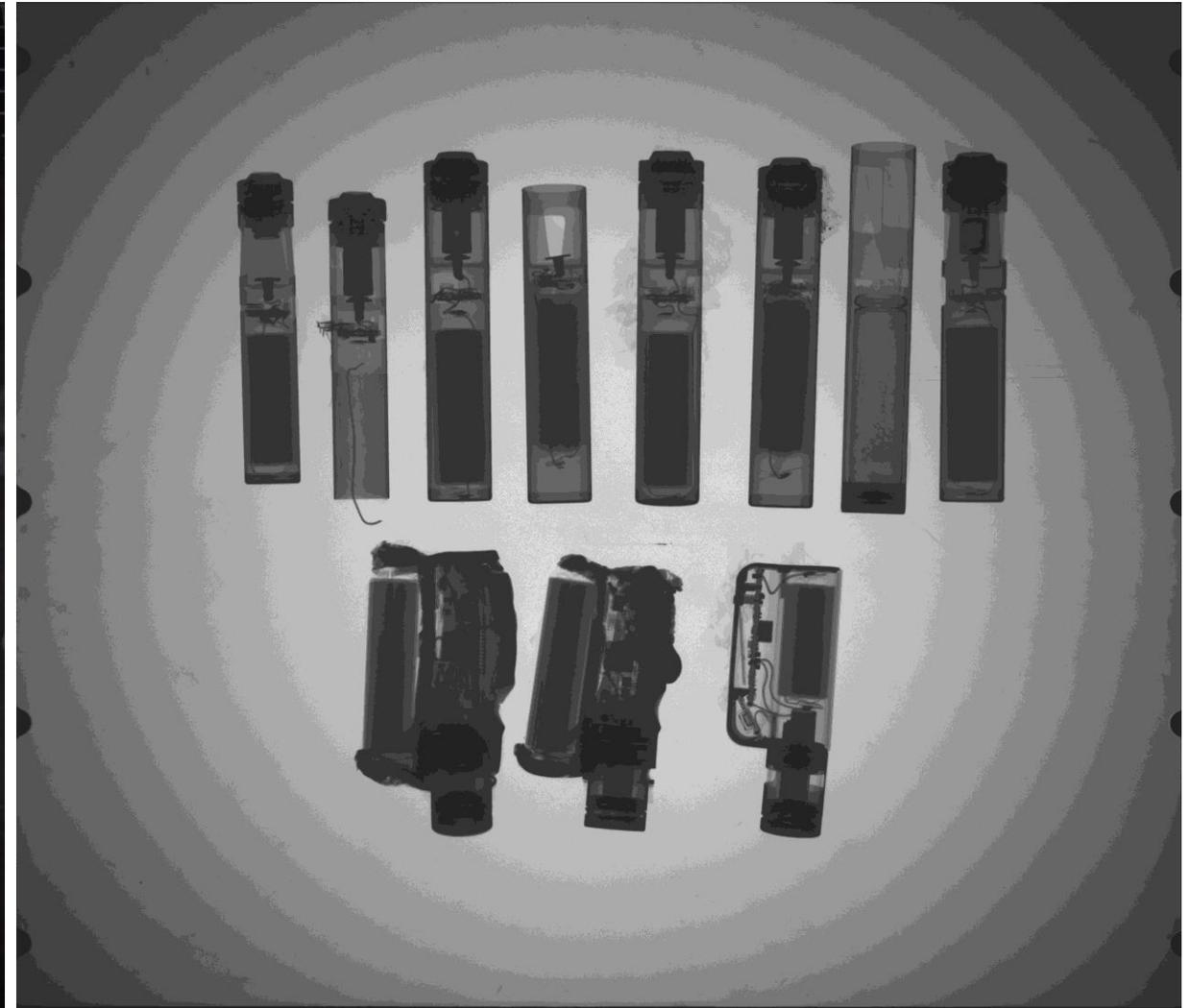
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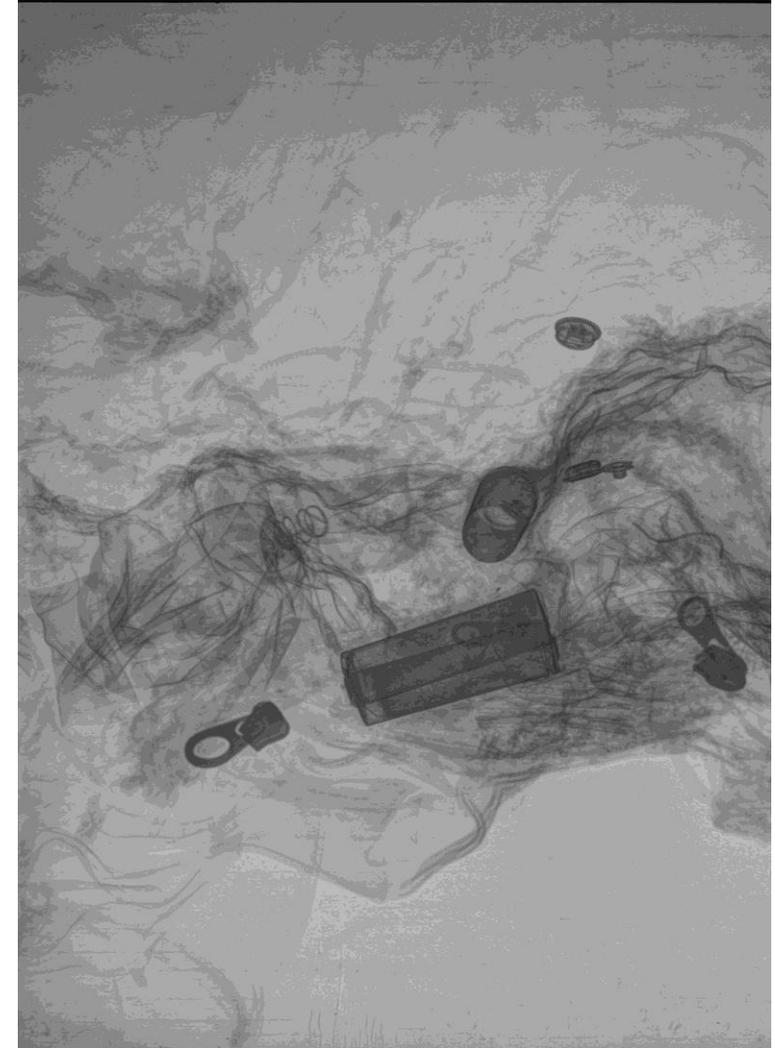
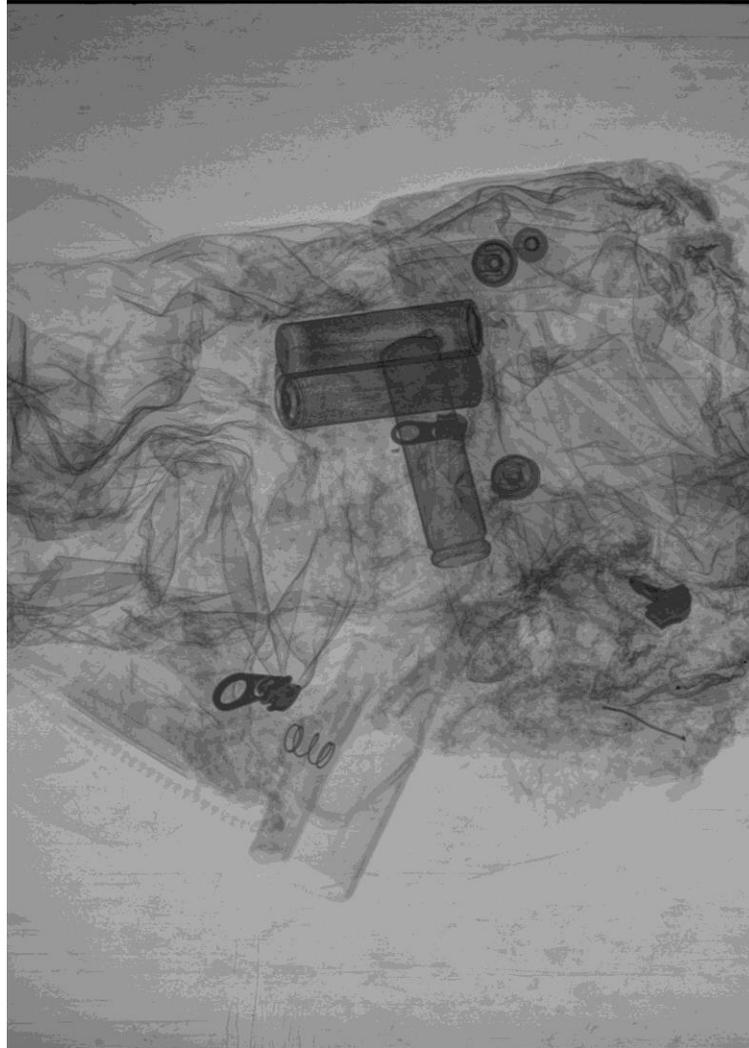
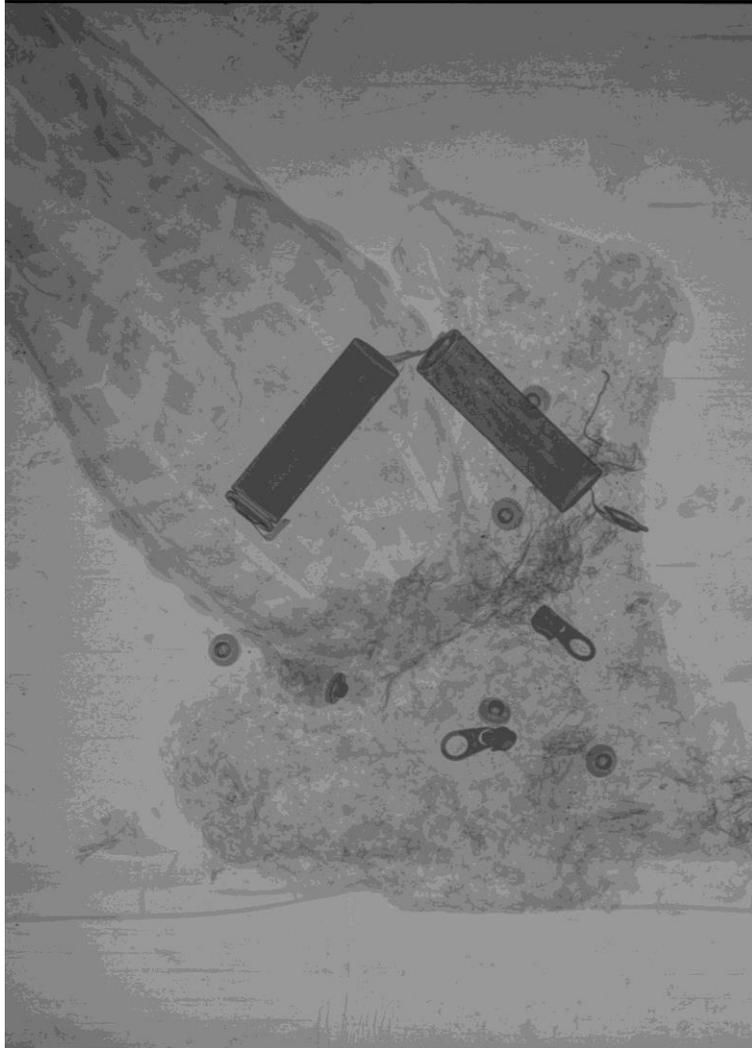
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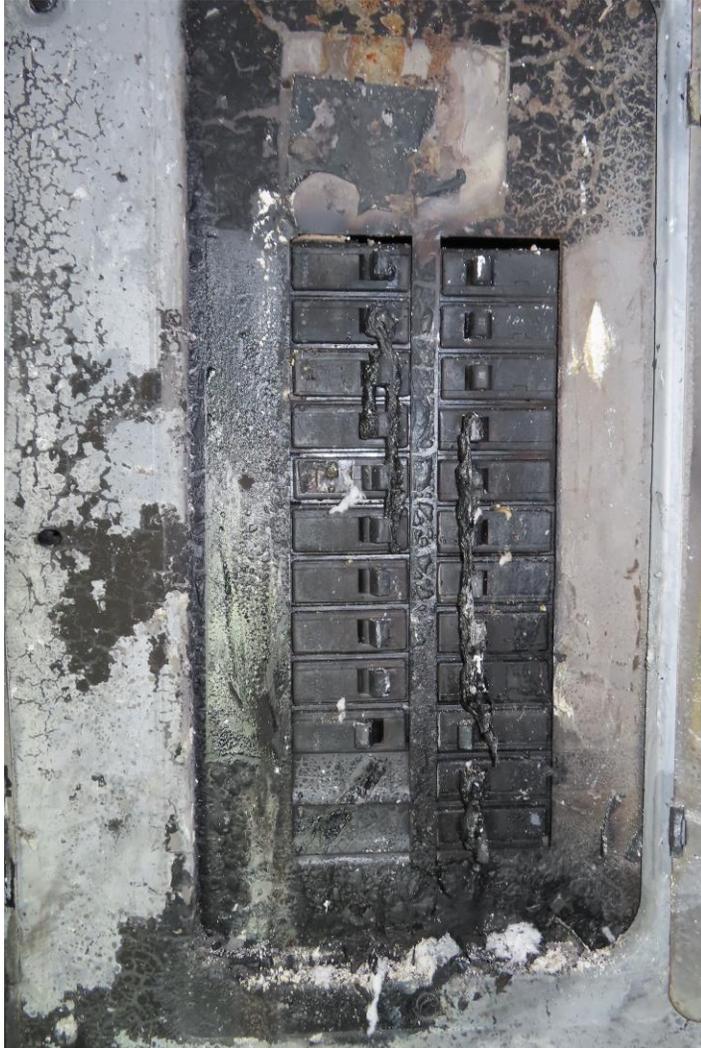
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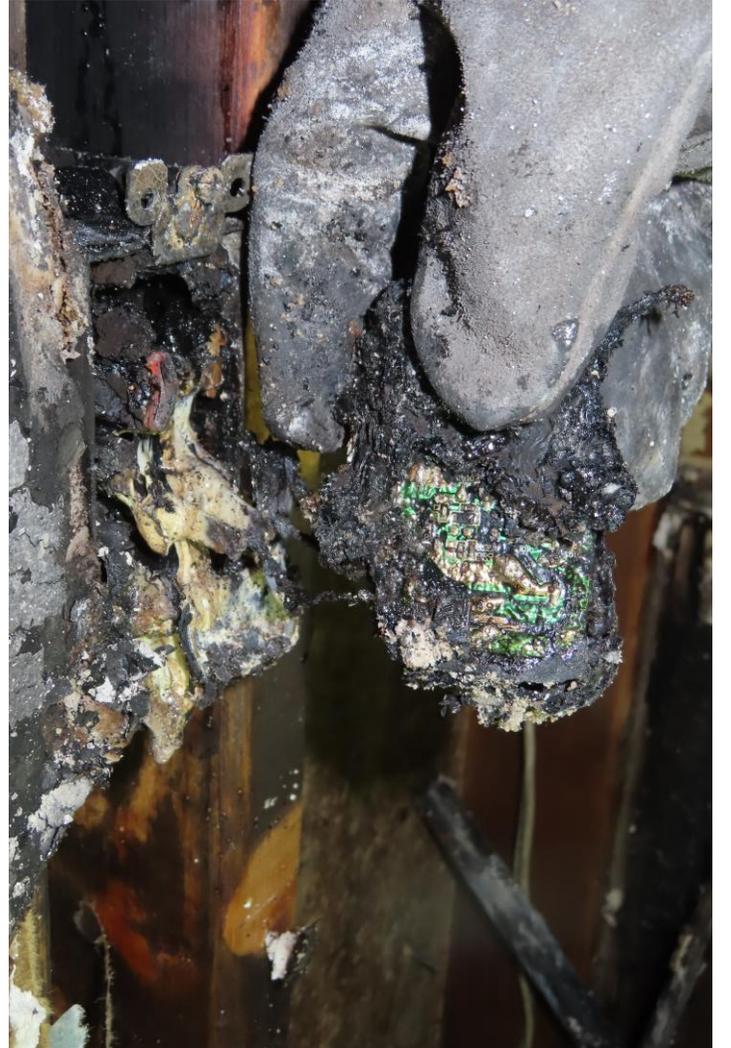
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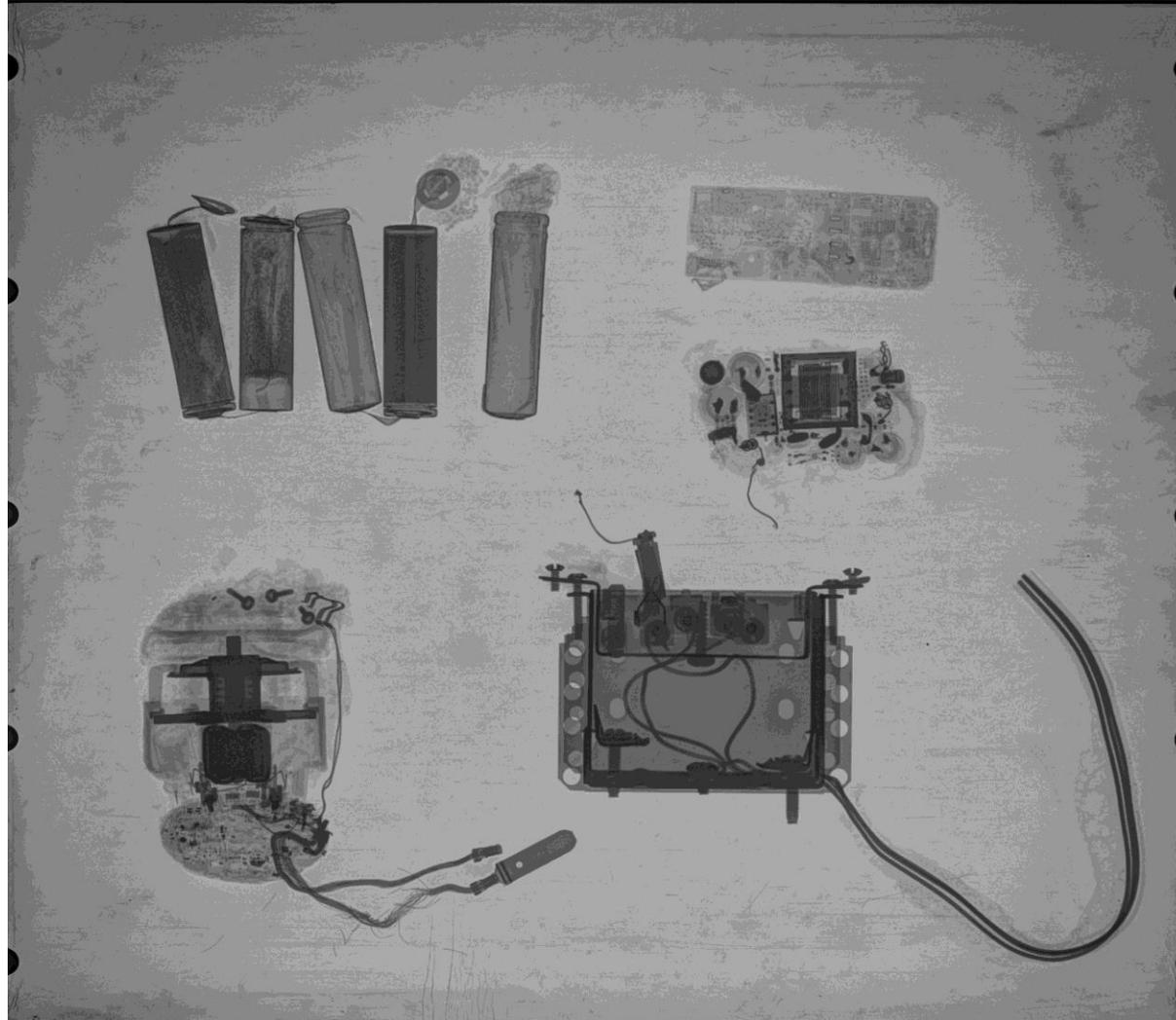
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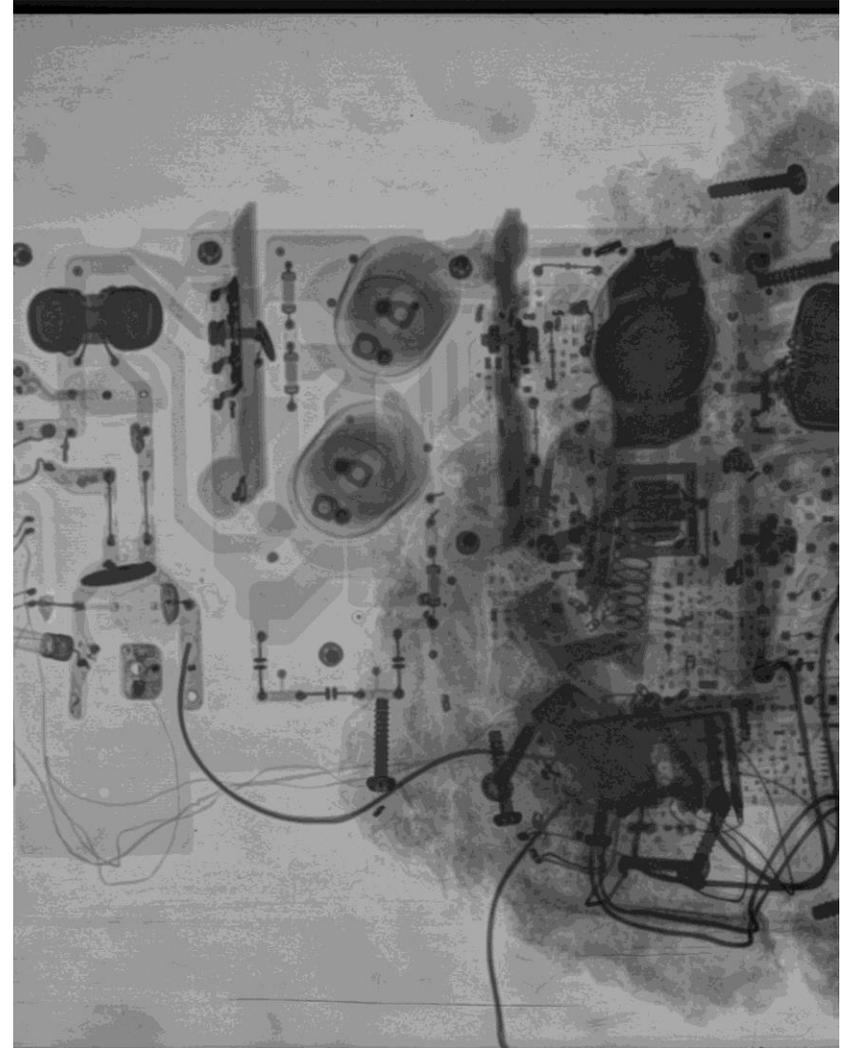
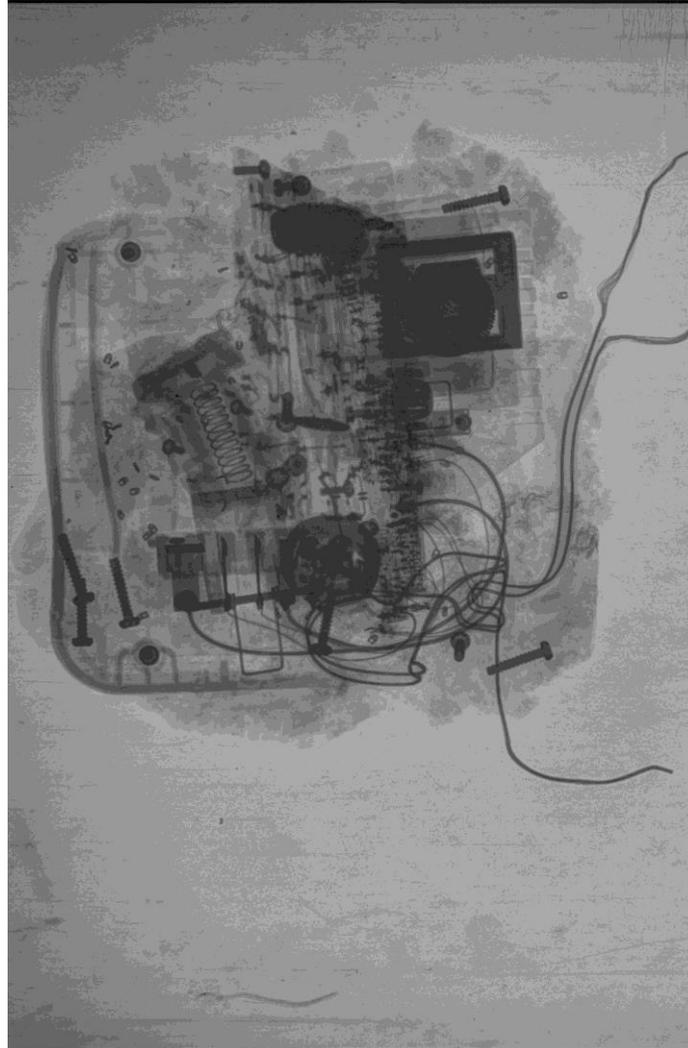
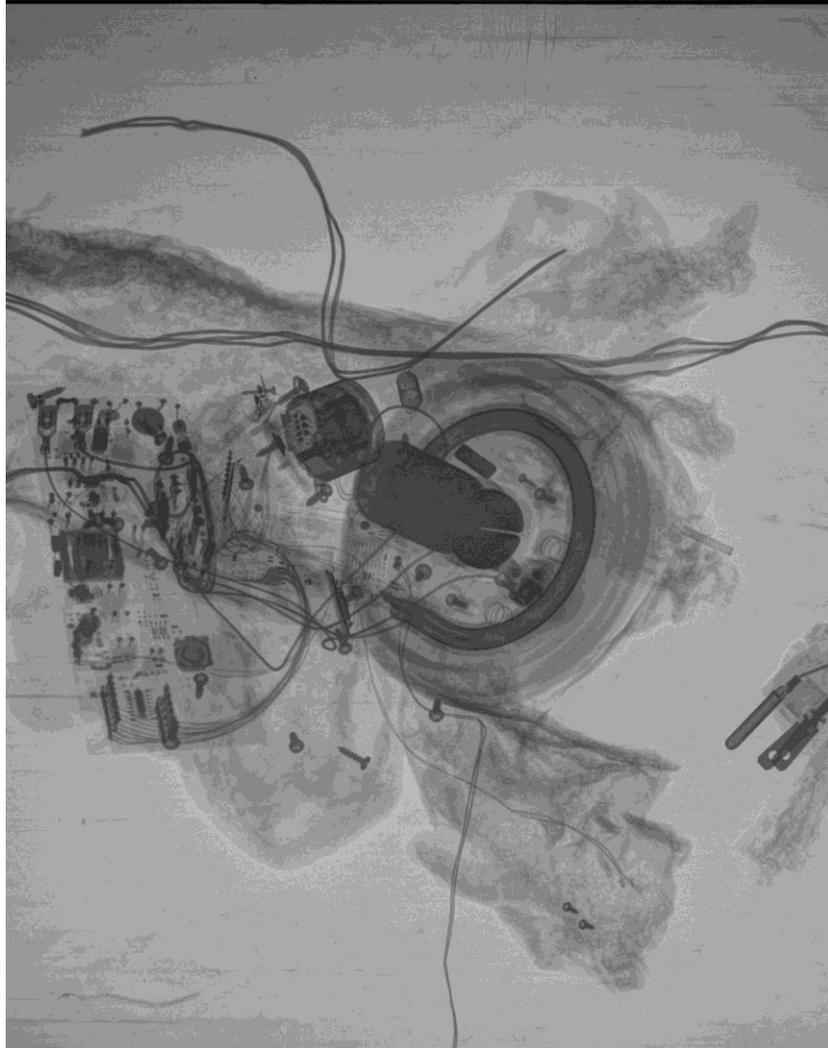
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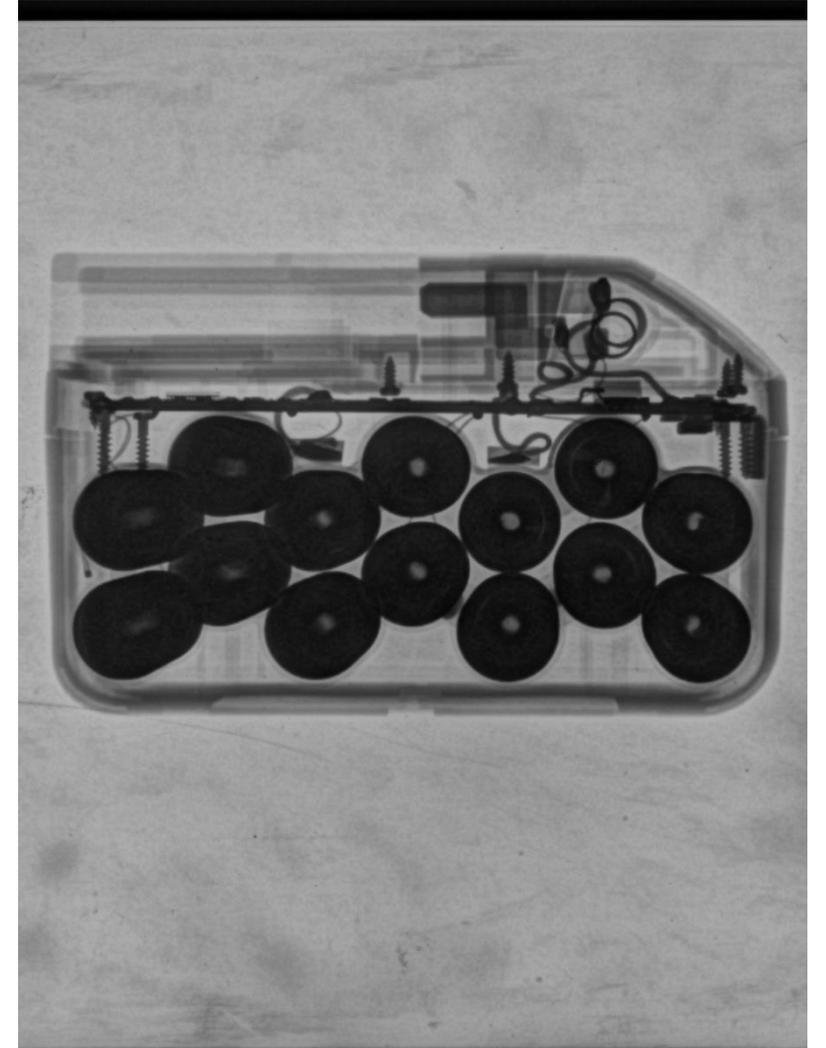
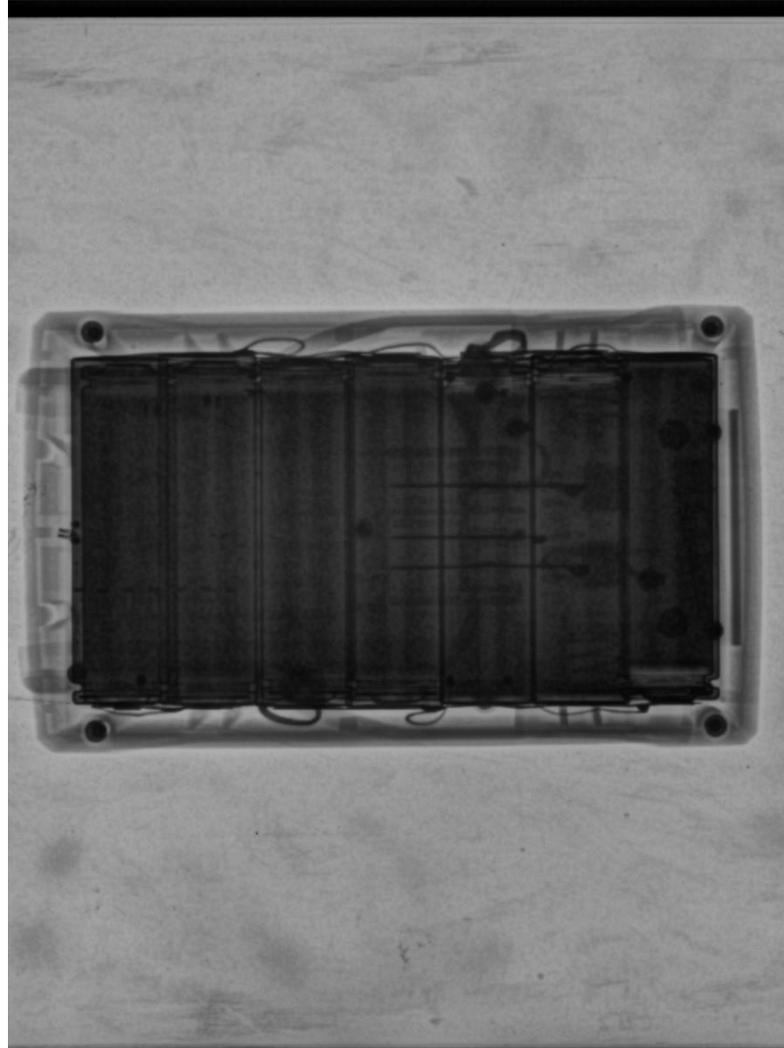
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Questions



Thank You