

EXHIBIT 1034

URT EX1034
URT Umwelt und Recyclingtechnik v. Duesenfeld
IPR2024-00887



Source: Volkswagen AG

Mechanical comminution in the recycling of lithium-ion batteries

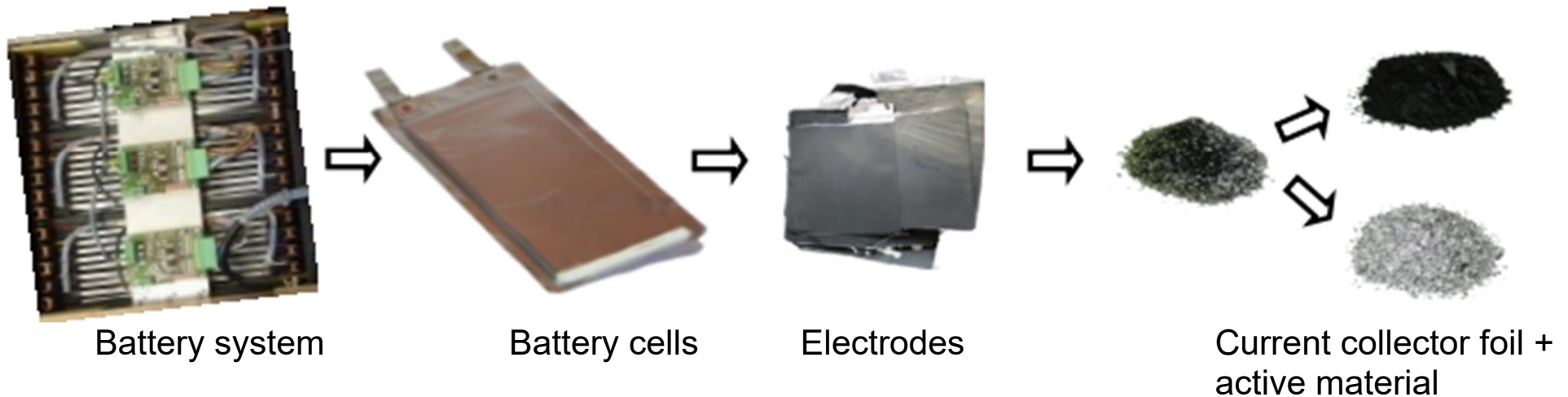
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Processing and Recycling, Freiberg, November 14, 2013

LithoRec II

- The aim is to further develop the recycling process designed in the LithoRec project

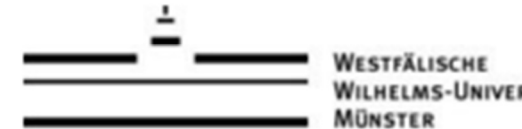


- Construction of a pilot facility to recycle 100,000 kg of lithium-ion battery cells per year including system components
- Maximization of the recycling rate

LithoRec II

Recycling of lithium-ion batteries

Project consortium



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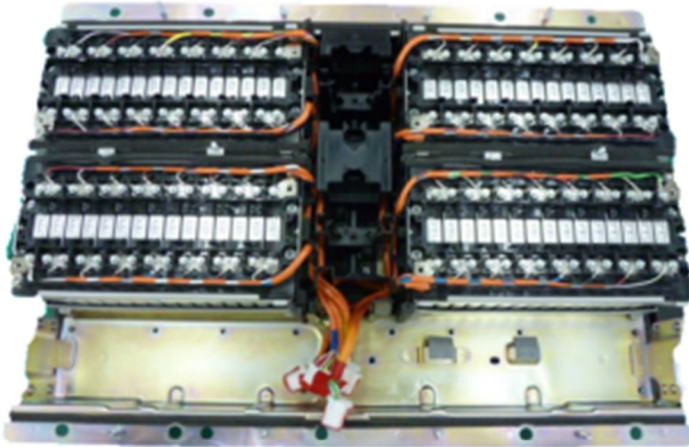
Project manager



Technical
University
Braunschweig

Specifications of the feed material

Battery system and battery module



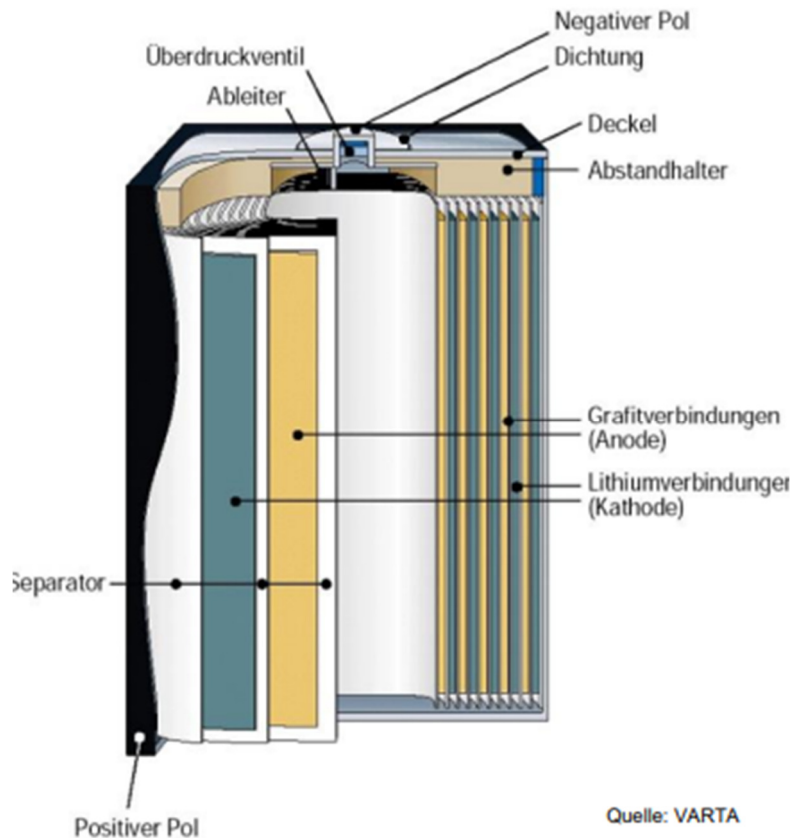
- 50–70% battery cells
- 15–45% housing components
- 2–6% cables
- 2–3% electronics, circuit boards
- 0–3% cooling tubes
- 0–3% conductor tracks
- 1–2% screws, metal parts
- < 1% tape, etc.

- The feed material is extremely heterogenous (in terms of item size and shape and of material)
- Mostly ductile working materials, sometimes steel plate with a wall thickness of up to 1 mm and / or solid steel items

Source: Volkswagen AG

Specifications of the feed material

Battery system and battery module



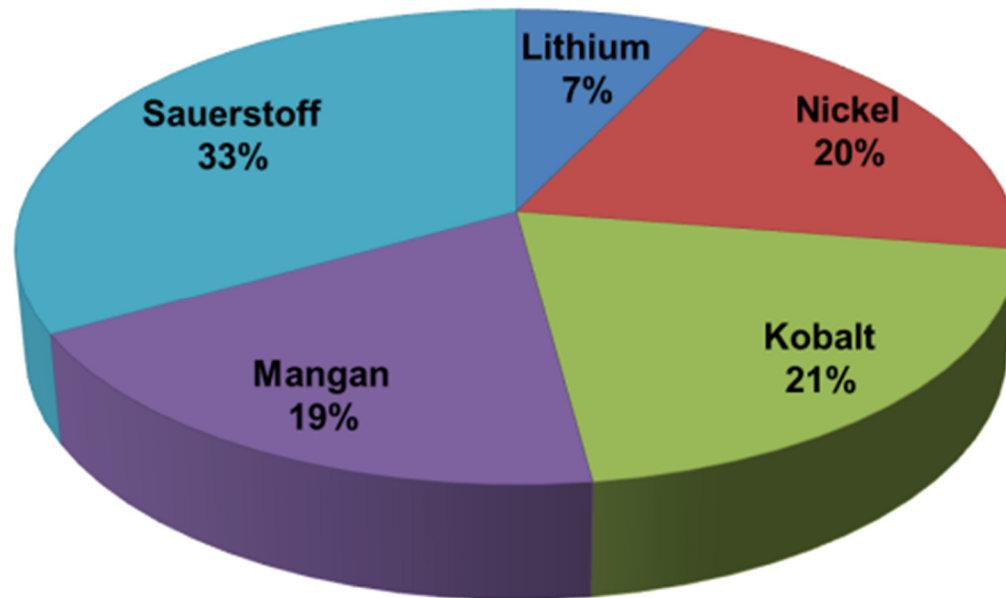
- Approx. 65% electrodes
 - Metal foil + coating + binder + conductivity additive
 - Anode: Cu foil + graphite
 - Cathode: Al foil + LiMO_2 ($M = \text{Mn, Ni, Co}$)
- 10–15% steel or aluminum housings
- 10–20% electrolyte
- 2–5% further parts
- Approx. 3% separator / foil

Clockwise from top left: Relief valve | Arrester | Negative pole | Seal | Cap | Spacer | Graphite compounds (anode) | Lithium compounds (cathode) | Positive pole | Separator

Source: VARTA

Stoichiometric composition of the active material

Lithium nickel cobalt manganese oxide

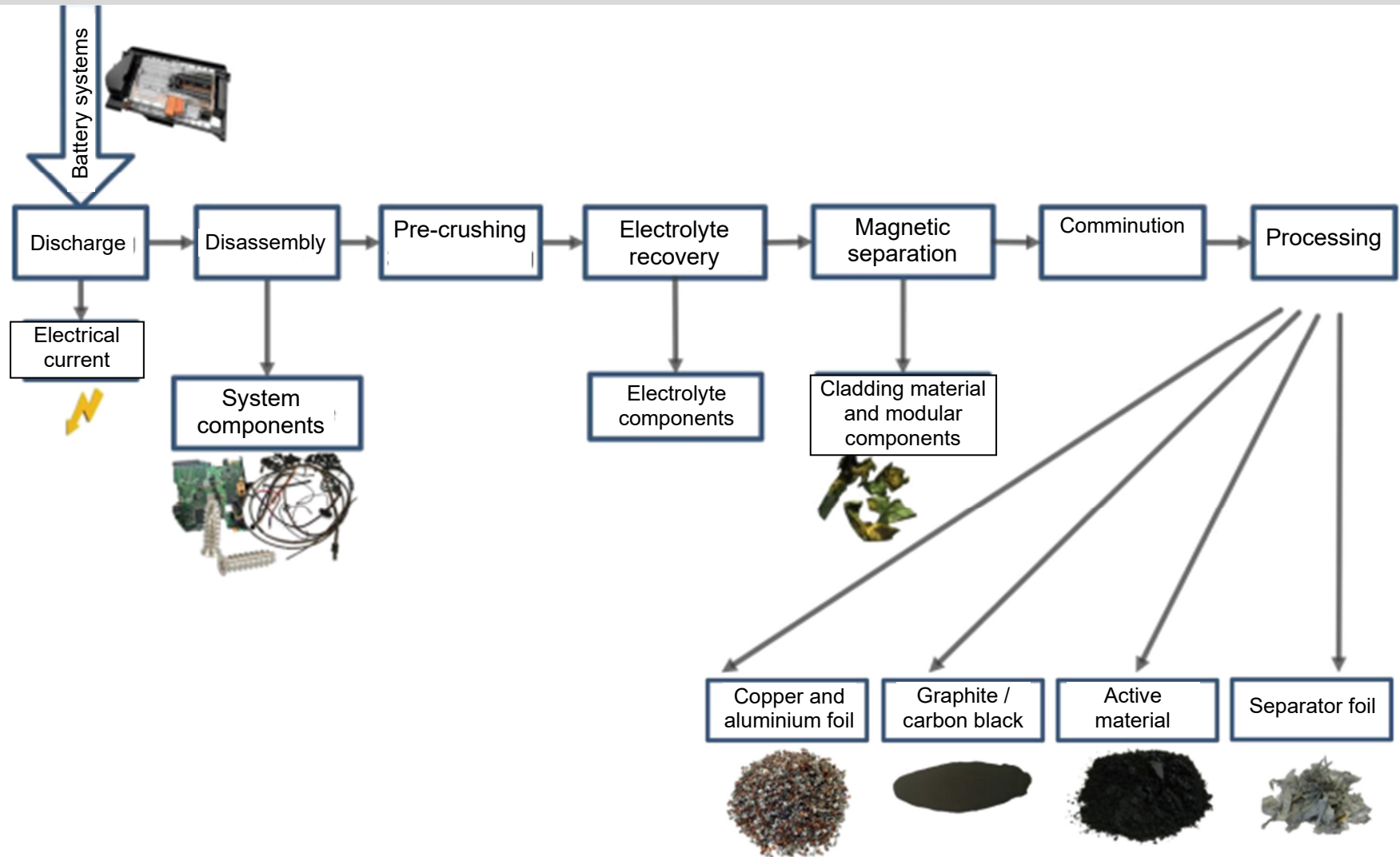


Clockwise from top left: Oxygen | Lithium | Nickel | Cobalt | Manganese

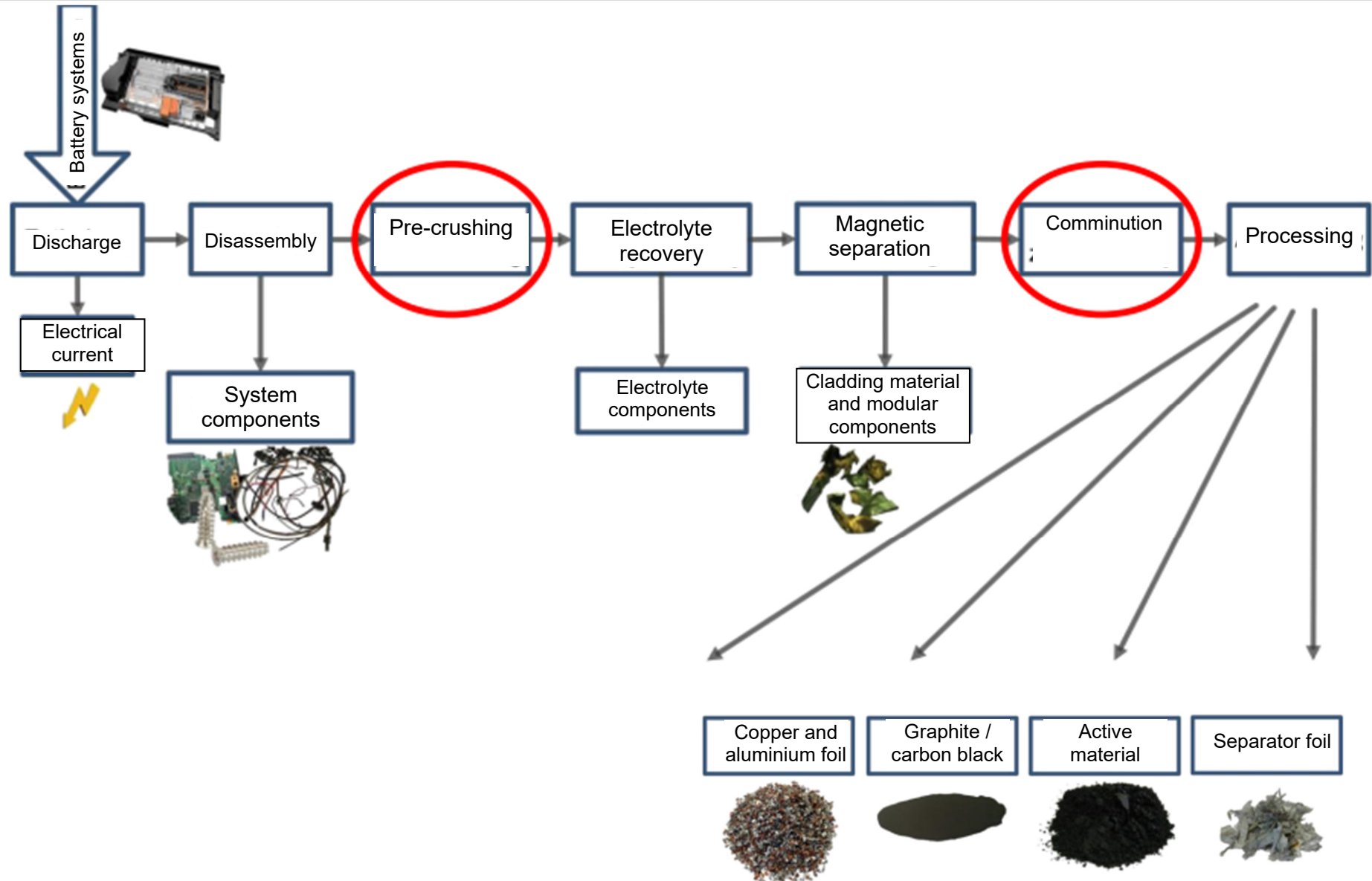
Per 200 battery cells

- Approx. 4 kg of lithium
- Approx. 12 kg of nickel
- Approx. 12 kg of cobalt
- Approx. 10 kg of manganese

Comminution steps in the recycling process



Comminution steps in the recycling process



Contents of lithium-ion batteries

Components of the electrolyte

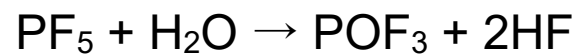
- **Solvents** of the electrolyte are flammable

- Dimethyl carbonate (DMC)
- Ethyl methyl carbonate (EMC)
- Diethyl carbonate (DEC)



Source: Menke Industrieverpackungen

- **Conducting salt:** lithium hexafluorophosphate (LiPF_6) tends to decompose at increased temperatures and in the presence of moisture [1]



[1]: Hui Yang et al., Journal of Power Sources 161, 573–679, 2006

Contents of lithium-ion batteries

Components of the coatings

- Binder: **polyvinylidene fluoride (PVDF)**

- Decomposition in a fire
- Generation of hydrogen fluoride



- Components of the **coating materials**

- Risk of dust explosion
- Components of some cathode coating materials are carcinogenic





HOSOKAWA
ALPINE

Technical approaches to comminution

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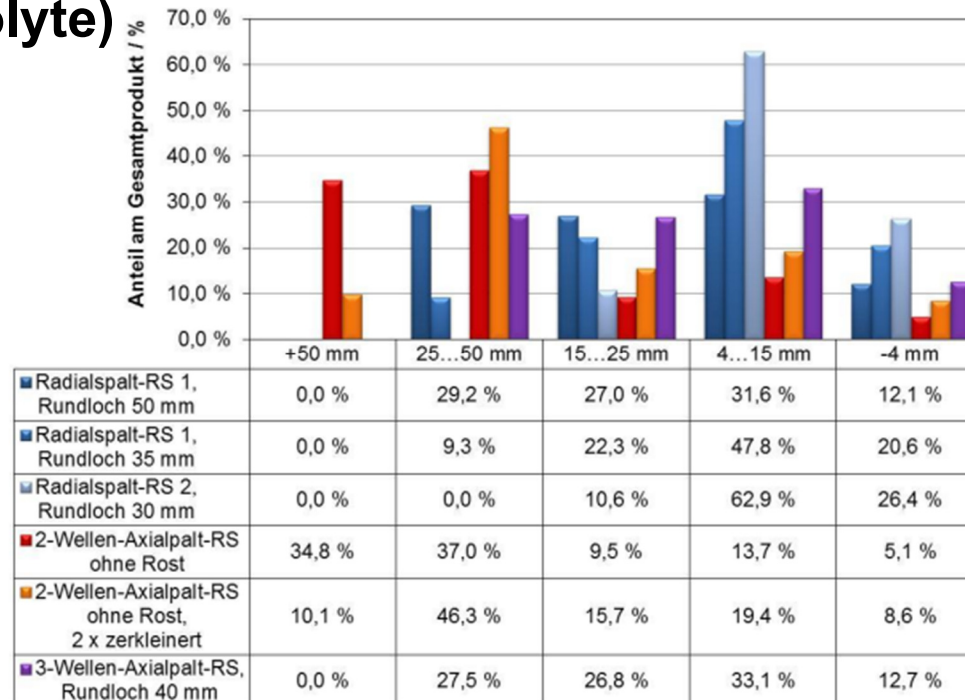
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Pre-crusher

- Results of comminution tests with various pre-crushers (LFP cells without electrolyte)



[Top to bottom: Proportion of the entire product / %

Radial gap rotary shear 1, round aperture, 50 mm

Radial gap rotary shear 1, round aperture, 35 mm

Radial gap rotary shear 2, round aperture, 30 mm

Twin-shaft axial gap rotary shear, without a grate

Twin-shaft axial gap rotary shear, without a grate, 2 x comminuted

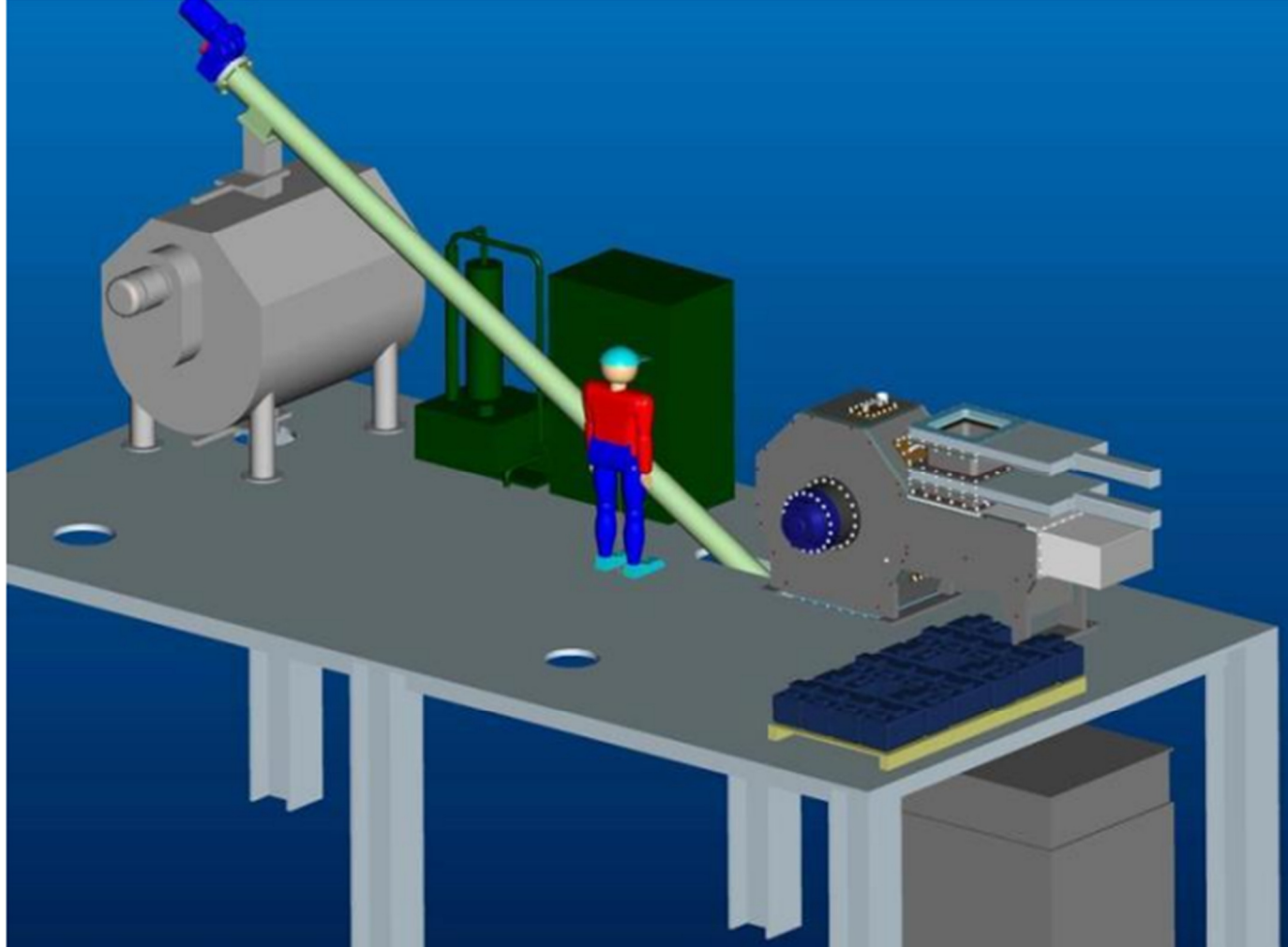
Triple-shaft axial gap rotary shear, round aperture, 40 mm]

Pre-crusher

- **Specifications for the pre-crusher**
 - Radial gap rotary shear
 - Sieving grate, aperture widths 30–50 mm
 - Feed item mass up to around 30 kg
 - Forced feed of the material to the rotor
 - Reversible function of the rotor
 - Can be started up when full
 - Airtight housing
 - Inert gas flow to extract the solvent fumes
 - Inertizable lock for the material to be introduced
 - Air-tight connection to the next process (electrolyte recovery)
- **New design based on DURALINE**



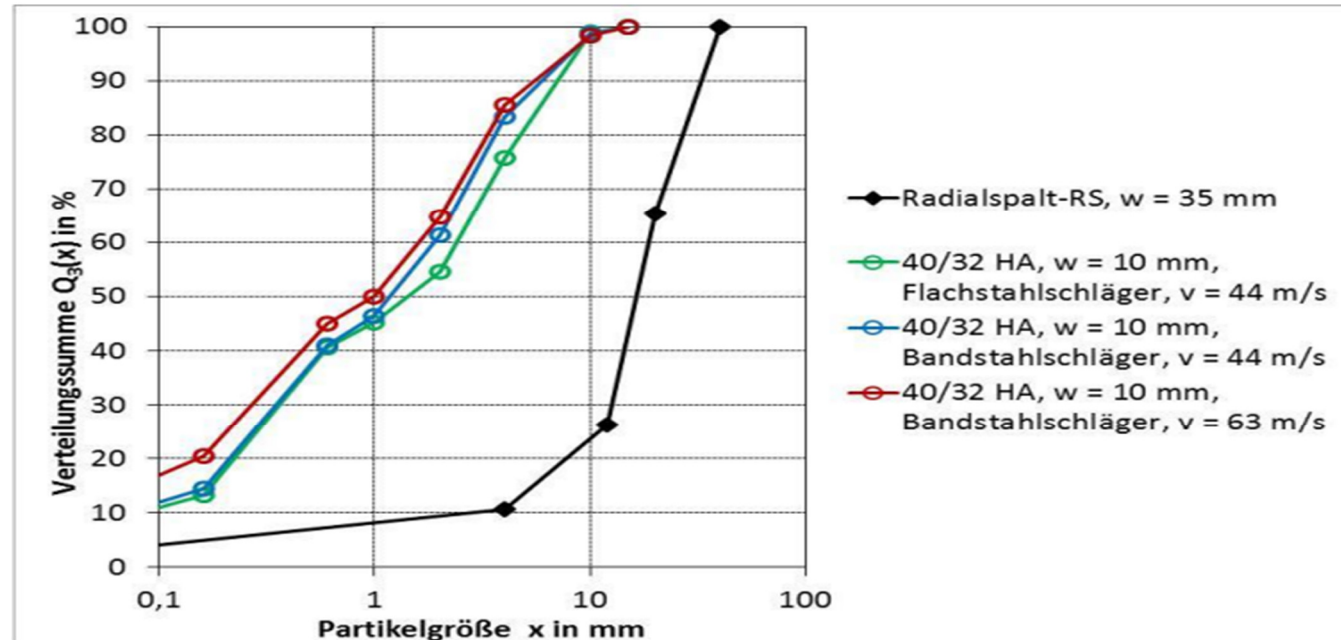
Pre-crusher



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Comminution

■ Comminution tests with a hammer mill



[Y-axis: total distribution $Q_3(x)$ in %

X-axis: Particle size x in mm

Radial gap rotary shear, $w = 35$ mm

40/32 HA, $w = 10$ mm, flat steel beater, $v = 44$ m/s

40/32 HA, $w = 10$ mm, steel strip beater, $v = 44$ m/s

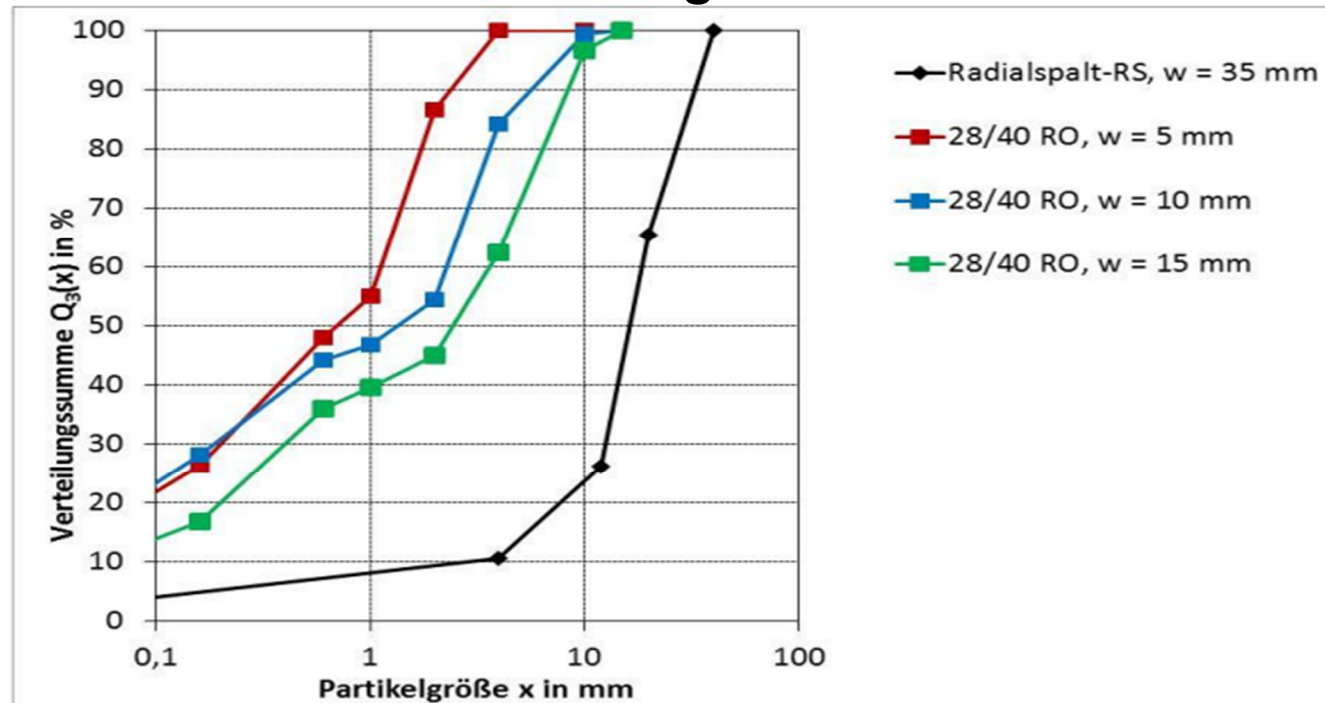
40/32 HA, $w = 10$ mm, steel strip beater, $v = 63$ m/s]



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Comminution

■ Comminution tests with a knife edge mill



[Y-axis: total distribution $Q_3(x)$ in %

X-axis: Particle size x in mm

Radial gap rotary shear, $w = 35$ mm

28/40 RO, $w = 5$ mm

28/40 RO, $w = 10$ mm

28/40 RO, $w = 15$ mm]



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Comminution

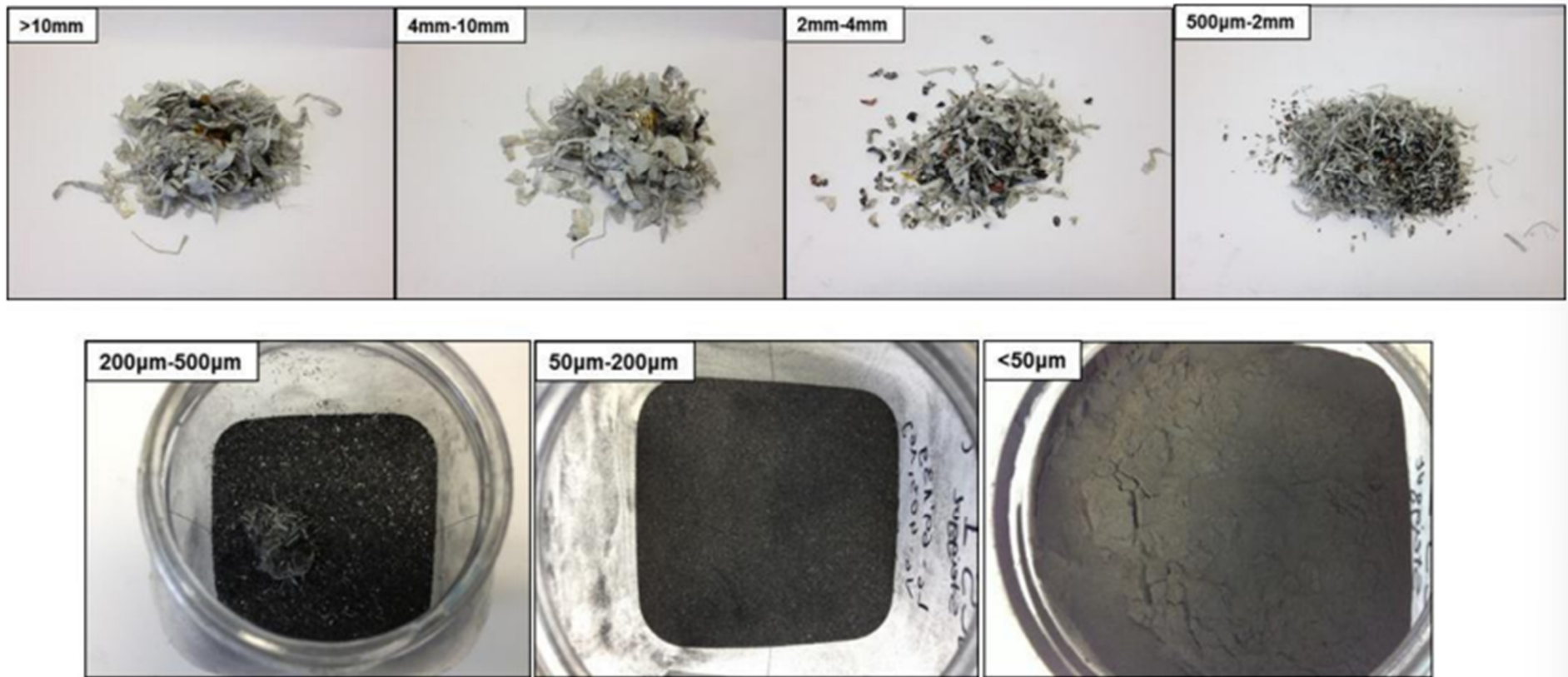
- Operating tests at Electrocycling, Goslar



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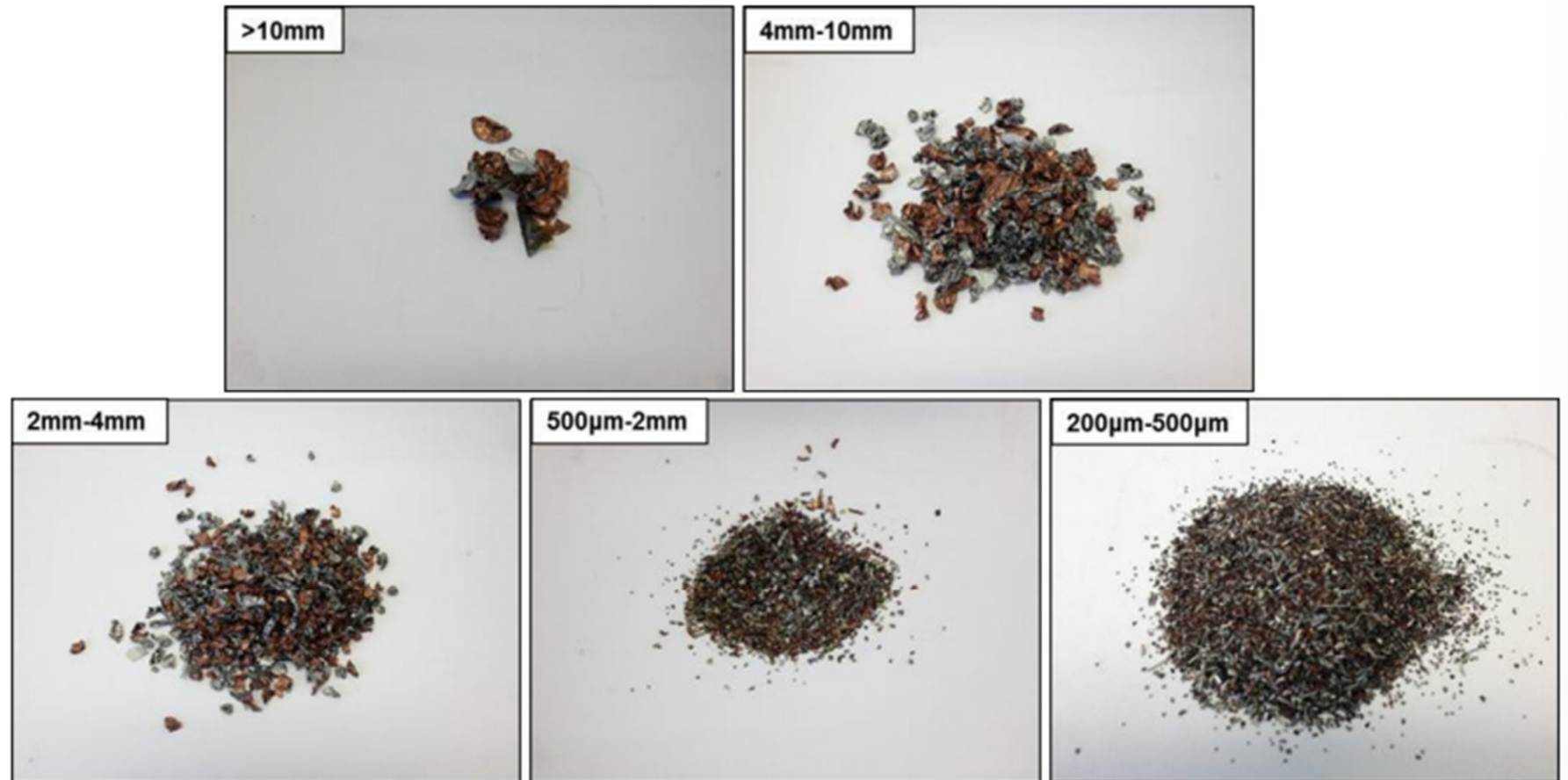
Comminution

- Results of the operating tests at Electrocycling, Goslar → rising matter



Comminution

- Results of the operating tests at Electrocyling, Goslar → falling matter



Comminution

- **Summary of the tests:**
 - The ROTOPLEX knife-edge mill produces the best results for:
 - Deformation of the comminuted product
 - Comminution of the coating components
 - Protection of the knife-edge mill using a magnetic separator and/or heavy item trap necessary
 - Clarification needed of the risk of potential dust explosion → could end up changing the process



Prospects

- **Installation of the system elements and commissioning of the pilot facility at Electrocycling, Goslar, around mid-2014**
- **Pilot operation with tests to characterize the comminution and processing products and the output of recyclable materials**
 - Variation in the feed material (battery module from the test vehicles of VW and Audi)
 - Variation in the machine parameters
- **Active materials containing lithium are used in the pilot facility for hydrometallurgical processing at Rockwood Lithium, Langelsheim**
- **Conclusion of the project in around mid-2015**



Thank you ...

For your attention!

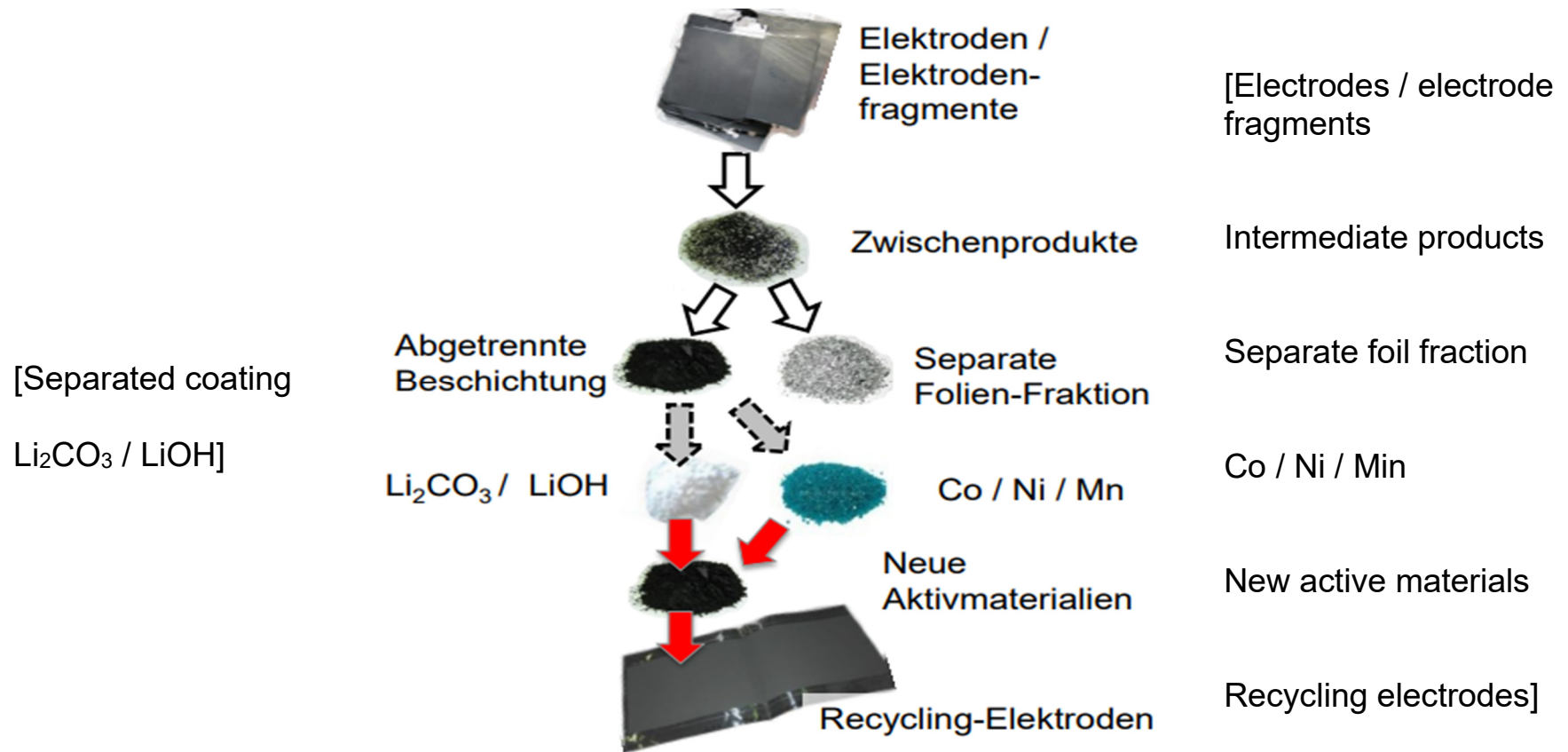
To the **LithORec II** consortium

And to the sponsor and
the project manager



Federal Ministry for the
Environment, Nature
Conservation, and
Nuclear Safety

VDI|VDE|IT



How a lithium-ion battery works

