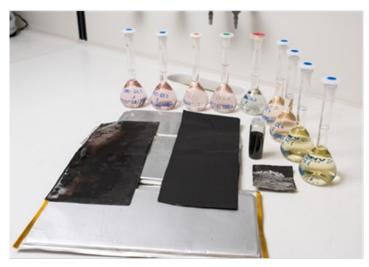
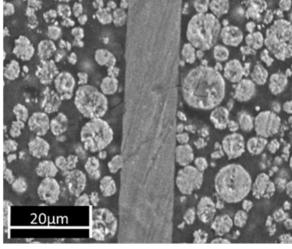


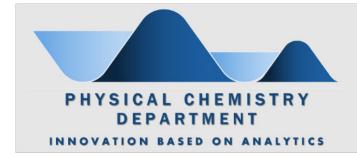
# EXPERTICE IN THE RESEARCH FOR LITHIUM ION BATTERY RECYCLING











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# R&D FOR INDUSTRY: RECYCLING OF LITHIUM-ION-BATTERIES



### **Fields of Expertise**

# **Recycling of Lithium Ion Batteries** end-of-life lithium ion batteries from cars, off spec batteries and scrap from lithium ion battery production **Mechanical-Thermal Recycling** comminution and separation under inert gas **Hydrometallurgical Recycling of NMC Black Mass** dissolution, separation, extraction Hydrometallurgical Recycling of LFP **Recovery of Graphite Electrochemical Refinement** Impurity and Degradation Traceability **Black mass Refinement** Reducing content of side component Strategies of Direct Recycling Recovery of NMC and LFP for re-use

### **Fields of Activity**

### **Industrial Recycling**

material flow balances for optimization:
analysis of material fractions after each process
step, e.g. exhaust gases, dust fractions, process
chemicals, impurities, carry-over of material
development of new process steps

### **Fundamental Research**

study of <u>degradation processes</u> during deep discharge, comminution or opening of cells and during recycling

new approaches to recycling

### **Chemical Analytics**

materials analysis: spectroscopy, microscopy, electrochemistry, particle analysis

High-precision chemical analytics

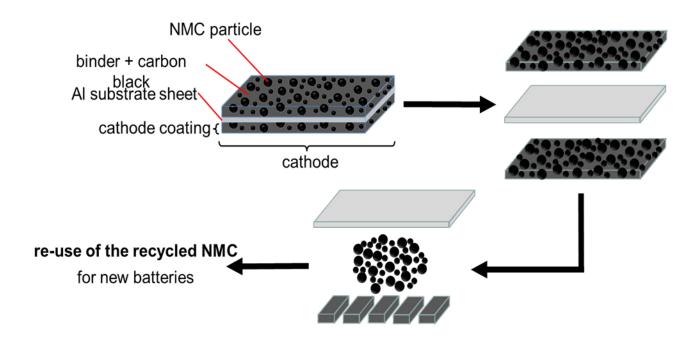
analytical methods suitable for industry

### FUNCTIONAL RECYCLING: OLD MATERIAL IN NEW BATTERIES



### Functional recycling:

Recovery of a material while maintaining its chemical and physical functionality.

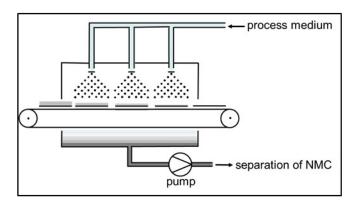


Recycling capacity: 1500 metric tons per year

Recycling efficiency: > 95%

CO<sub>2</sub> savings with NMC reuse : up to18% \*

### **World's First Functional Recycling Line**

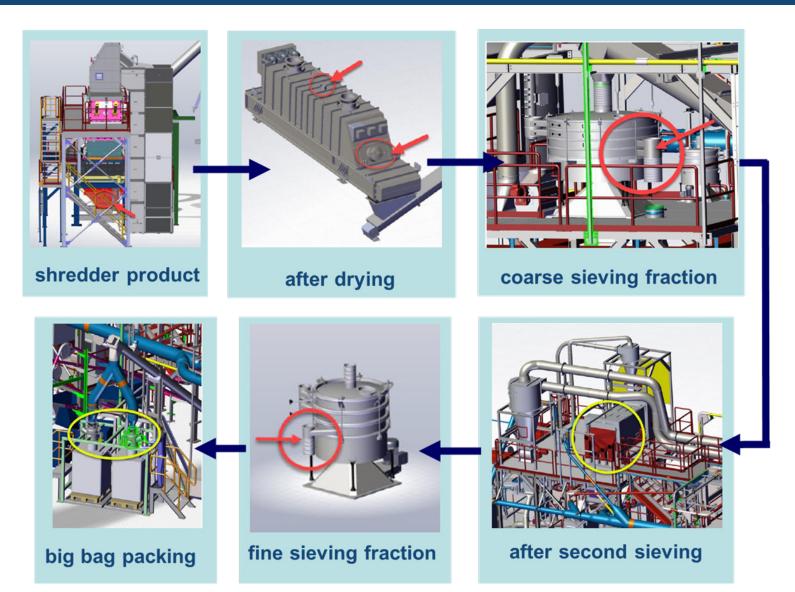




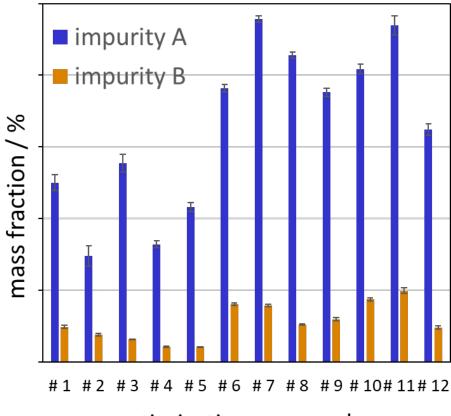
# STEP-BY-STEP ANALYSIS OF INDUSTRIAL RECYCLING:

### MONITORING AND TRACKING OF IMPURITIES





### Monitoring and tracking of impurities

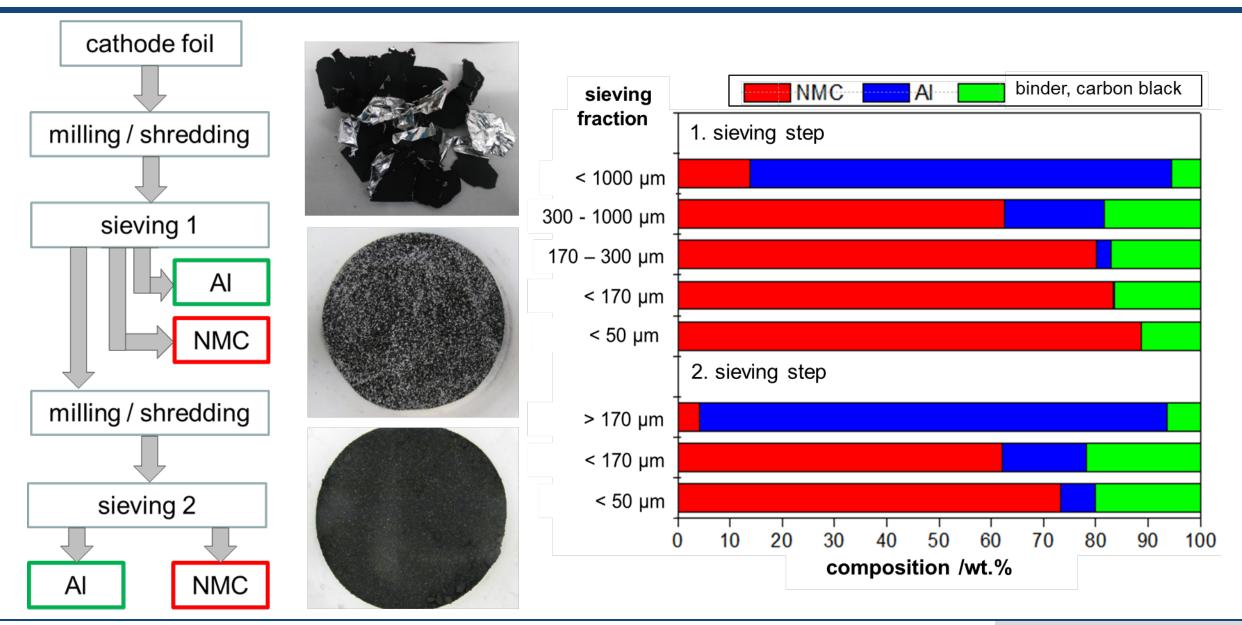


optimization run number

# MECHANICAL PROCESSING OF CATHODE MATERIAL:

RECYCLING OF OFF-SPEC CATHODE SHEET ROLLS





# **OUR CORE EXPERTISE: ANALYTICS!**



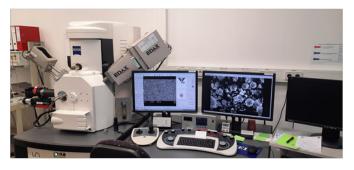
### **Analytical Techniques**

high-precision compositional chemical analytics by ICP-OES, ETV, CS-AAS; ion chromatography, gas chromatography, mass spectrometry, infrared spectroscopy and infrared microscopy, Raman spectroscopy and Raman microscopy confocal microscopy and interferometry, surface topography analysis, scanning electron microscopy incl. EDX and EBSD, thermal analysis, particle analysis, all electrochemical techniques

### Raman microscopy



**SEM-EDX-EBSD** 



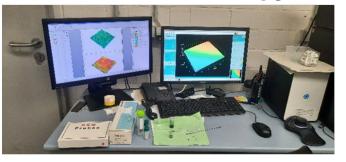
**ICP-OES** 



**Infrared microscopy** 



**Confocal microscopy** 



**Sample Preparation** 



