

# *Roll to Roll Equipment Business for EV Batteries*

**ULVAC, Inc.**

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*Leading the World  
In Vacuum Technology*

**ULVAC**

# Summary

## ❑ Why is Roll to Roll (R2R) Deposition Technology necessary?

With the rapid expansion of EVs and EV batteries, vacuum deposition technology is newly adopted and gaining importance, which enables battery components to be thinner and purer.

- Growing demand for R2R Thin Film Formation Technology as an alternative manufacturing method for Lithium-ion battery components
- Potential for further demand growth in anticipation of all-solid-state batteries

## ❑ Why is ULVAC? :

ULVAC is a manufacturer that can solve technical problems through thermal damage suppression technology for thin films and double-sided batch deposition technology.

- Electrode formation on ultra-thin film (suppression of thermal damage)
- High production efficiency and low cost (double-sided deposition technology)

Today, we will introduce the development status of "R2R deposition technology for Metalized polymer current collector" and the Initiative in the project of the METI Green Innovation Fund for "lithium vacuum deposition technology".

# Acceleration of EV shift worldwide

- Prohibit the sale of new internal combustion engine vehicles (gasoline/diesel), including hybrids, by 2030



- Ban on sales of new gasoline-powered vehicles by 2035 (except for hybrid vehicles)

Countries declared carbon neutrality targets  
Big automobile manufacturing countries  
declared **“Out of the gasoline car”**.  
Gasoline-powered vehicles will be banned  
from 2030-2035

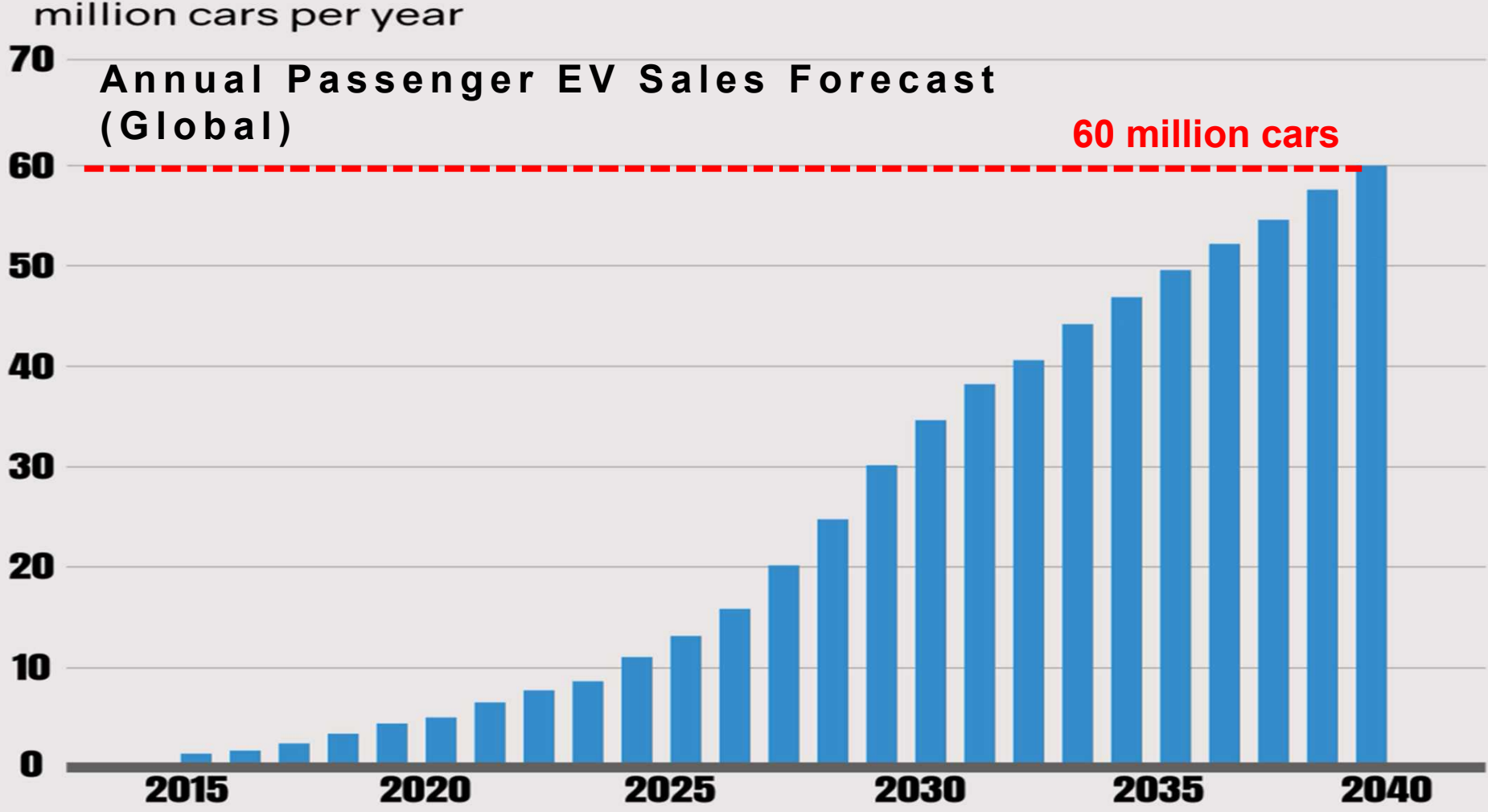


- Zero-emission vehicles to account for 50% of new car sales by 2030
- California bans Sales of New Gasoline-Powered Vehicles by 2035

- Ban on sales of new gasoline-powered vehicles in 2035 (except for hybrid cars)



# Rapid expansion of EV market $\Rightarrow$ Rapid increase in EV battery demand



Increase to **60 million worldwide** by 2040 (**55%** of **all passenger cars**)

# Technology competition for next-generation EV **batteries (LiB)**



## High capacity

Compact and high capacity  
Energy density 400wh/kg



## High power

Charging speed of 2C or higher  
(within 30 minutes)  
(20% ⇨ 80% charge time  
within 15 minutes)



## Long life

Cold resistant (-10°C)  
and High cycle life



## High safety

No ignition  
(Nail penetration test,  
etc.)



## Low cost

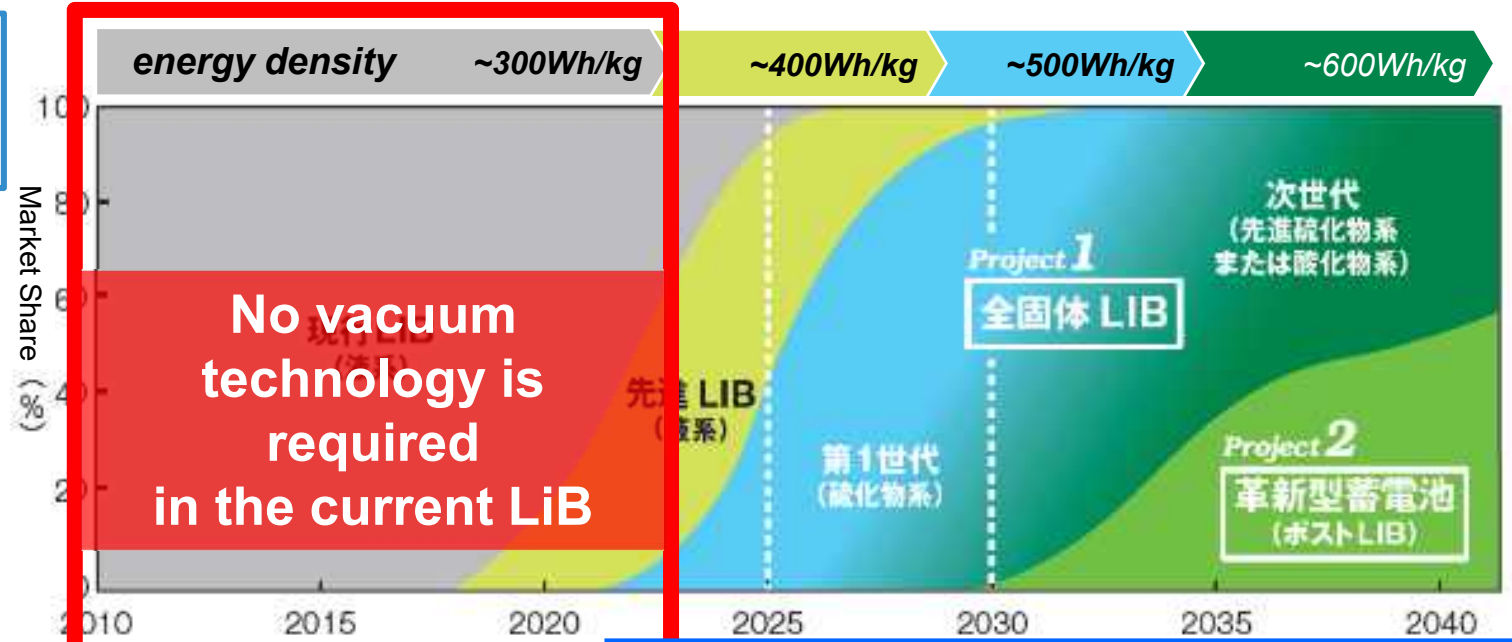
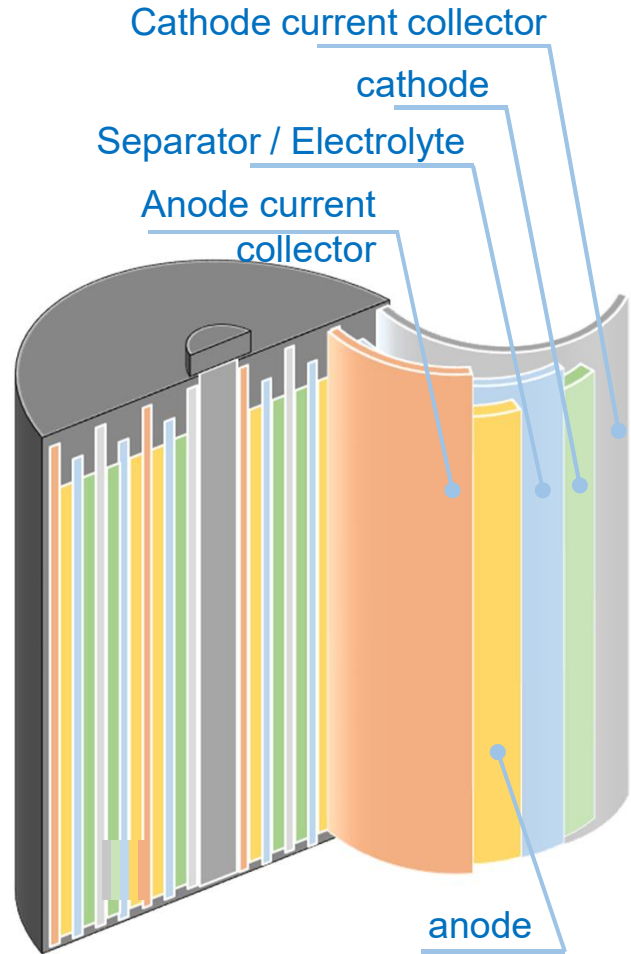
Half the cost  
(100USD/1kWh)

Key technologies to satisfy the requirements above simultaneously  
**ULVAC's R2R Thin Film Formation Technology**



# Trends in EV Battery Technology and Vacuum Technology Adoption

To realize Higher Performance EV Batteries → Increasingly high-energy and thinner various components

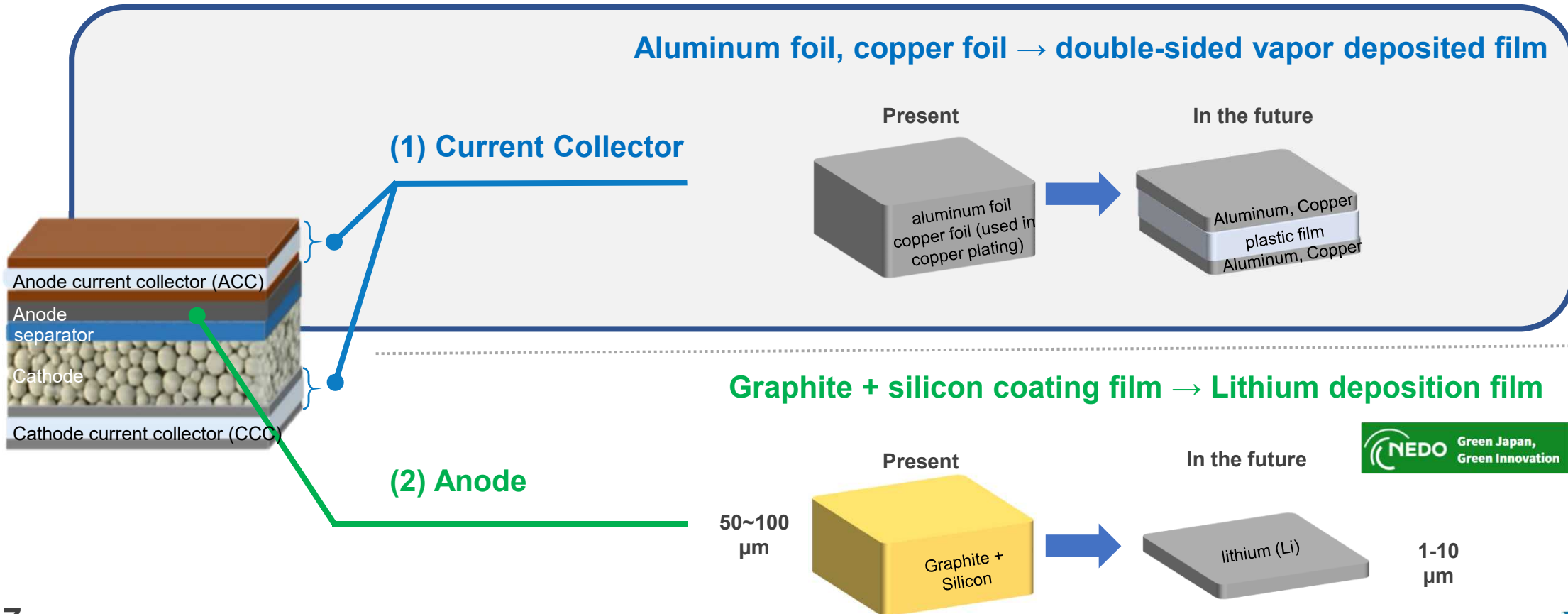


Positive electrode current collector	Al foil	1 μm thickness	6 μm thickness	4 μm thickness
Cathode	LFP/NCM	High Ni compounds	Sulfur / Air	
Separator	PP	PP + ceramic coating	all-solid-state (oxide-based)	
Electrolyte	liquid system	polymer-based	all-solid-state (oxide-based)	
Anode	graphite	Graphite + Silicon	lithium metal	
Anode current collector	Cu Foil 10 μm thickness	8 μm thickness	6 μm thickness	4 μm thickness

**Vacuum Technology utilized in next generation LiB materials**

# ULVAC's Thin Film Deposition Technology for EV Batteries / Summary

- Developed Roll to Roll evaporation equipment to realize smaller, larger capacity, and safer EV batteries
- ① Current collector: Started investment to replace metal foil with double-sided vapor-deposited film to achieve safety and weight reduction (FY2022)
- ② Anode: To replace conventional "graphite + silicon" to achieve high capacity ⇒ "lithium vapor deposition film" :  
⇒ Adopted by NEDO Green Innovation Fund Project "Development of Next-Generation Storage Batteries and Next-Generation Motors" to enhance development



# ULVAC's Thin Film Deposition Technology for EV Batteries

## Advantages of Metalized polymer current collector (double-sided vapor deposited film)

### (1) Safety

The structure of "insulating substrate + thin-film conductive layer" enables short-circuit current to be interrupted immediately when the battery is short-circuited and effectively prevents melting of the film and thermal runaway of the EV battery.

### (2) High energy density

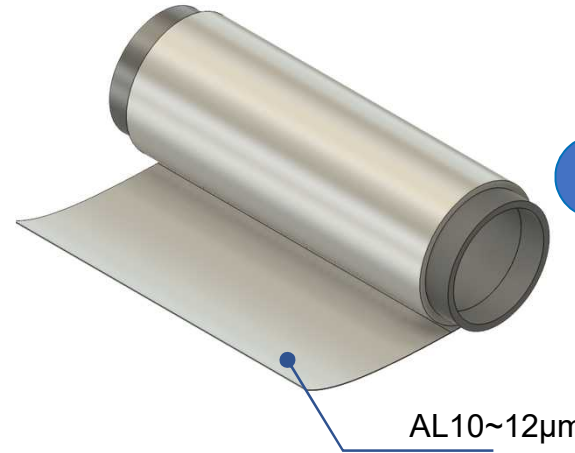
The weight of the Metalized polymer current collector can be significantly reduced to increase the battery's weight energy density due to the low density of the PET film used as the base material.

### (3) Reduction of Environmental Impact

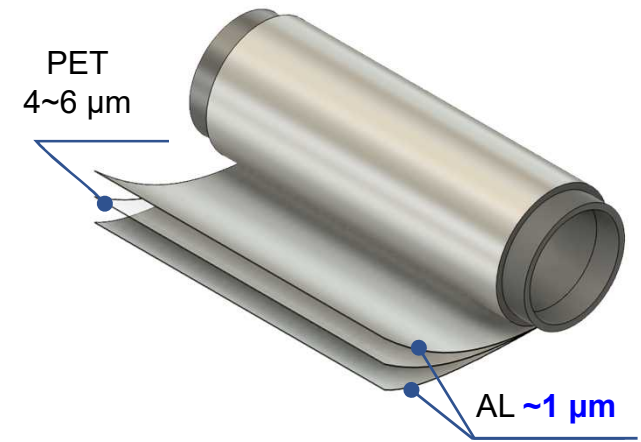
Reduction in the use of metal materials that have a high environmental impact during refining. Also can reduce material costs.

## (1) Current Collector

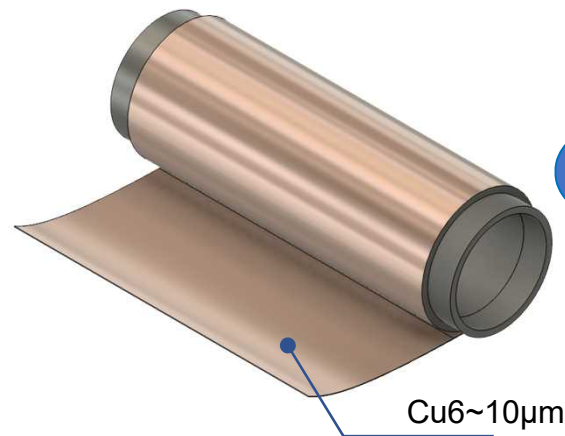
Cathode current collector (AL foil)



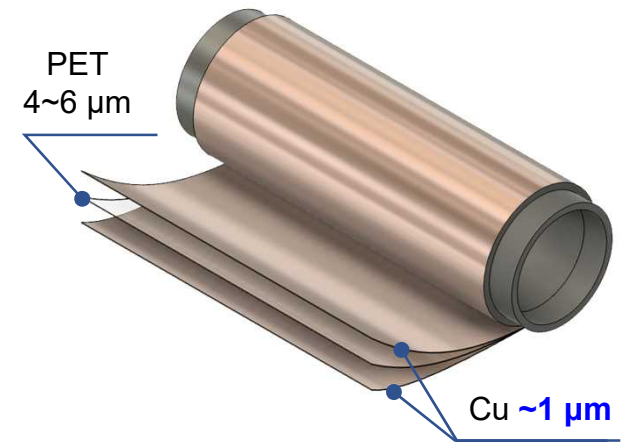
Metalized polymer current collector for Cathode (AL/PET/AL)



Anode current collector (Cu foil)



Metalized polymer current collector for Anode (Cu/PET/Cu)





# ULVAC's Thin Film Deposition Technology for EV Batteries

(1) Current Collector

**Production technology for Metalized polymer current collector (Metal/PET/Metal laminated film)**

## Suppression of thermal damage to film

While PET film has a thermal resistance of about 100°C, the deposition of evaporated particles usually heated to about 1000°C

⇒ **Technology is needed to control thermal damage to the film**

## Productivity Improvement of vacuum equipment

While raw material costs have been reduced due to lower use of metal materials, the processing costs increased due to the use of expensive vacuum equipment.

This is a challenge, and there is a need to improve the productivity of the vacuum equipment.

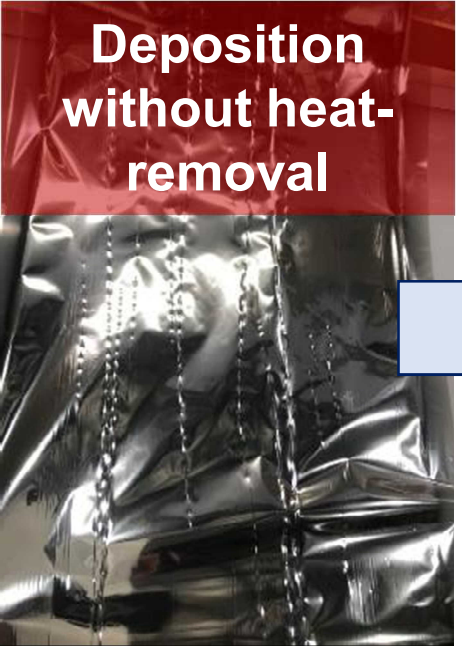
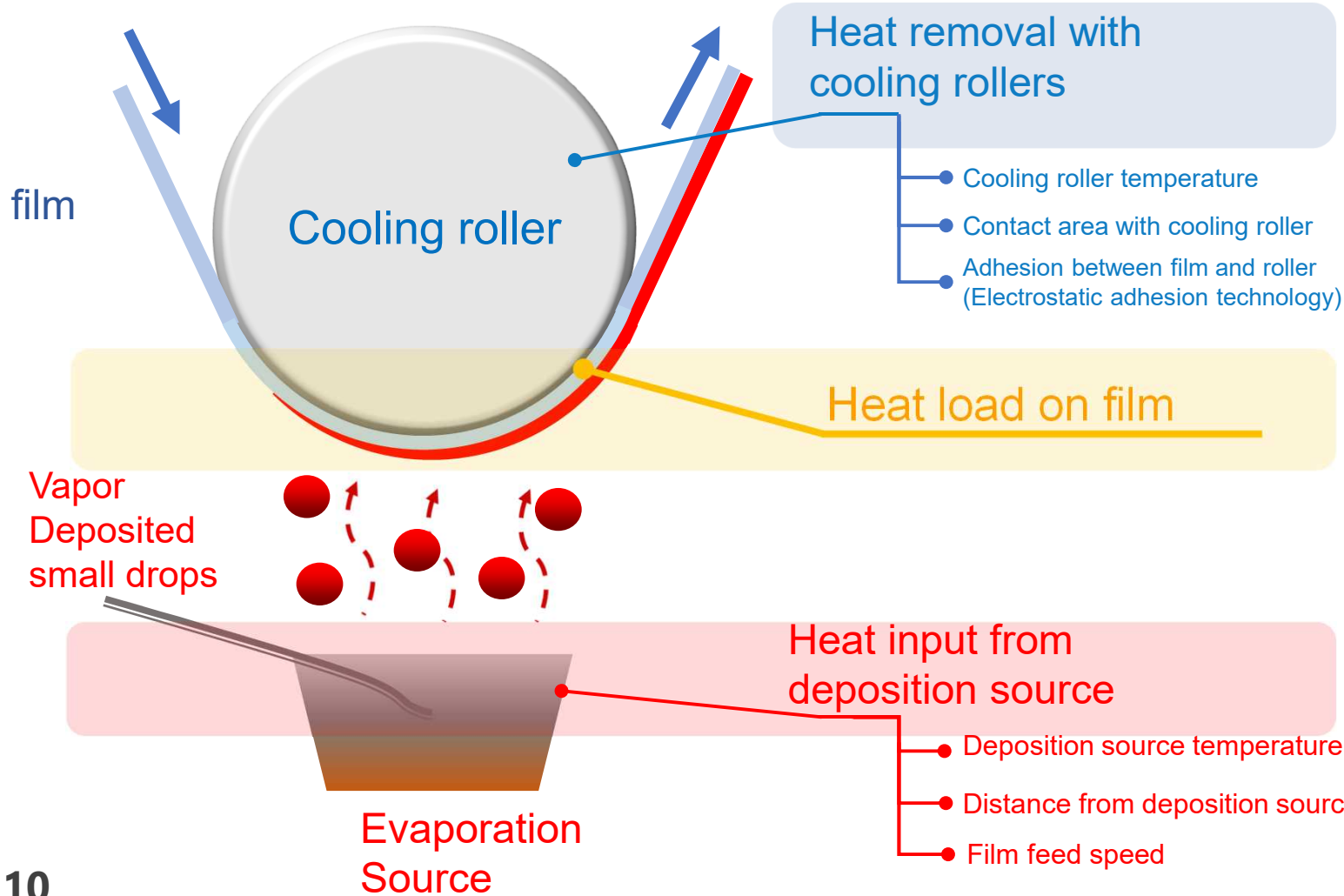
⇒ **Wide film support, increase production speed, and batch processing on both sides of the film are the key to the “Productivity Improvement”.**



**Wrinkles and tears.  
Thermal damage occurs**

# ULVAC's Thin Film Deposition Technology for EV Batteries

## Suppression of thermal damage to film

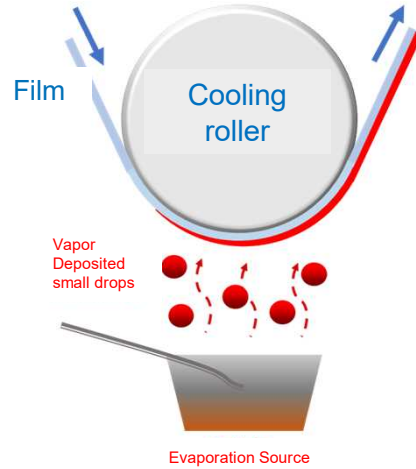


# ULVAC's Thin Film Deposition Technology for EV Batteries

## Productivity Improvement of vacuum equipment

Conventional evaporation equipment (single-sided deposition)

Double-sided deposition	Two depositions on each side
Film width	1000mm
Film length	2000m
Winding speed	10m/min

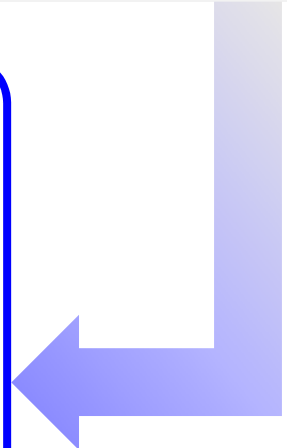
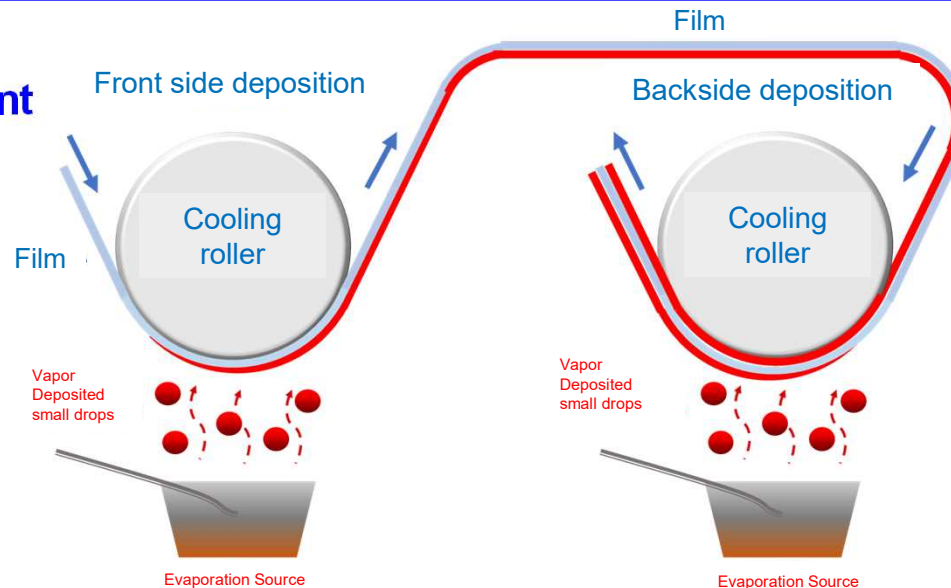


### ULVAC's Core technologies

- Ultrathin film winding and conveying technology
- High-speed deposition technology
- Double-sided batch deposition transfer technology

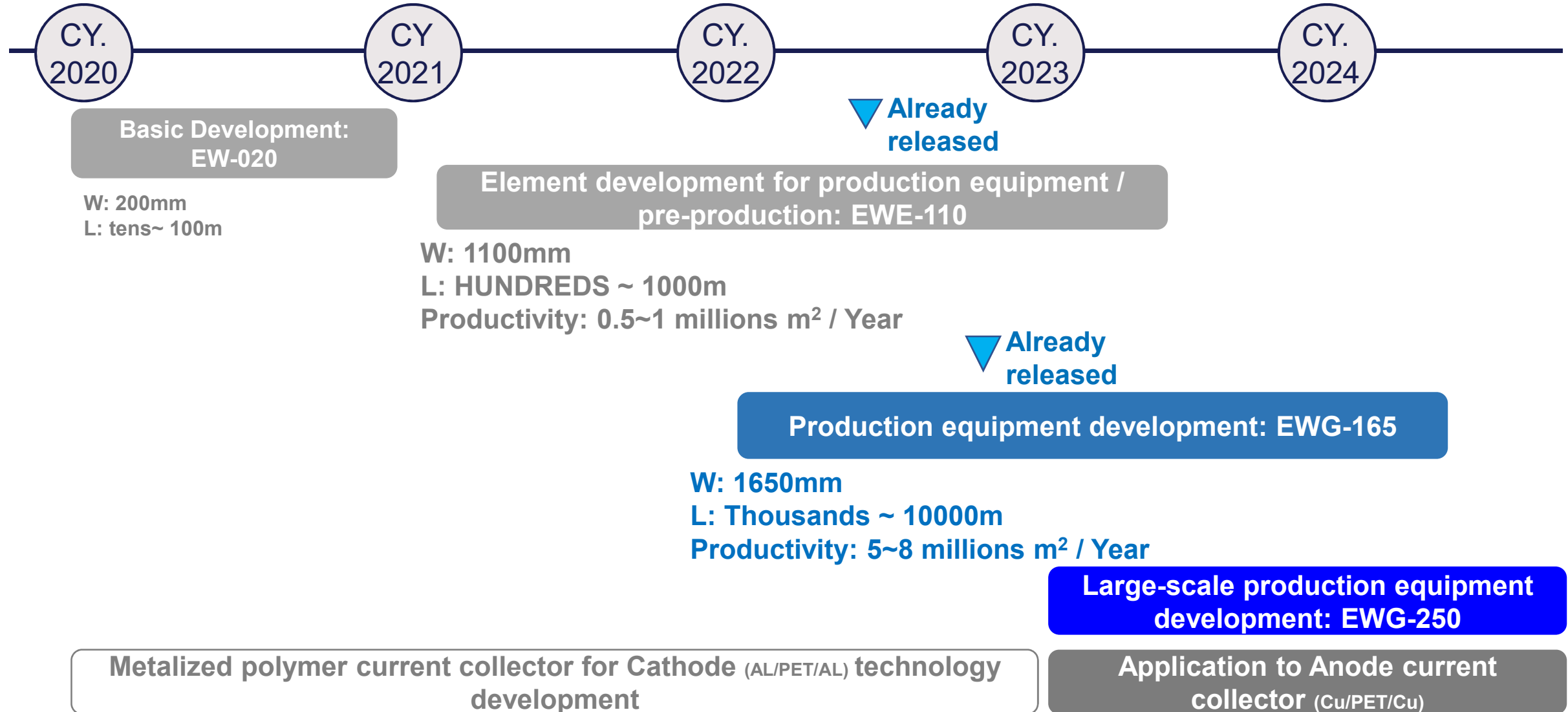
### New ULVAC Technology Evaporation Equipment for Double-sided Deposition

Double-sided deposition	Simultaneous deposition on both sides
Film width	1650mm
Film length	3000m
Deposition speed	17m/min



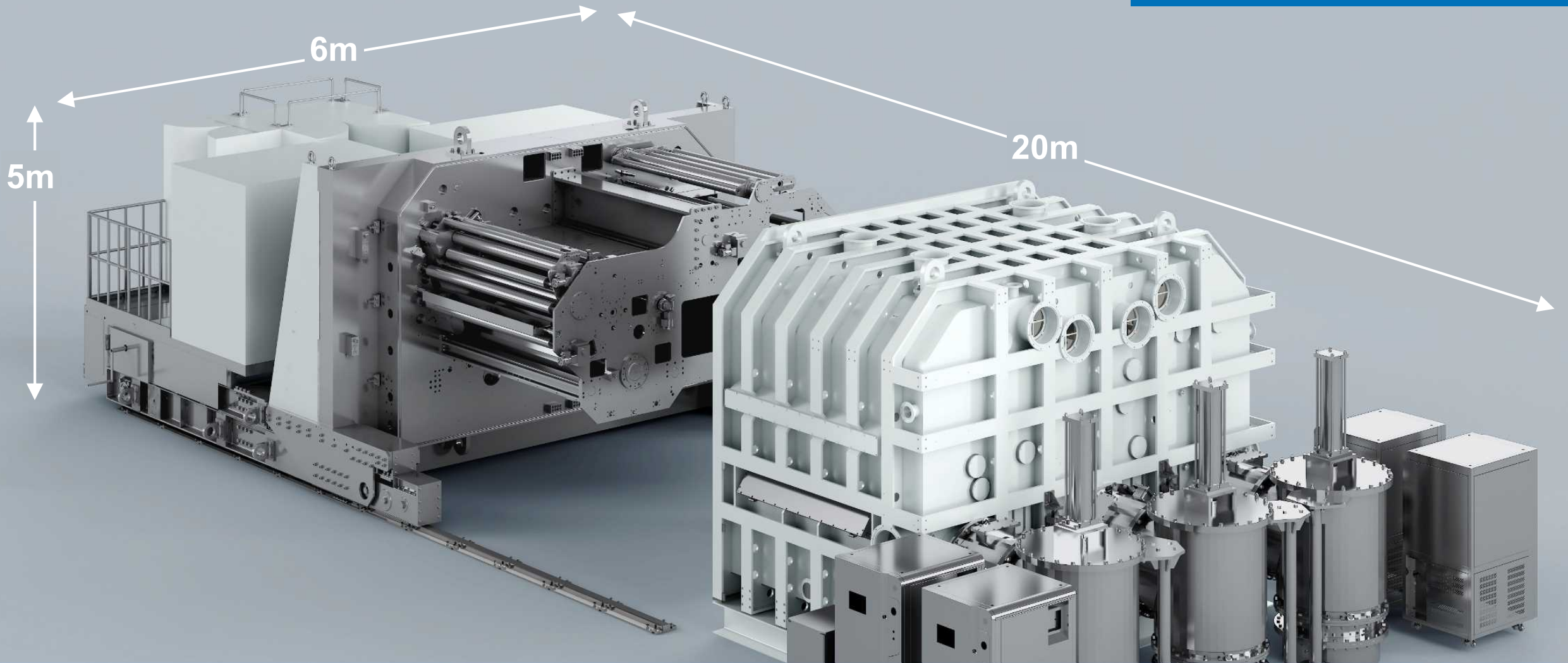
# ULVAC's Thin Film Deposition Technology for EV Batteries

(1) Current Collector





(1) Current Collector

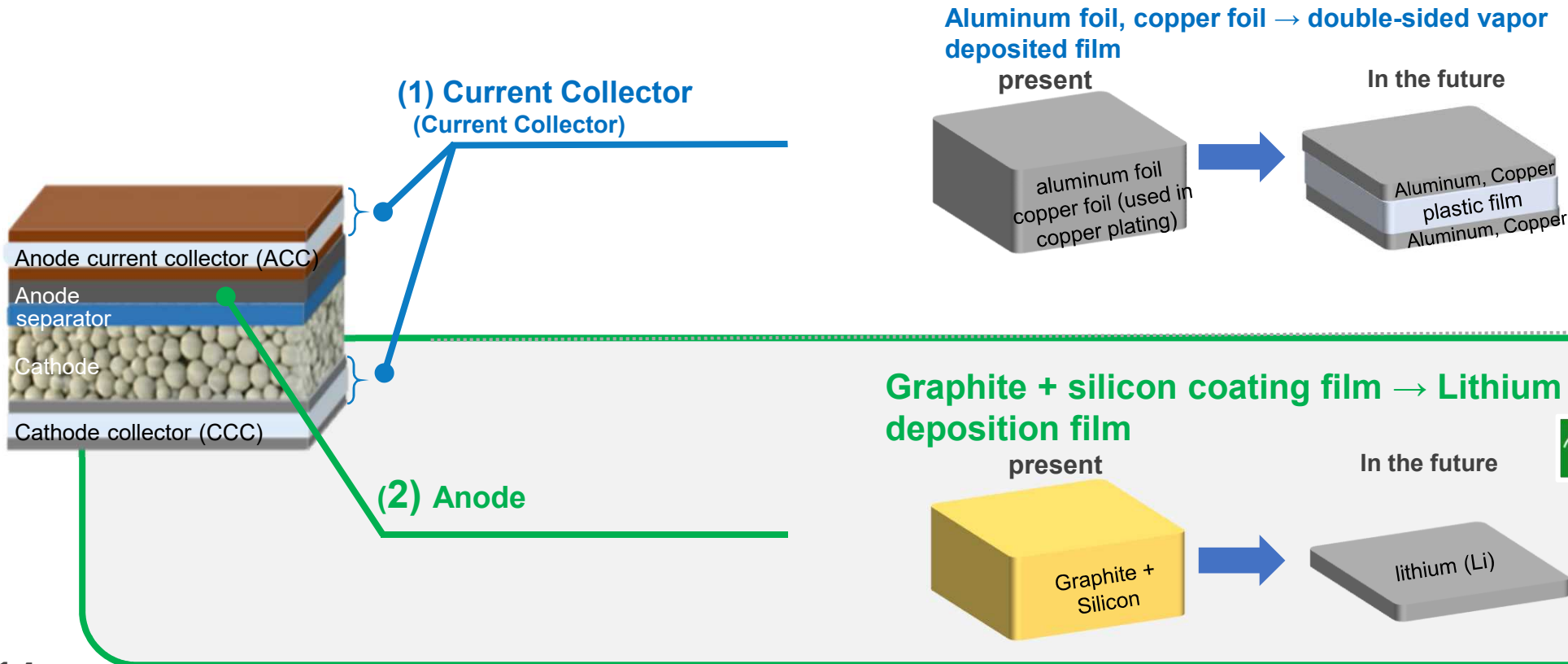


Available for 1650mm film width  
Roll to Roll deposition system for Metalized polymer current collector  
EWG-165



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# ULVAC's Thin Film Deposition Technology for EV Batteries

(2) Anode



energy density

350 mAh/g

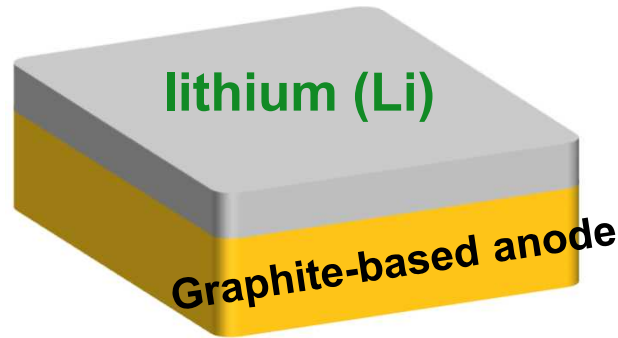
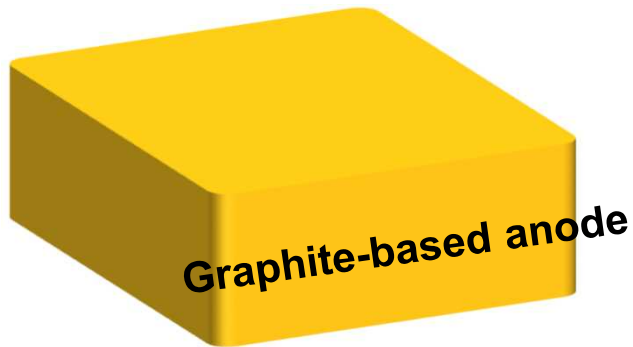
energy density

1000mAh/g

energy density

3500 mAh/g

Metal lithium contributes to improved Anode performance



# ULVAC's Thin Film Deposition Technology for EV Batteries

## Lithium metal anode production technology

### Production of lithium metal foil with low impurities

If impurities or surface irregularities are existing on the surface of the lithium metal anode, the Needle-like protrusions called “Dendrites” are formed, and Dendrites will be ignited when reaching the cathode.

⇒ Necessary to form metallic lithium with high purity and less surface irregularities.

### Copper foil conveying technology in vacuum

Conventional Roll to Roll equipment handles highly elastic plastic film.

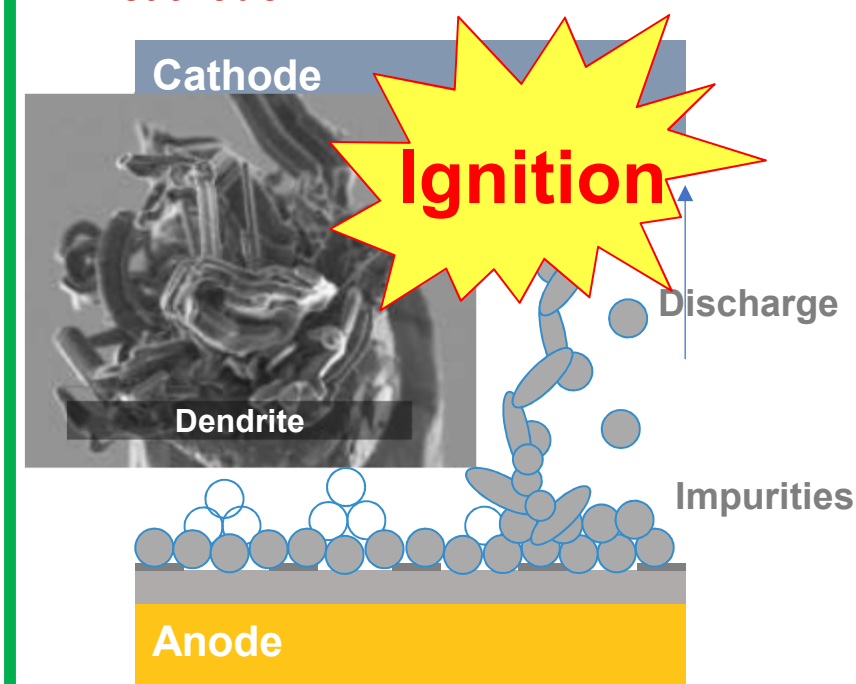
On the other hand, usually the Anode of a lithium battery has low elasticity.

⇒ Necessary to handle wrinkle-prone metallic foil.

## (2) Anode

### Anode Technology Issues

When the dendrites (needle-like protrusions) reached the cathode...



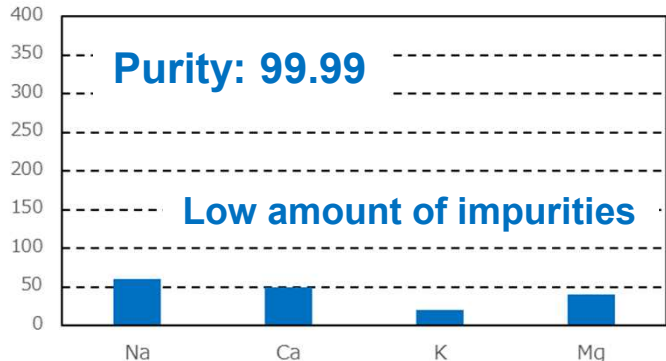
Ref. ) K. Kanamura *et al.*, BLI X, Symposium on Energy Storage (2017), p. 4, 6  
O. Mashtalir *et al.*, ACS Omega (2018) 3, 181-187

# ULVAC's Thin Film Deposition Technology for EV Batteries

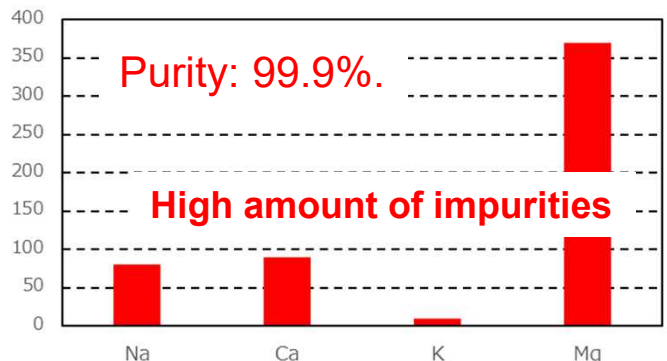
(2) Anode

High Purity Lithium

Vacuum deposition

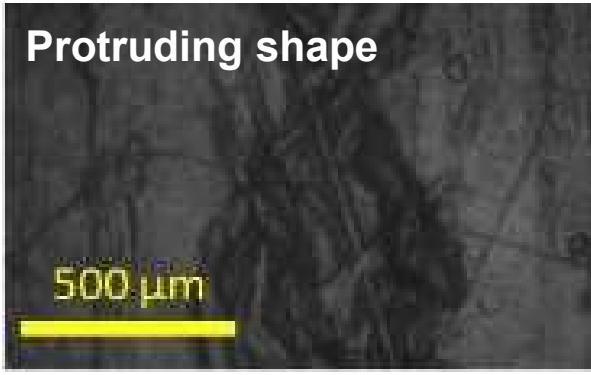
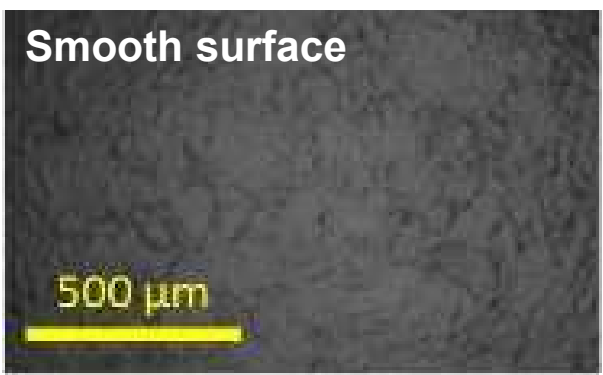


Conventional technology (rolling)



Source) 60th Battery Discussion Group 2019, 1B29

Surface smoothness



A production technology for lithium metal foil with high purity and smoothness has been established. Transition to the development of applications for the anode of next-generation batteries, represented by all-solid-state batteries

# ULVAC's Thin Film Deposition Technology for EV Batteries

## Lithium metal anode production technology

### Production of lithium metal foil with low impurities

⇒ If impurities or surface irregularities are existing on the surface of the lithium metal anode, the Needle-like protrusions called “Dendrites” are formed, and Dendrites will be ignited when reaching the cathode.

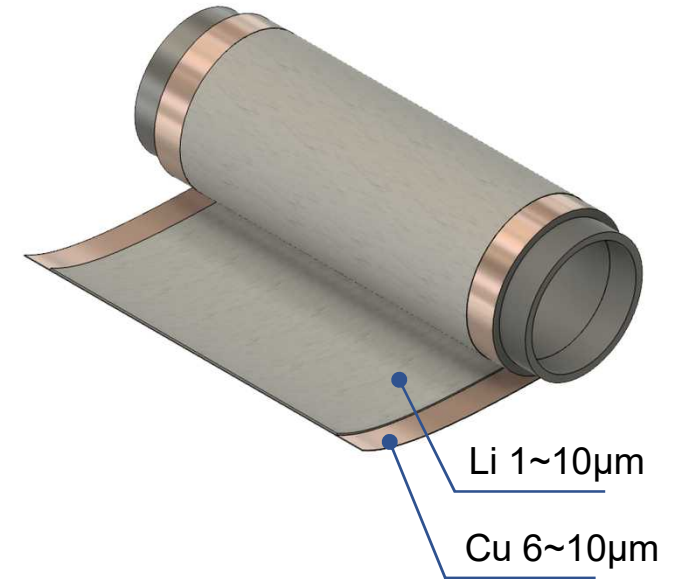
Necessary to form metallic lithium with high purity and less surface irregularities.

### Copper foil conveying technology in vacuum

Conventional Roll to Roll equipment handles high Elastic plastic film.  
On the other hand, usually the Anode of a lithium battery has low Elasticity.  
⇒ Necessary to handle wrinkle-prone metallic foil.

## (2) Anode

Lithium metal anode (Li/Cu)



Substrate Properties	PET	<b>copper foil (using copper plating)</b>
Elasticity (Growth rate)	188%.	<b>7%</b>



### グリーンイノベーション基金事業／次世代蓄電池・次世代モーターの開発

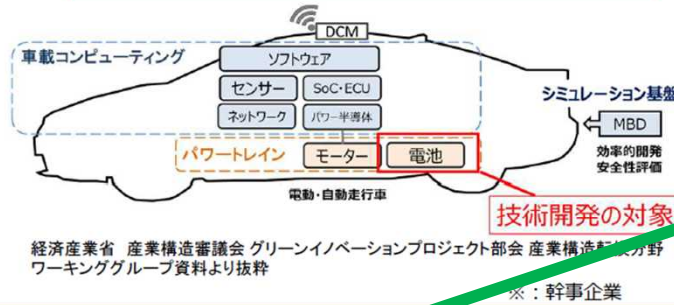
別紙 2

#### 研究開発項目1-1 高性能蓄電池・材料の研究開発、研究開発項目1-2 蓄電池のリサイクル関連技術開発

##### 事業の目的・概要

- 全固体電池などの**高性能蓄電池**やその**材料**の開発  
目標：航続距離などに影響するエネルギー密度が現在の2倍以上 など
  - 省資源材料**（コバルト（Co）や黒鉛など）や材料等の**低炭素製造プロセス**開発
  - 低コスト、高品質なレアメタル回収を実現する**蓄電池リサイクル技術**の開発  
目標：リチウム70%、ニッケル95%、コバルト95%の回収
- 事業規模：約2,132億円
  - 支援規模\*：上限1,205億円  
\*インセンティブ額を含む。今後ステージゲートなどで事業進捗などに応じて変更の可能性あり。
  - 事業期間：2022年度～2030年度
  - 補助率など：2/3補助→1/2補助→1/3補助（インセンティブ率は10%）

##### 事業イメージ



##### 高性能蓄電池（研究開発項目1-1）

- 全固体電池の早期実用化**  
様々な技術アプローチで開発加速。有望技術の見極めを進めていく。
- 本田技研工業(株)\*、(株)本田技術研究所**  
：製造時のCO<sub>2</sub>排出量を抑え、将来の材料進化にも対応可能な、柔軟性のある**全固体電池量産技術**の徹底的な磨き上げ
- 日産自動車(株)**：全固体電池の特徴を最大限に活かす**野心的な電池設計、高品質量産**に挑戦
- (株)GSユアサ**：独自開発の**高性能固体電解質**や材料表面加工技術を活用し、**多様な正極材・負極材の組み合わせ**で性能を追求
- 液系LIBや樹脂電池の高性能化**
- パナソニック エナジー(株)**：液系LIBの更なる高容量化。Coフリー正極活用や高密度充填パック電池設計
- マツダ(株)**：高入出力・高容量を両立する液系LIB開発。Coフリー正極や高性能負極活用
- APB(株)**：正極材、負極材、樹脂の性能向上等を通じ、高容量な**全樹脂電池**を開発

##### 蓄電池材料（研究開発項目1-1）

- 次世代蓄電池の材料技術の開発**  
正極、負極、電解質など、全固体電池を含む**高性能リチウムイオン電池の材料技術の開発**を支援。
- 住友金属鉱山(株)**：高性能正極材料  
高容量材料組成検討・粒子特性制御、表面加工技術、製造段階のCO<sub>2</sub>削減を可能とする**新規製造プロセス**の開発
- (株)アルバック**：リチウム金属負極生産技術  
全固体電池を見据え、独自の真空蒸着技術を活用した**薄膜リチウム金属負極の生産技術開発**
- 出光興産(株)**：固体電解質  
粒子形状の制御された**固体電解質の大規模製造技術開発**
- (株)大阪ソーダ**：超高イオン伝導性ポリマー  
次世代負極（シリコン、リチウム金属）のデメリットである**体積変化を緩衝する全固体電池用超高イオン伝導性ポリマー**を開発

##### リサイクル技術（研究開発項目1-2）

- レアメタル回収技術の高度化研究**  
乾式処理<sup>(1)</sup>や湿式処理<sup>(2)</sup>、**ダイレクトリサイクル<sup>(3)</sup>**など、多様なアプローチでリサイクル技術を高度化。
- (1) 熱処理による金属分離  
(2) 水溶液中処理による金属分離  
(3) 回収した材料を金属ごとに分離することなく、直接電池材料に戻す技術
- 住友金属鉱山(株)\*、関東電化工業(株)**  
：乾式・湿式を組み合わせた独自の製錬技術を開発し、高回収率・低コスト化を実現
- JX金属(株)**：無害化前処理技術並びに湿式処理による金属回収技術の高度化
- (株)JERA\***・**住友化学(株)**：非焙焼方式の材料分離回収技術および回収した正極材の**ダイレクトリサイクル、アップリサイクル**の研究開発
- 日産自動車(株)**：特定電極のみをリサイクルすることで、電池ライフサイクルでのCO<sub>2</sub>排出量を低減する技術開発

Adopted by NEDO Green Innovation Fund Project “Development of Next-Generation Storage Batteries and Next-Generation Motors”

### Battery Materials (R&D Items 1-1)

#### ◆ Development of material technology for next-generation storage batteries

Supporting the development of material technologies for high-performance lithium-ion batteries, including All-Solid-State batteries, such as Cathodes, Anodes, and Electrolytes.

- **ULVAC, Inc.**  
**Lithium Metal Anode Production Technology**  
Development of thin-film lithium metal anode production technology utilizing proprietary vacuum technology with a view to realize All-Solid-State batteries



# ULVAC Vacuum Technology Contributes to Many Industries and Applications



**ULVAC**