All-solid-state lithium battery using $LiBH_4$

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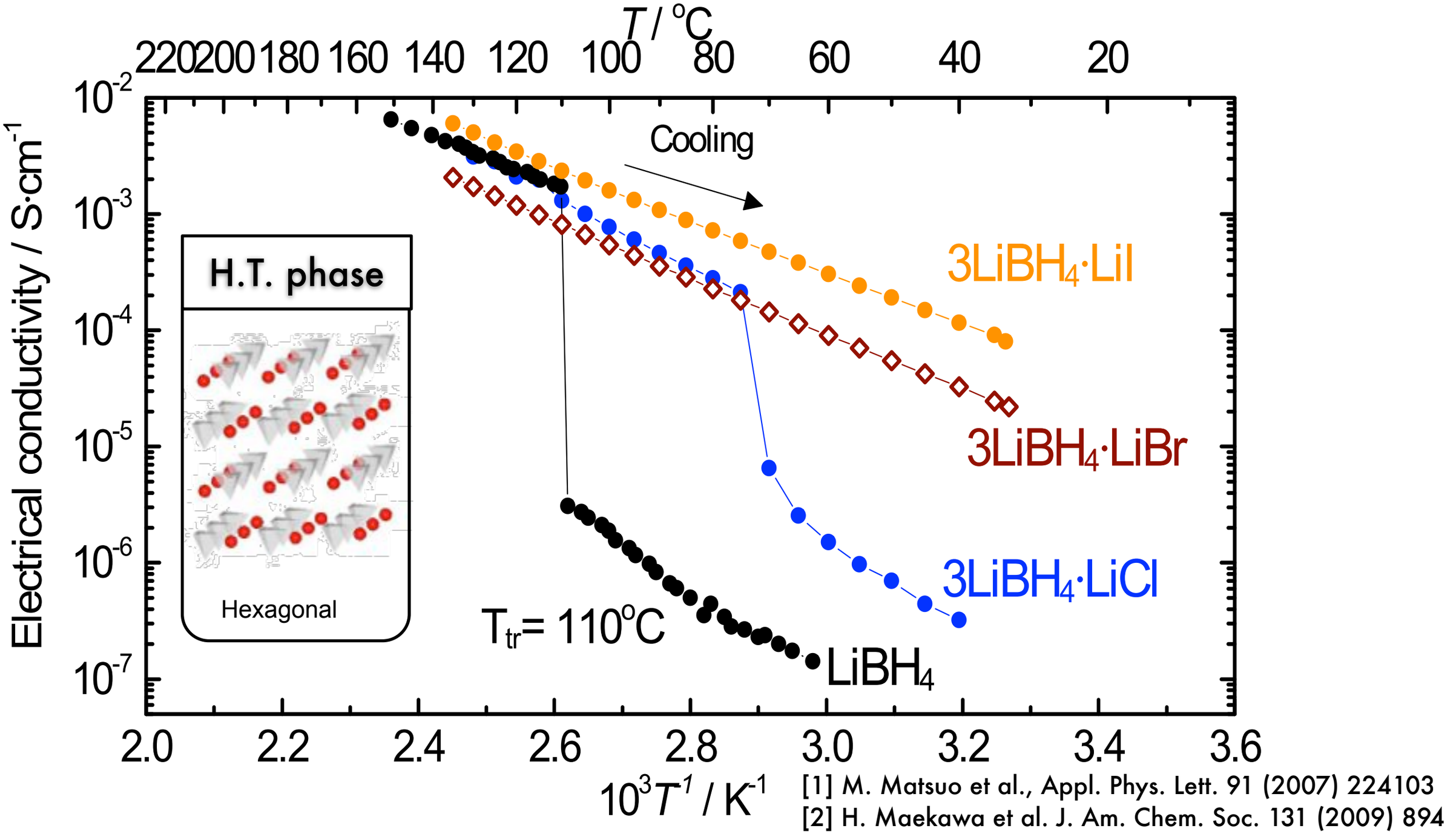
Solid electrolyte: $LiBH_4$

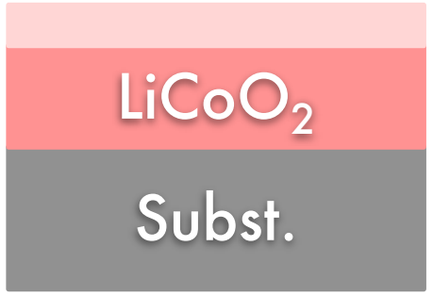


[1] M. Matsuo et al., Appl. Phys. Lett. 91 (2007) 224103
[2] H. Maekawa et al. J. Am. Chem. Soc. 131 (2009) 894

- Enhancement of Li-ion conductivity at 115˚C accompanied by phase transition
- The H.T. phase can be stabilized by partial substitution of BH_4^- by halides.

Fabrication process

Li_3PO_4 intermediate layer



Li_3PO_4

- High chemical and thermal stability
- Relatively high ion conductivity in the amorphous state
- Low electric conductivity

Thin-film $LiCoO_2$ by PLD

Li_3PO_4-coated $LiCoO_2$ thin-films prepared by PLD.

- Smooth surface
- Easy control of the thickness
- No additive is necessary (e.g. carbon black)

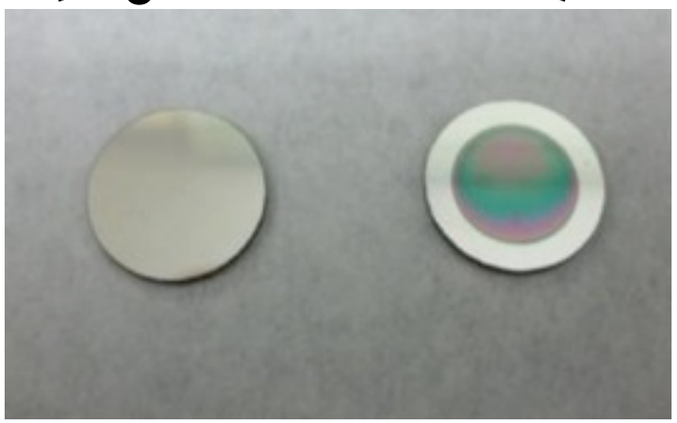
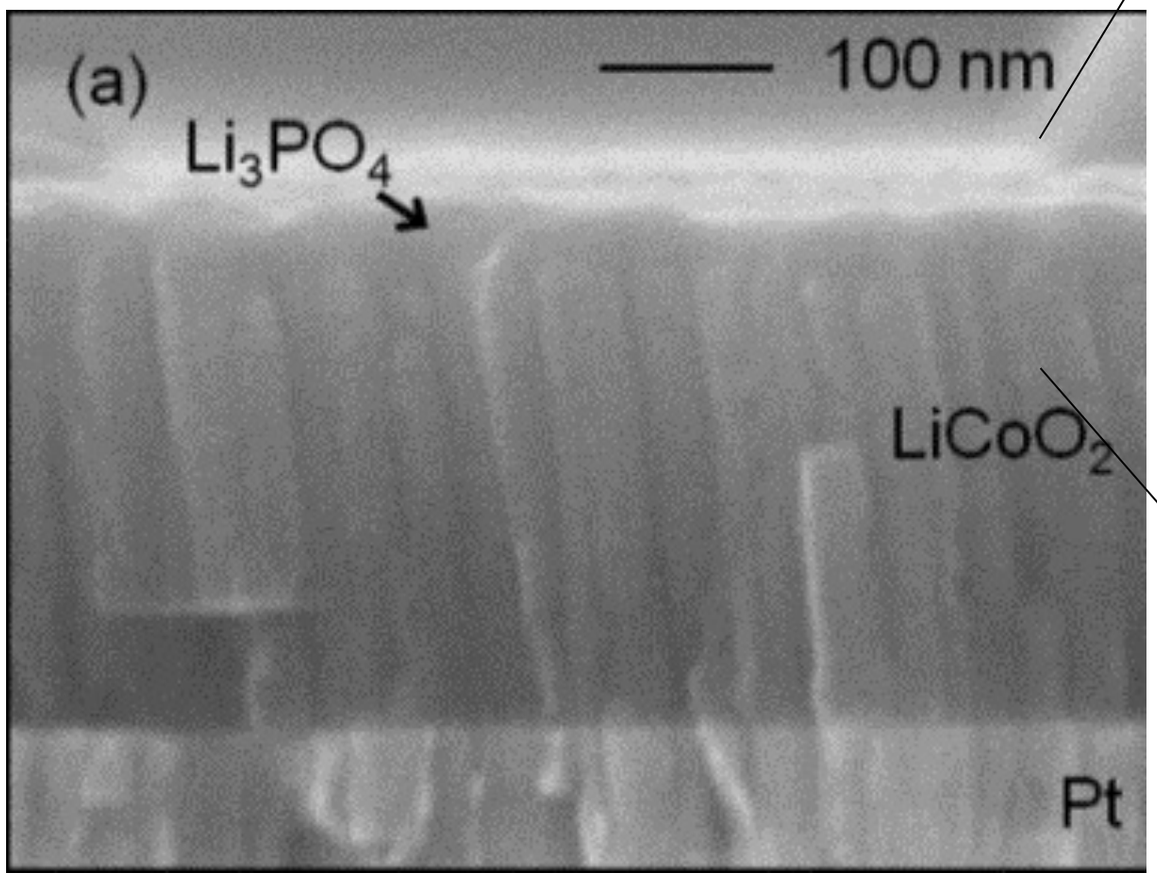


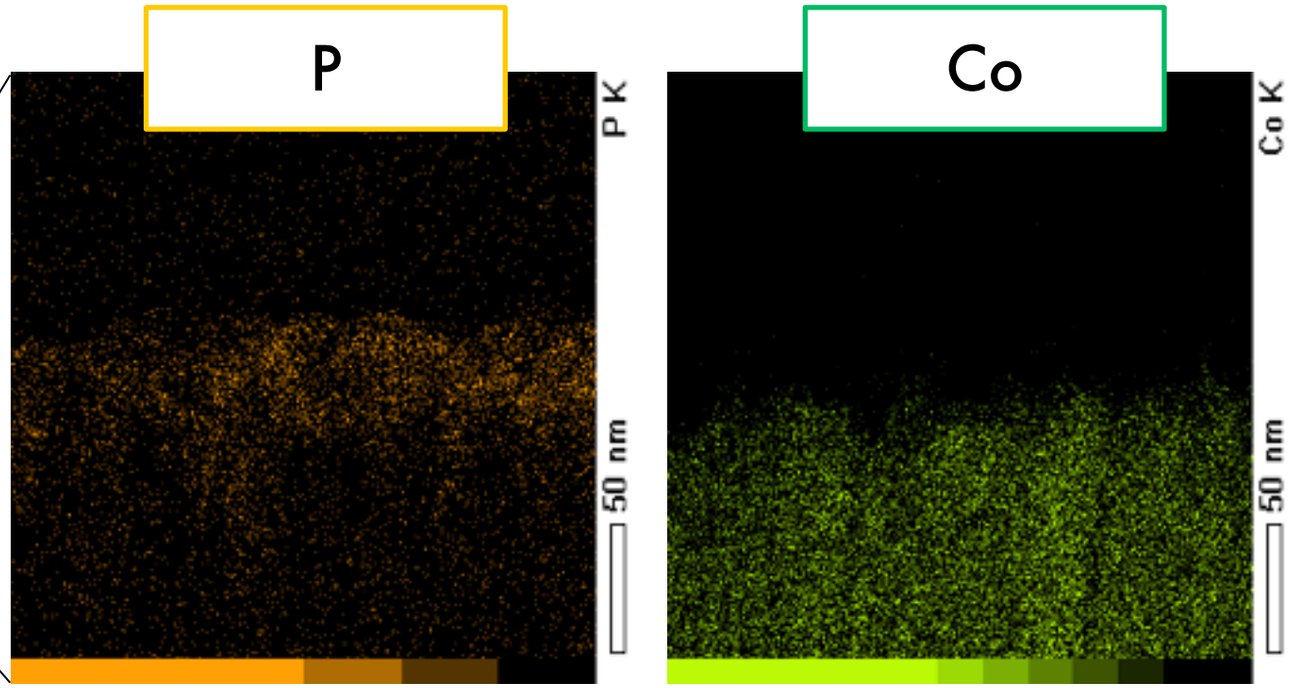
Table. Optimized growth conditions for thin-films

	$LiCoO_2$	Li_3PO_4
Target	$LiCoO_2+Li_2O$	Li_3PO_4
Atmosphere	O_2 10 Pa	O_2 1 Pa
Subst. Temp.	300°C	R. T.
Laser Power	300 mJ	150 mJ
Laser Freq.	10 Hz	5 Hz
Depo. Time	15 min	4 min
Thickness	300 nm	25 nm
Type	Crystal	Amorphous
σ(Li) @25°C	1×10^{-7} S/cm	4.6×10^{-7} S/cm

Cross-sectional SEM image of the thin-film

25 nm Li_3PO_4-coated $LiCoO_2$





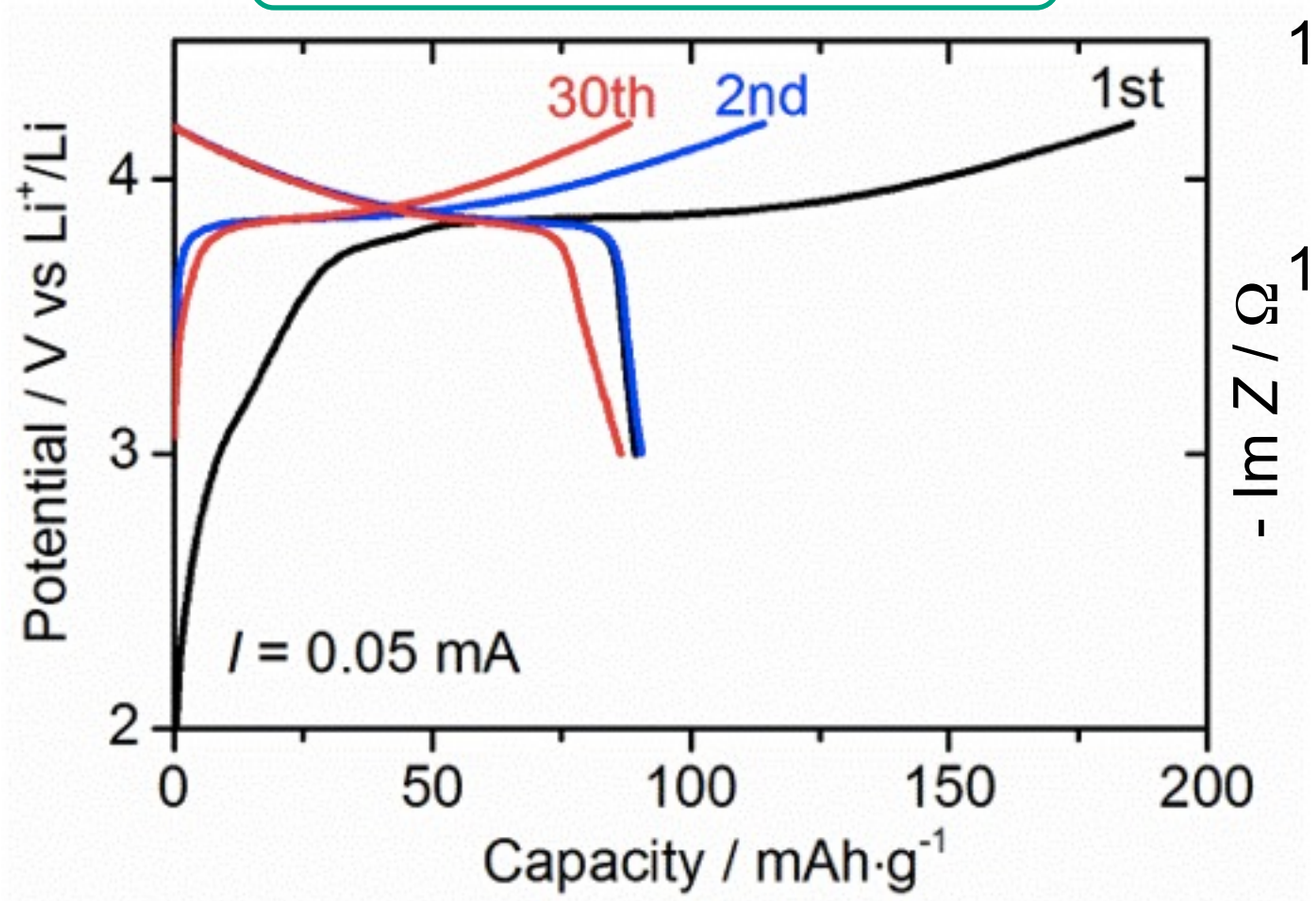
EDX analysis

- 25 nm-thick Li_3PO_4 intermediate layer was grown on the columnar $LiCoO_2$ thin-film.

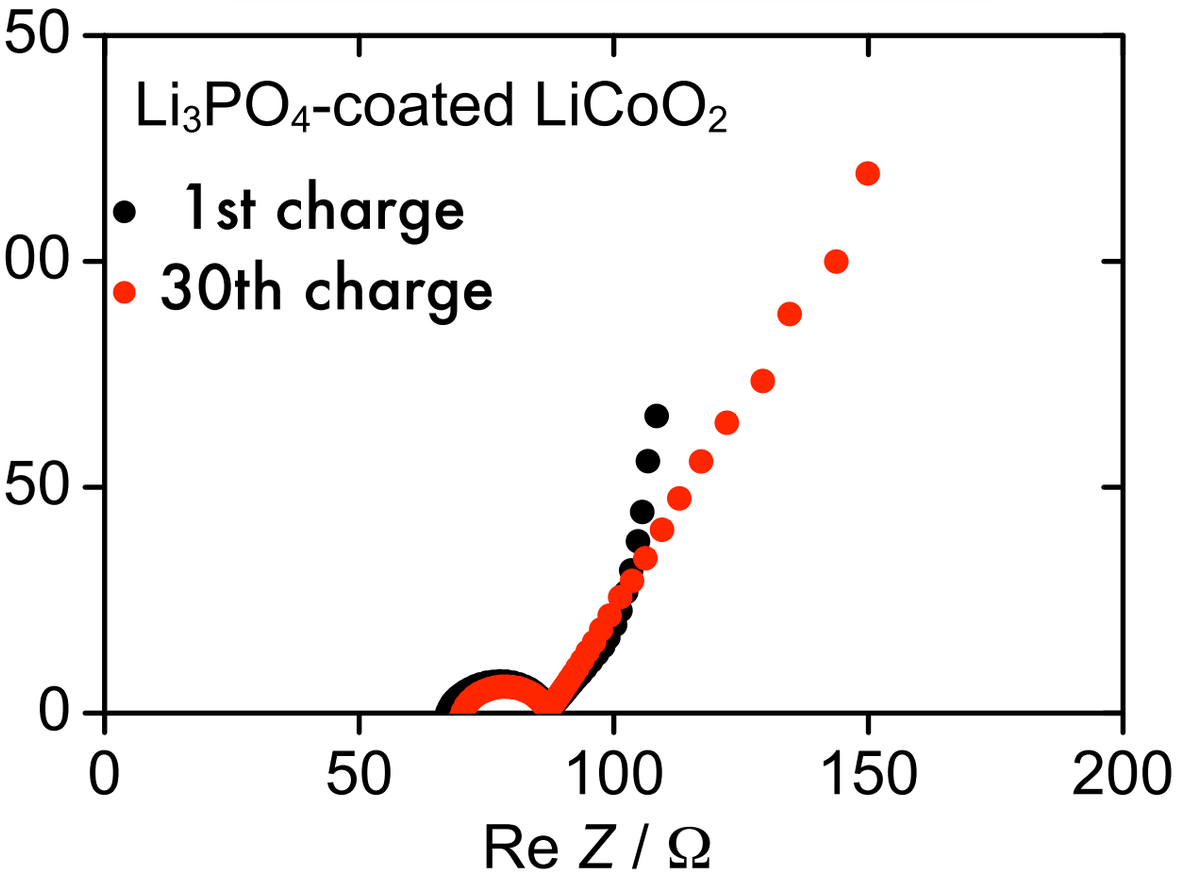
Takahashi et al., *J. Power Sources,* 226 (2013) 61.

Electrochemical properties

Charge-discharge



Nyquist plot



- 97 % of the initial capacity was retained after 30 cycles
- The value of the interfacial resistance (21 Ω) was 1/1000 of that in a cell without the intermediate layer.

Cathode	$R_{interface}$
$LiCoO_2$ bulk	350 Ω
$LiCoO_2$ film	15 kΩ
$Li_3PO_4/LiCoO_2$ film	21 Ω

Takahashi et al., *J. Power Sources*, 226 (2013) 61.