# Seamless Activated Carbon Electrode for Electrochemical Capacitors

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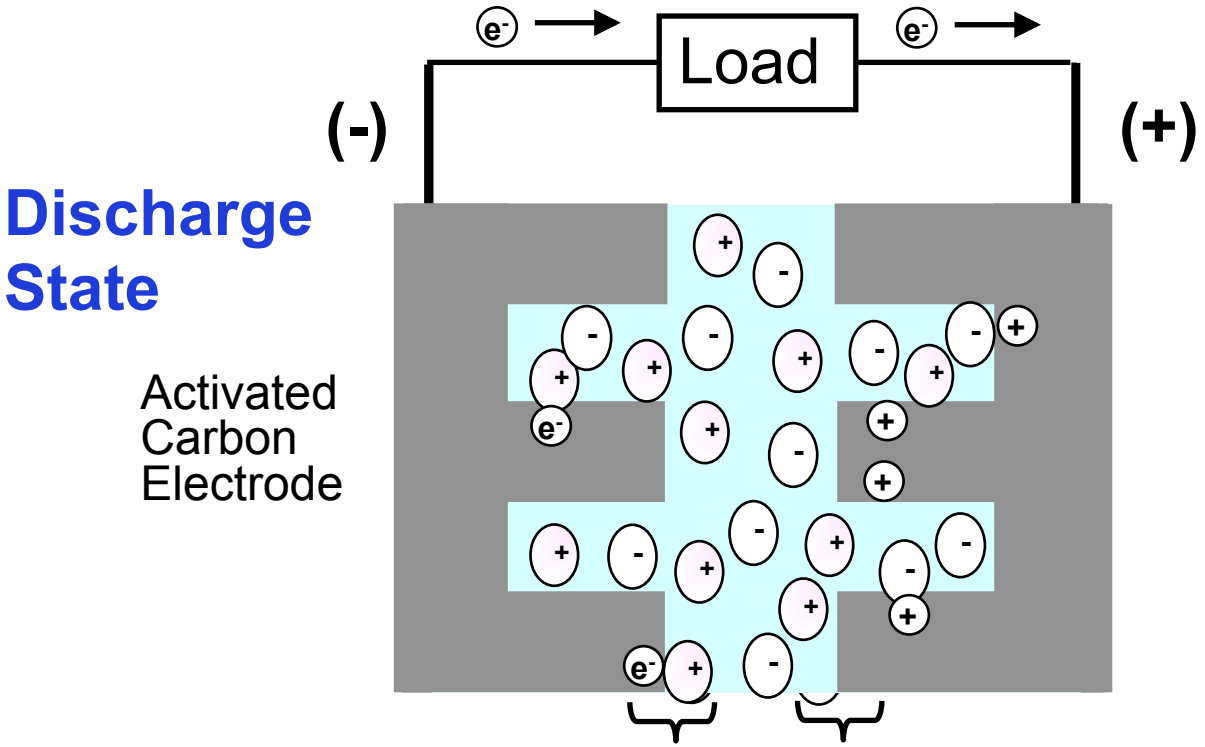
**5th German-Japanese Joint Symposium on Carbon Materials (Freiberg, Germany, 2015.7.21)**

**Electric Double Layer Capacitor (EDLC ) is composed of activated carbon (AC) electrodes.**




**Fast Charge/ Discharge, Long cycle life!!**

**Non-faradaic Reaction!**

**Weak point : Low energy density….**

$$E = \frac{C V^2}{2}$$

**The higher Voltage, higher Energy-density.**

**It is required for the application to energy storage.**

**However, high voltage (>3V) charging seriously damages capacitor.**

# Why does the capacitance decline happen?

On the interface between activated carbon & electrolyte,

***Electrochemical Decomposition*** of

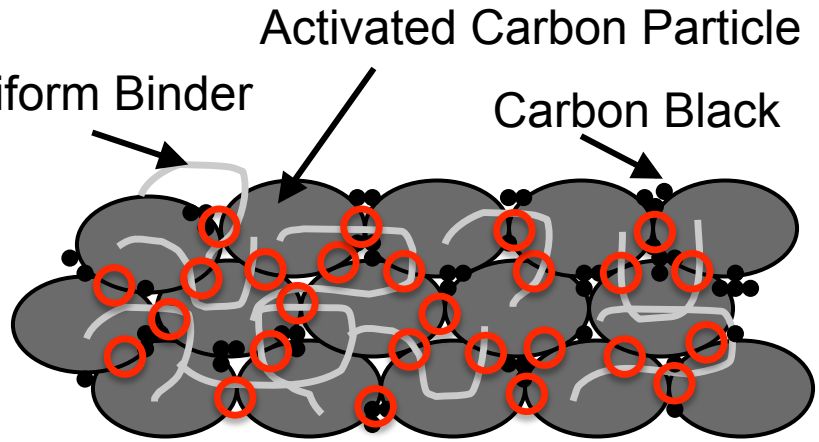
**Electrolyte** or **Activated carbon**

P. Azaïs, et al., *J. Power Sources*, **171**, 1046 (2007).
N. Naoi, et al., *J. Electrochem. Soc.*, **156**, A563 (2009).
P.W. Ruch, et al., *Electrochim. Acta*, **55**, 2352(2010).
D. Cazorla-Amorós, et al., *Carbon*, **48**, 1451 (2010).

- Micropore blocking by decomposition product
- Gas evolution
- **Poor Electric-Contacting of Activated Carbon Particles**

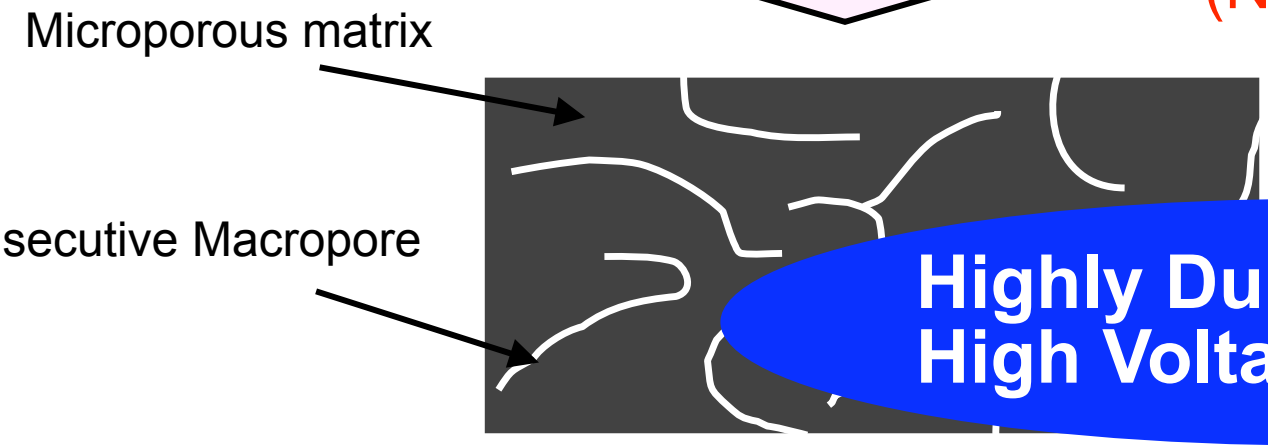
# Structure of EDLC Electrode

Conventional Electrode




Point contact

Seam-less Structure
(No Boundary)




**Highly Durable against High Voltage Charge!**

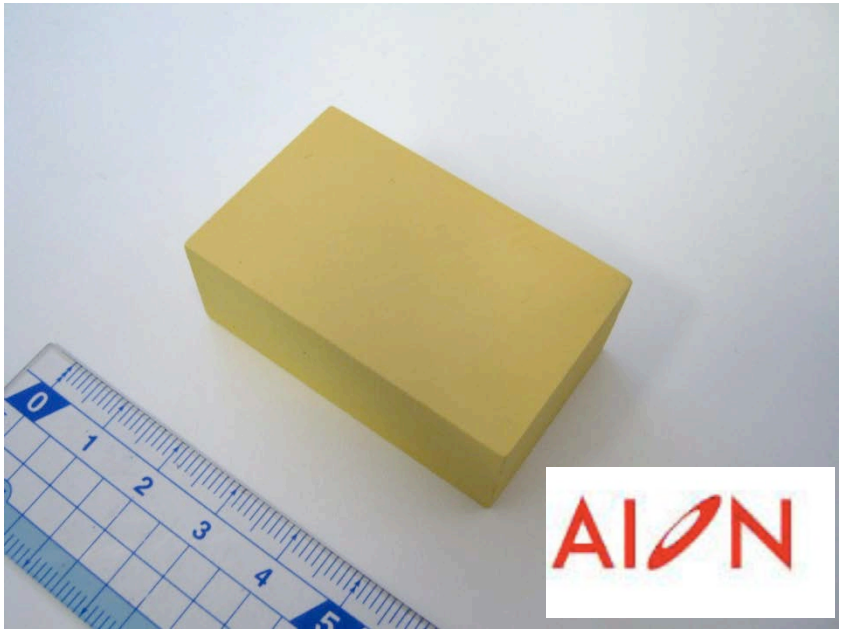
S.Shiraishi, *Boletín del Grupo Español del Carbón*, **28**, 18-24 (2013) .

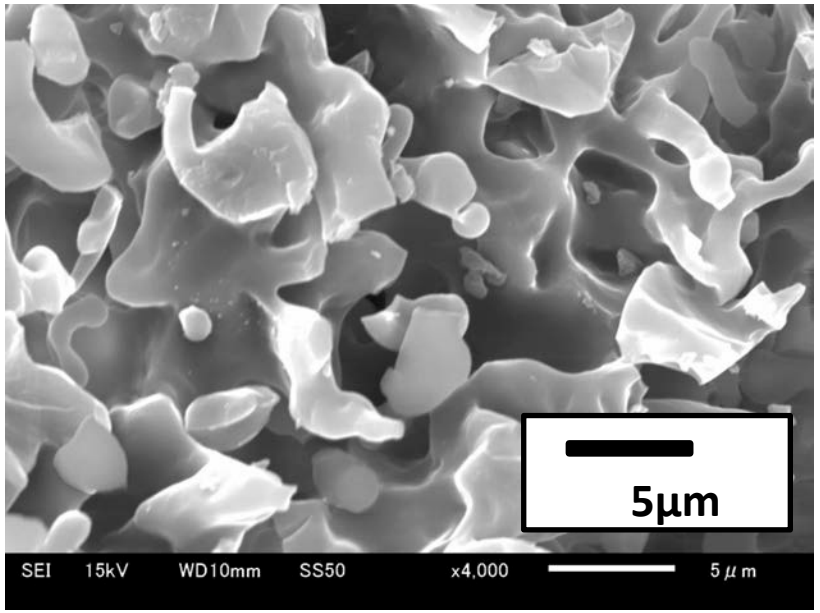
# Starting Material

It is necessary that $H_2O$ or $CO_2$ gas diffuse in the carbon precursor matrix inside to realize seamless activated carbon electrode

→ **Consecutively Macroporous Precursor**

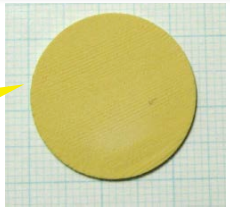
Macroporous Phenolic Resin（MICROLIGHT）



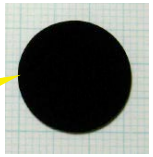




Composed of consecutive macropore of ~7µm

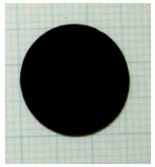
# Sample Procedure



Ø: 22mm
(~1 mm)



Ø :~ 16mm
(~0.8mm)



ML (MICROLIGHT, pore: 7μm)

*Carbonization*
$N_2$・800℃・1h

MLC (Carbonized MICROLIGHT)

*$CO_2$ Activation*
$CO_2$・850℃・6, 8h

8h

6h

**MLCCO2-8h (1960 $m^2g^{-1}$)**

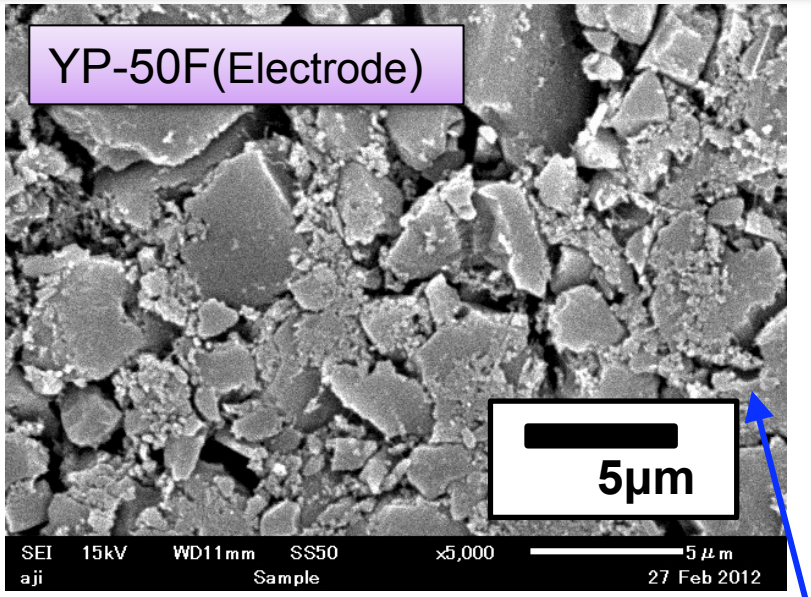
**MLCCO2-6h (1510 $m^2g^{-1}$)**

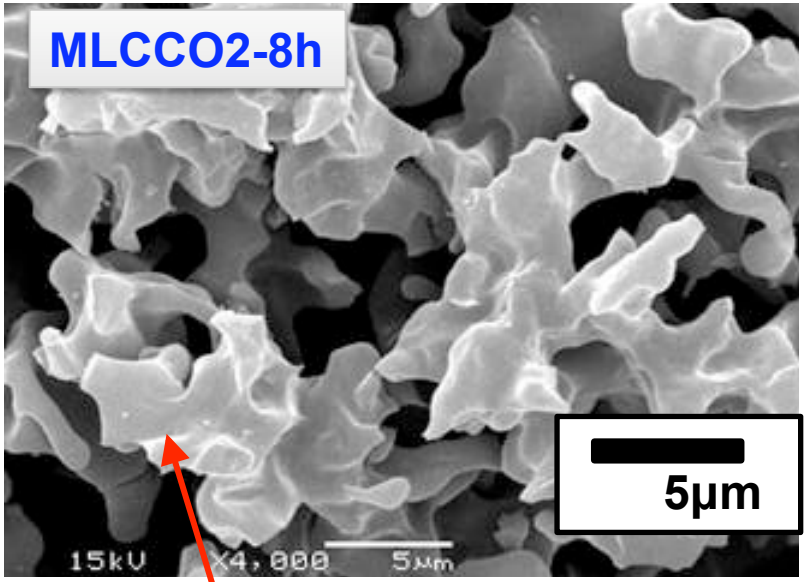
**Reference Sample**

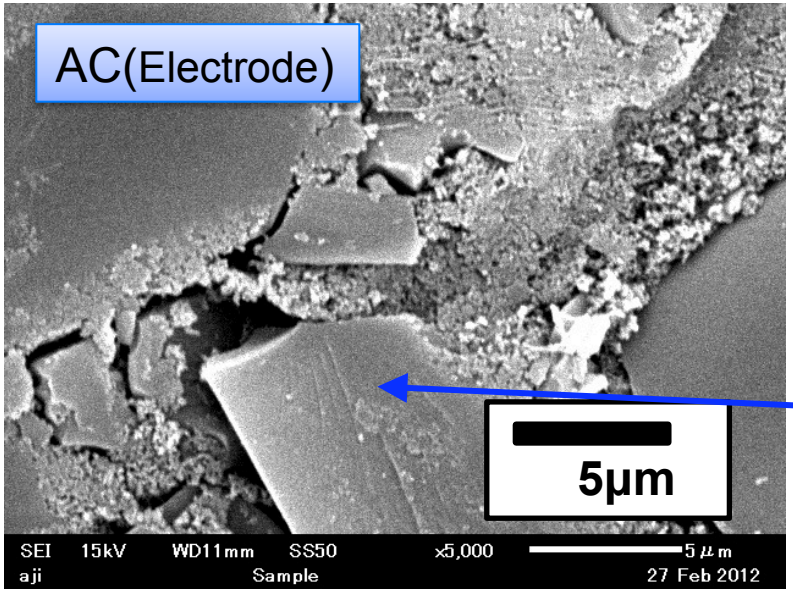
**YP-50F** (1590$m^2g^{-1}$, Coconut shell)
**AC** (1940$m^2g^{-1}$, Phenolic resin)

**Composite Electrode**
**(AC:Conductor:Binder=85:10:5wt%)**

# SEM Image (x 5000)



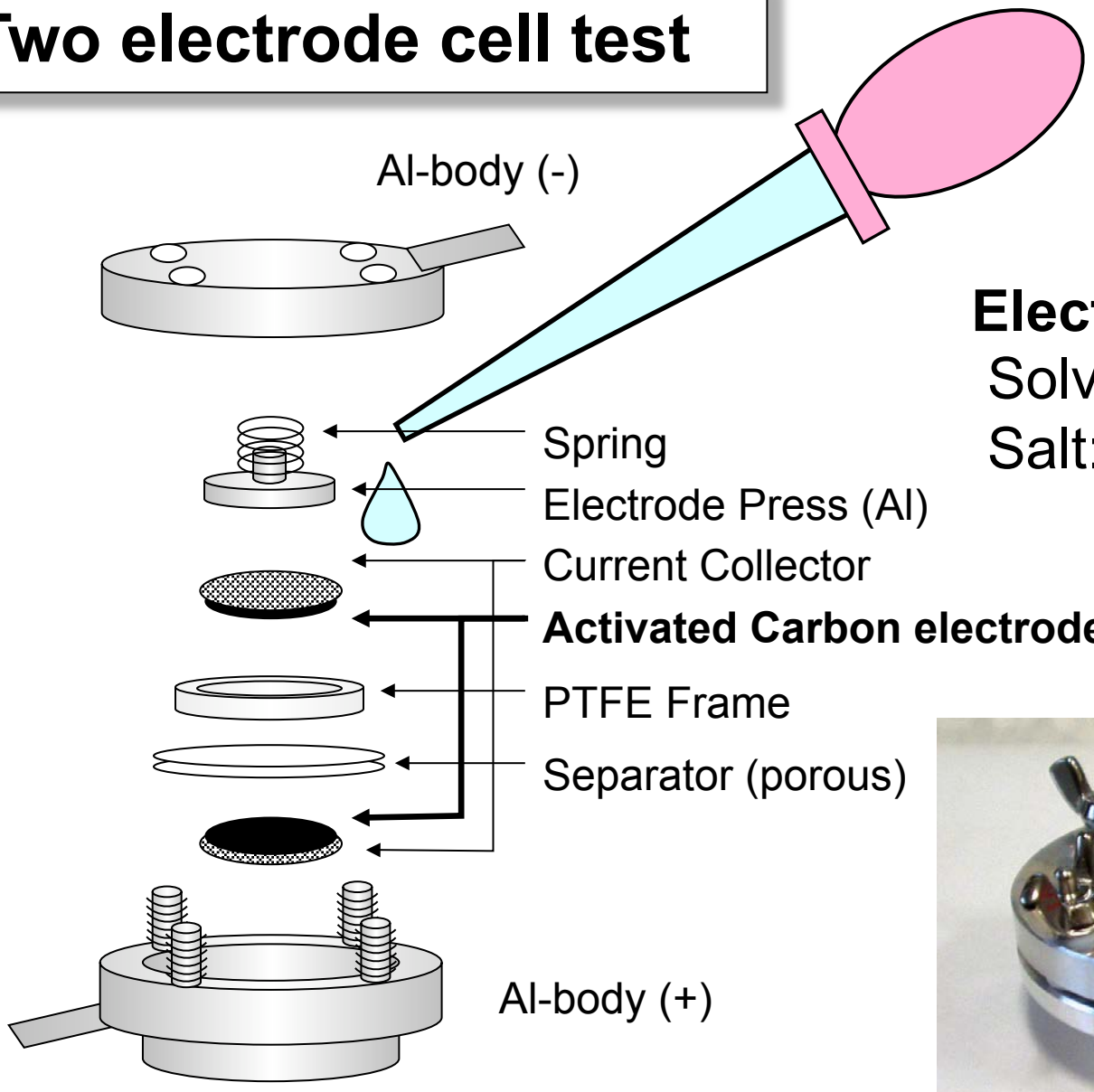



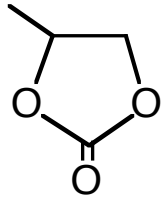




**No particle-boundary, seamless structure is maintained after activation.**

**Activated carbon particles are bound to each other.**

# Two electrode cell test



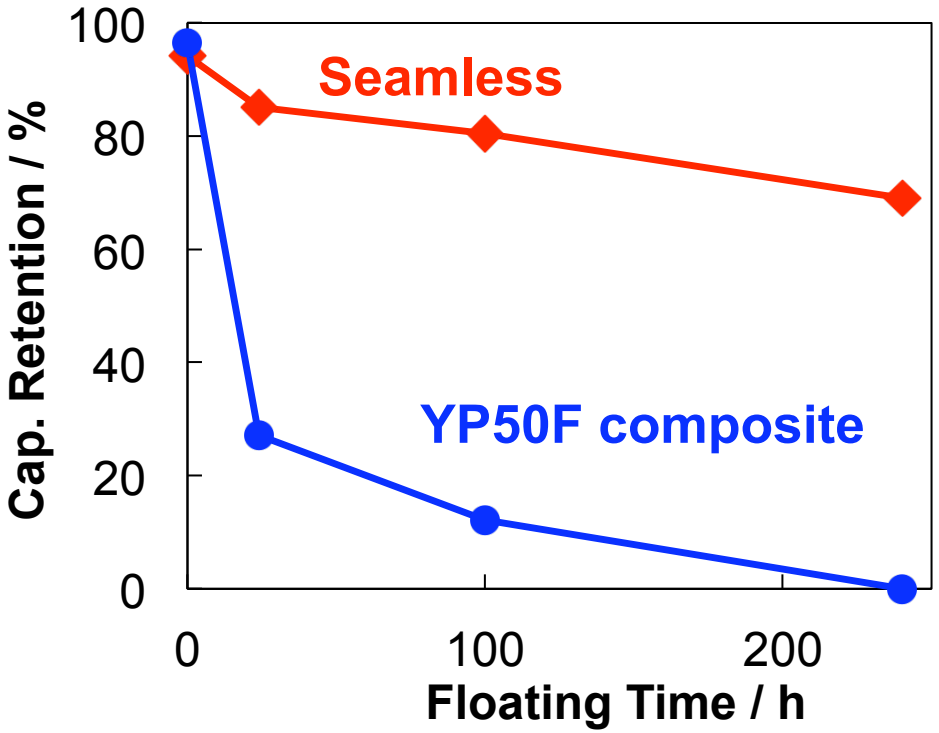
**Electrolyte**

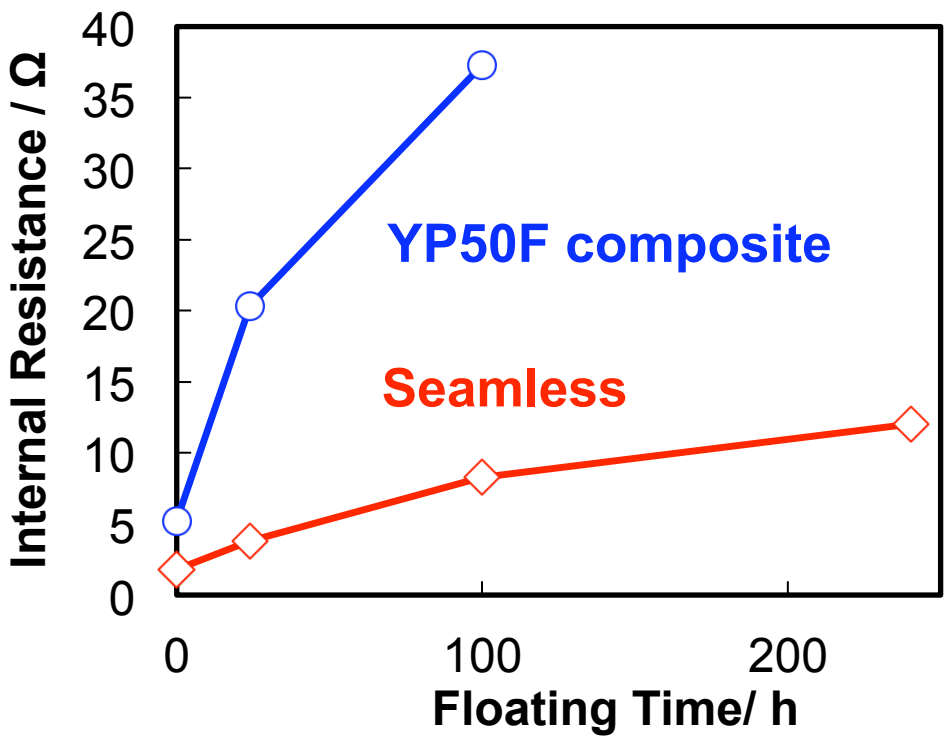
Solvent: Propylene carbonate

Salt: $(C_2H_5)_3CH_3NBF_4$

# Dependence on Time for Durablity test

Capacitance measurement (0~2,5V, 40℃) → Durability test (3.5V, 70℃) → Capacitance measurement (0~2,5V, 40℃)



# Large Size Preparation

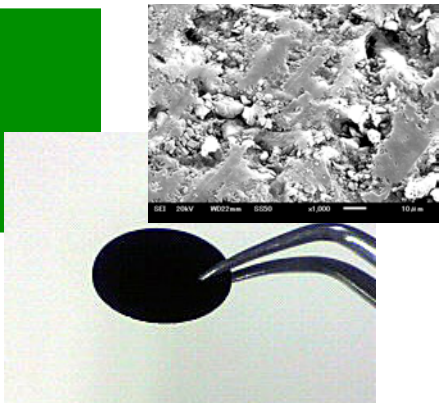
群馬大学
GUNMA UNIVERSITY

AIST

**9cm×9cm Size**
**Seamless-activated carbon electrode!**

# Future Plan of Germany & Japan Collaboration for Capacitor

**Application of CDC monolith as Capacitor Electrode**



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群馬大学 GUNMA UNIVERSITY

***Development of More Excellent Durable and High-capacitive EDLC***

# Conclusion

**Seamless activated carbon** electrode shows excellent durability against high voltage charging. This is due to the absence of the contact resistance between activated carbon particles.

**Additionally, we succeeded in developing densified-type seamless electrode, having higher volumetric capacitance than the commercial electrode.**

**Thank you for attention!**

**Danke schön!**