



The Latest Development of FLEMION™ Membrane

November 20 - 23, 2022
AGC Inc
Takayuki Kaneko



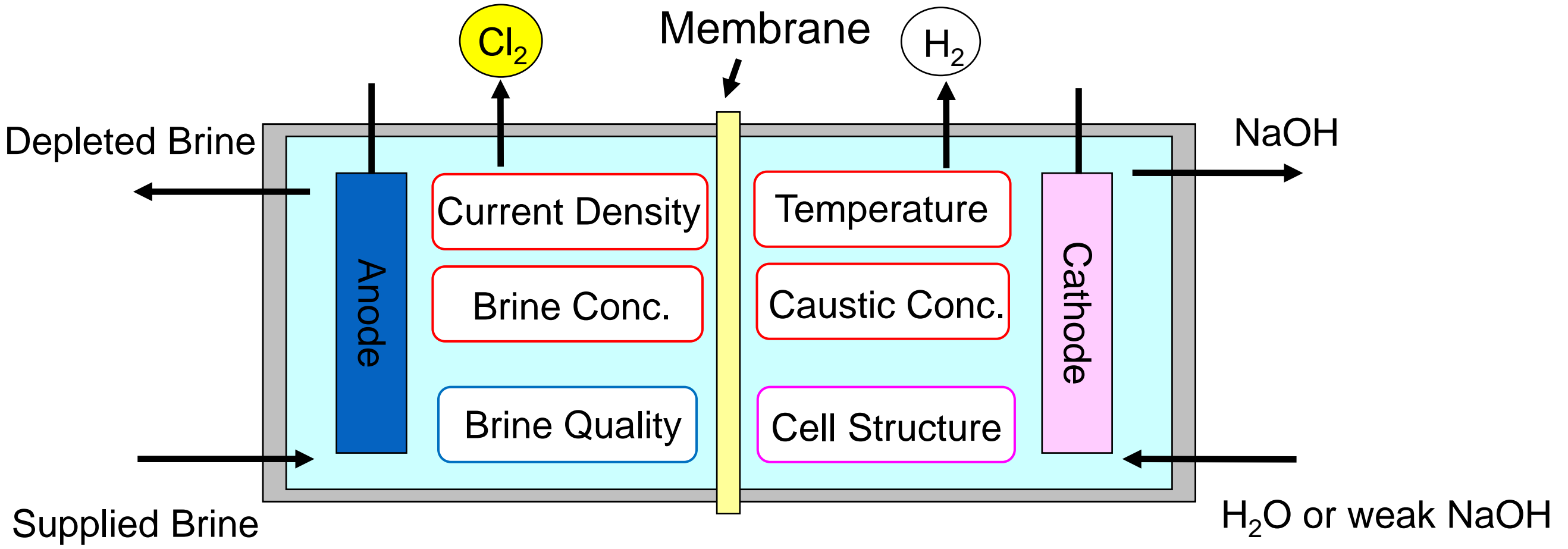
CloroSur
2022

COSTA DO SAUÍPE



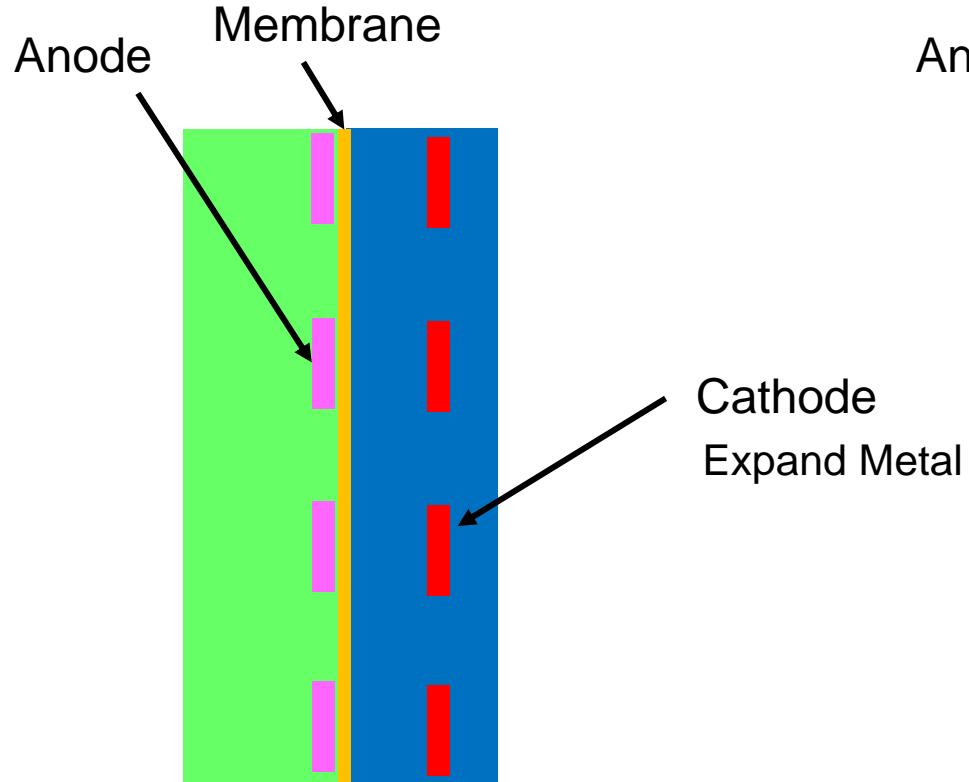
- Influence of Zero Gap on Membrane
- New Generation Membrane
- Technical Service Activity

Influence Factors on Membrane Performance

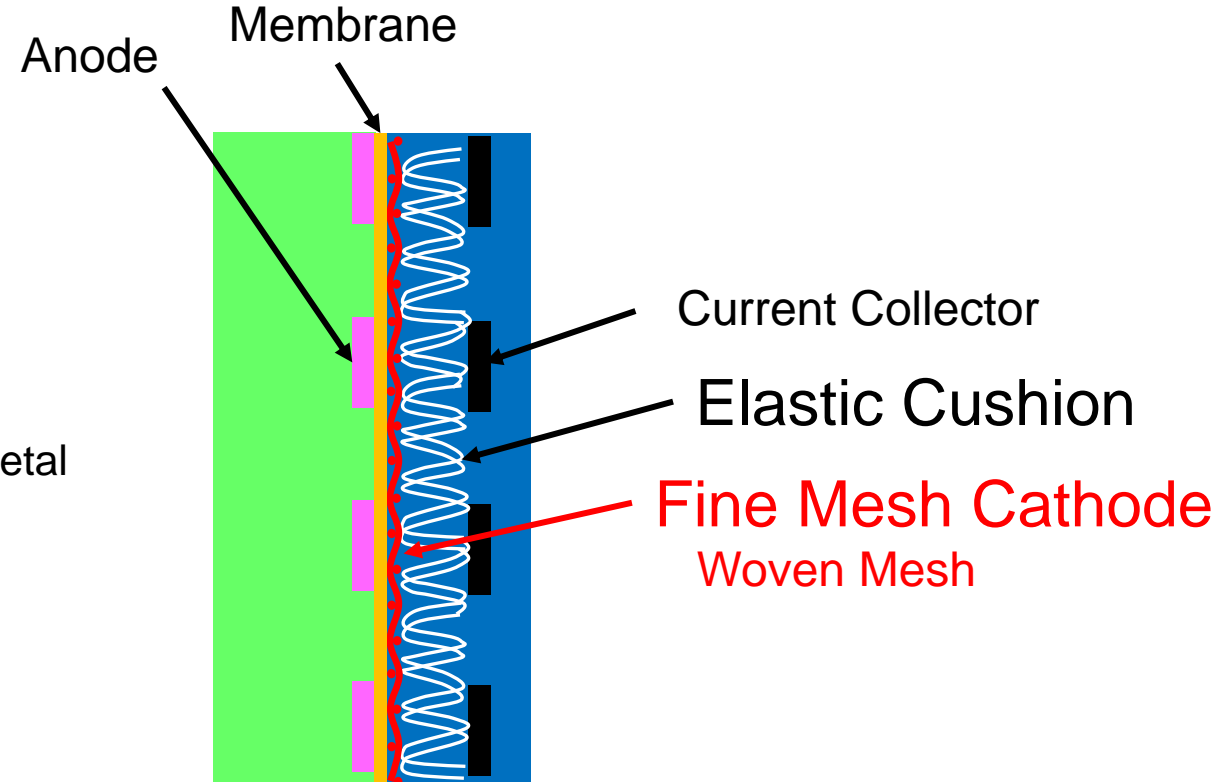


Configuration of Finite Gap and Zero Gap

Finite Gap

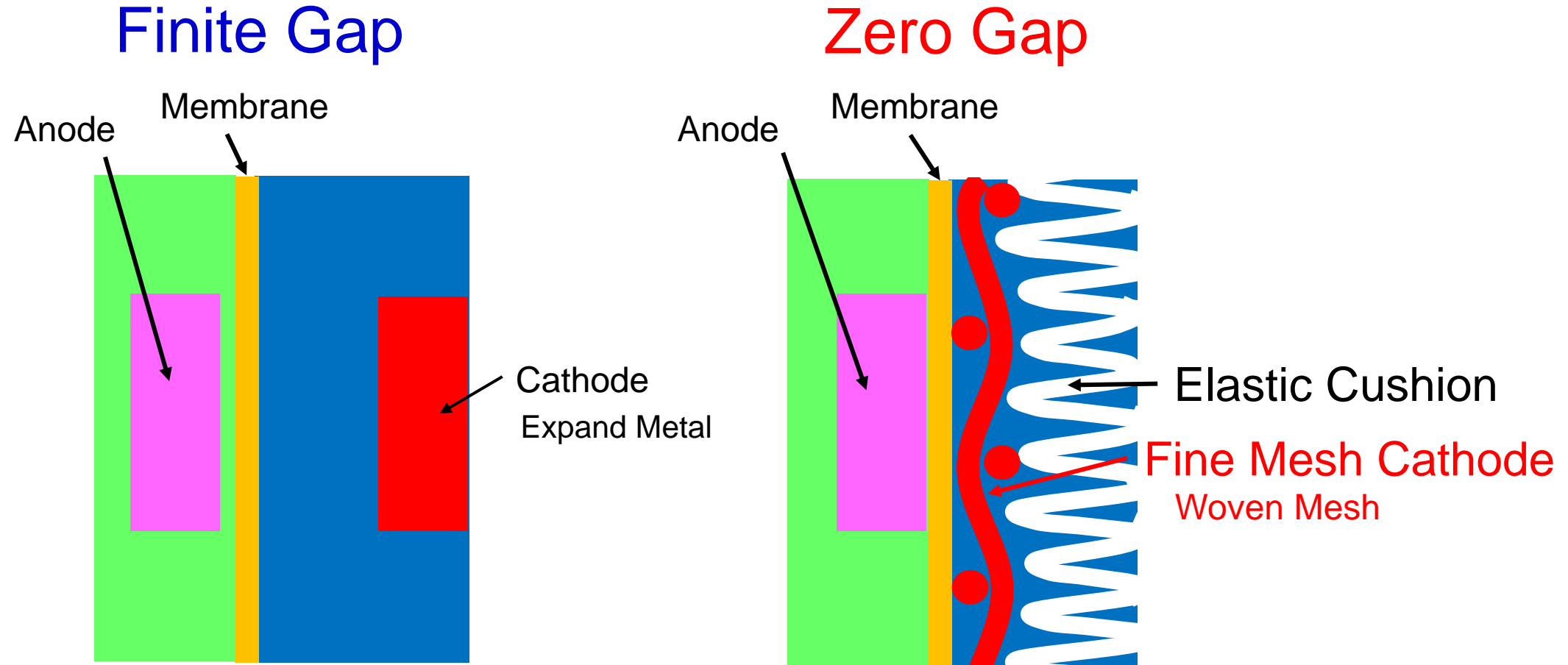


Zero Gap



Main difference is cathode side structure

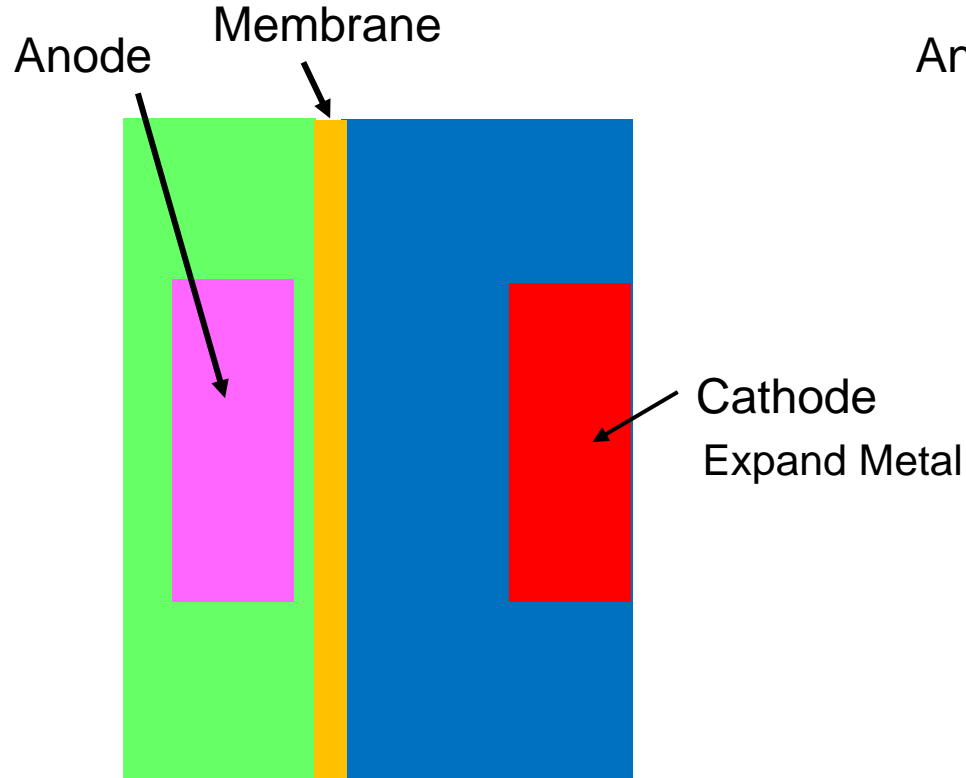
Note) The structure varies depending on each electrolyzer.



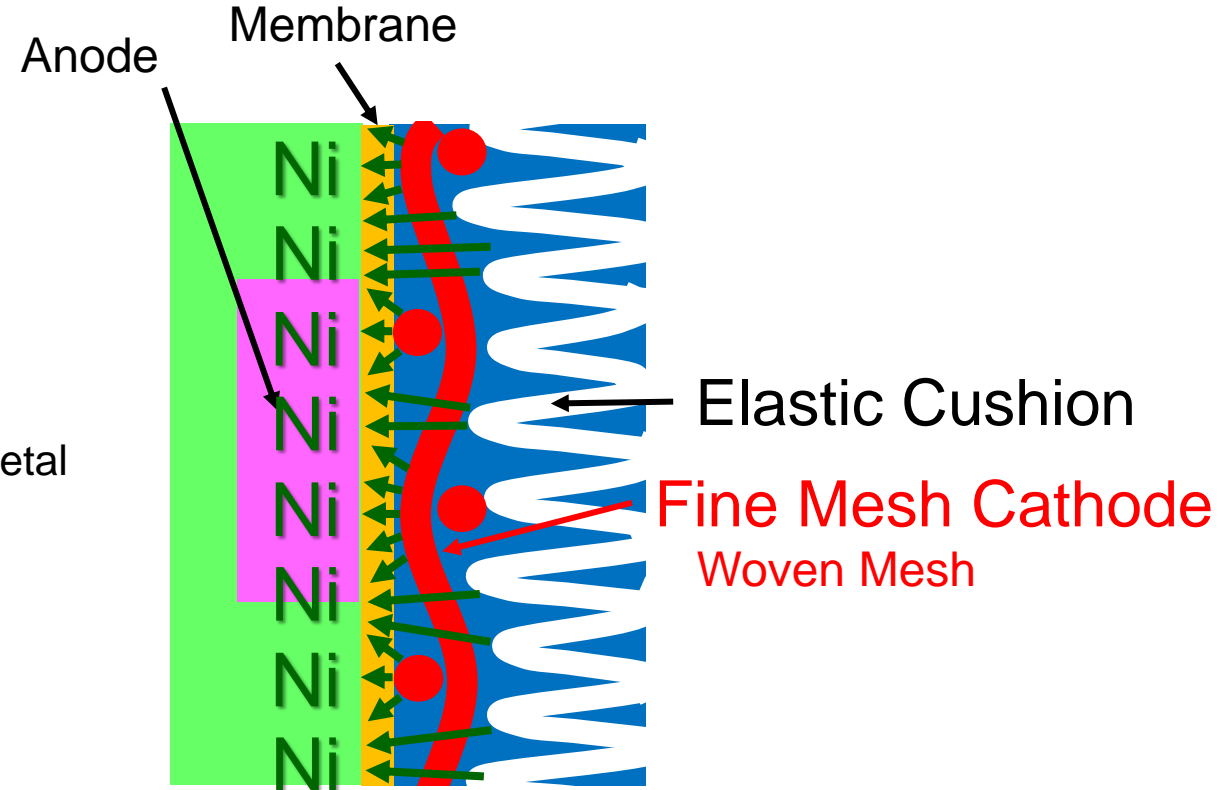
Main difference is cathode side structure
“Zero gap” has **Three** key points

1st Key Point : Ni stain

Finite Gap

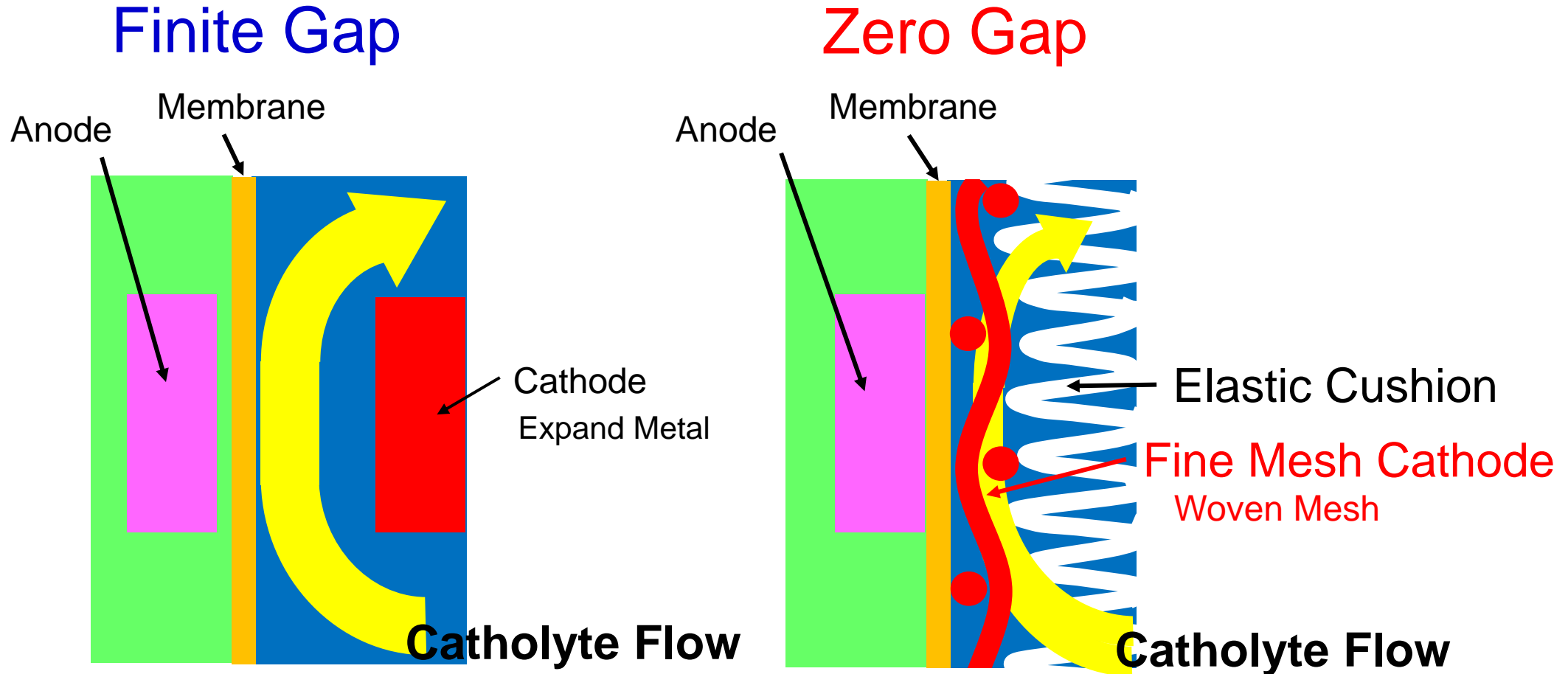


Zero Gap



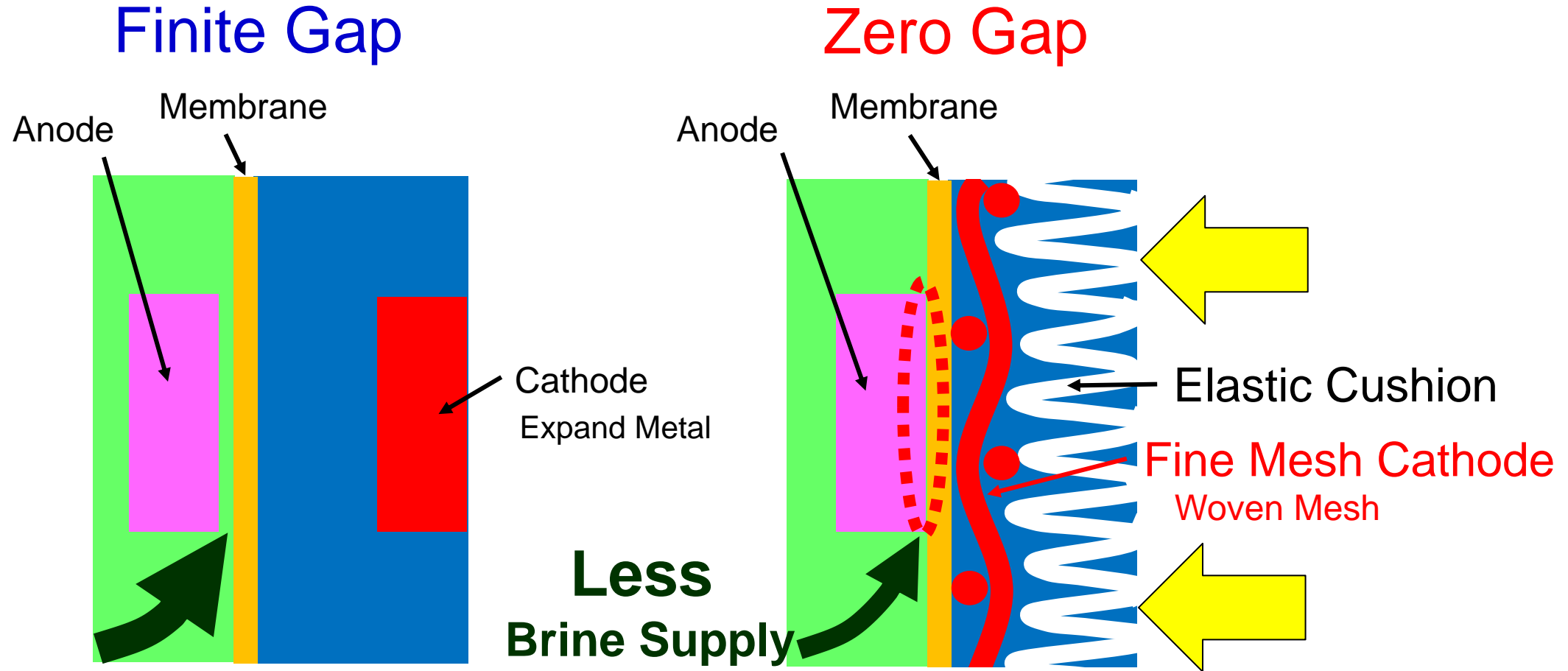
Contacting cathode parts may cause **Ni stain**

2nd Key Point : High Temperature



Less catholyte flow caused by structure → Less removal heat
→ **Higher temperature** of membrane

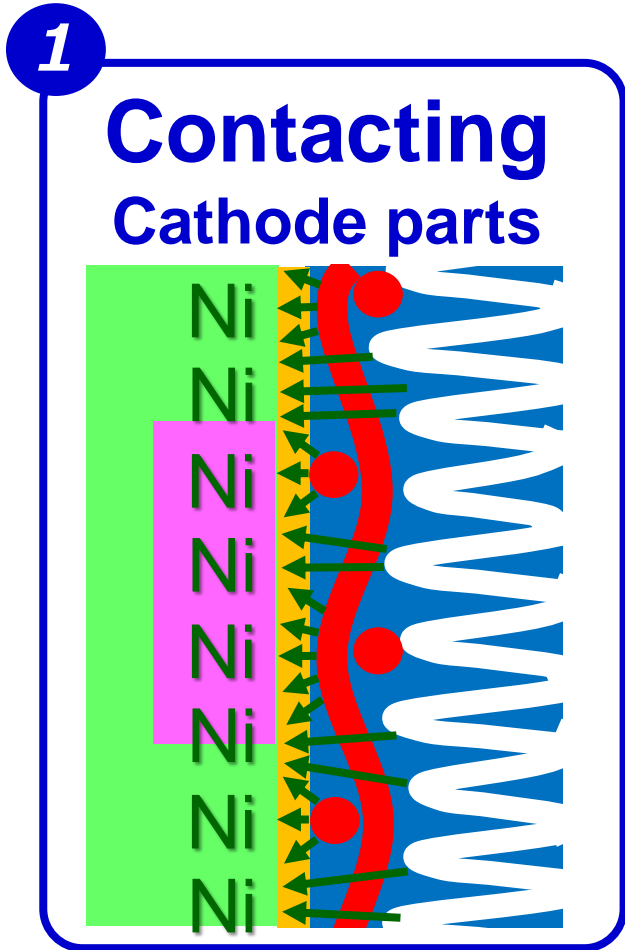
3rd Key Point : Weak Brine



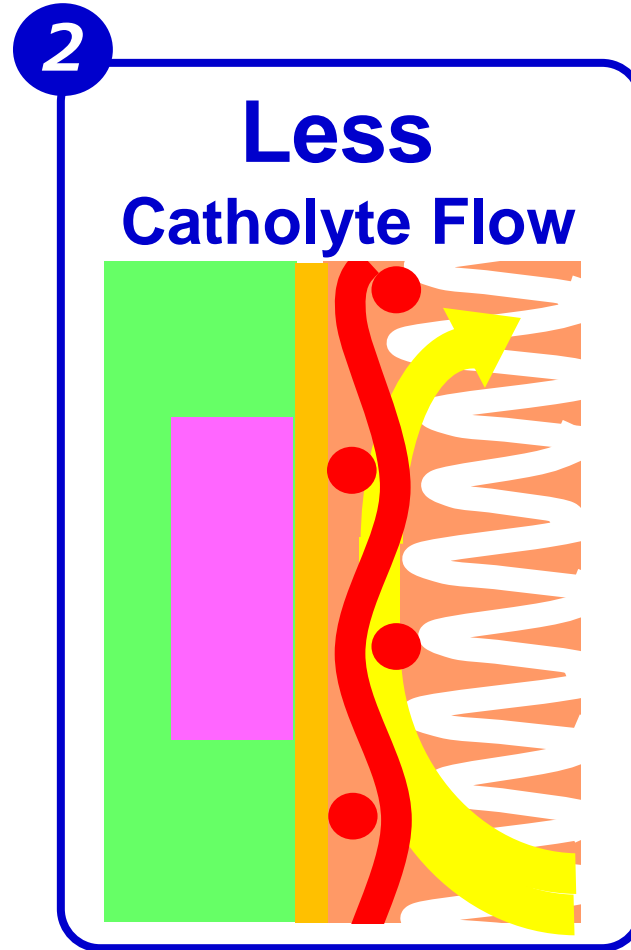
Less brine supply caused by structure
Elastic cushion push membrane to the anode.

→ **Weak brine**

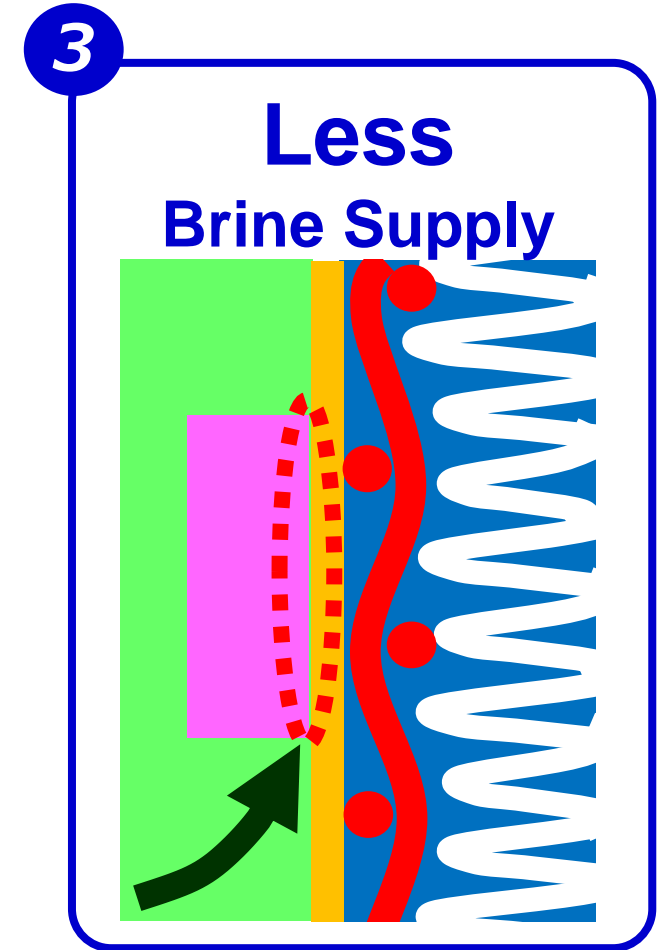
“Zero gap” has **Three** Key Points



1 Ni stain

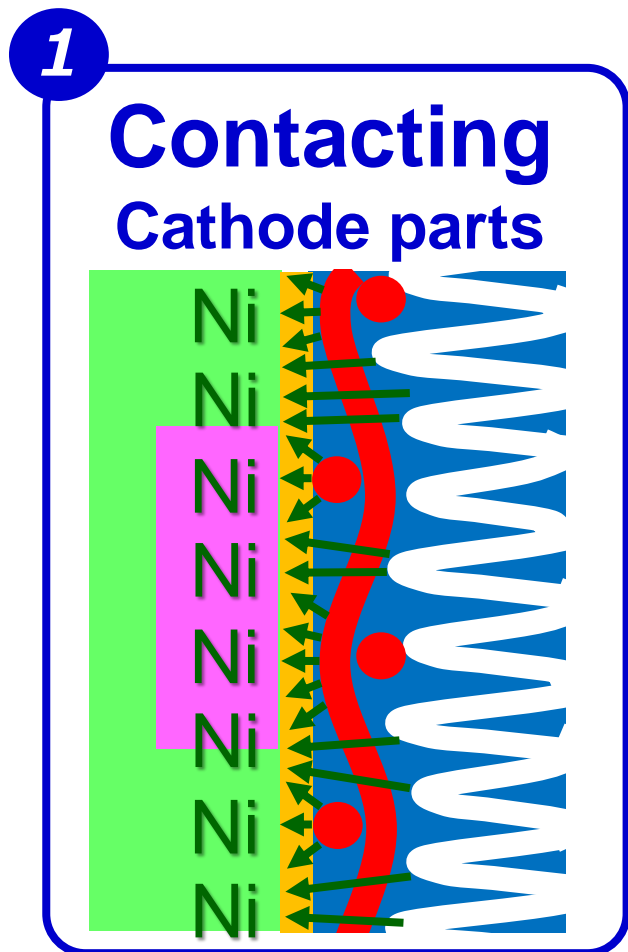


2 High
Temperature

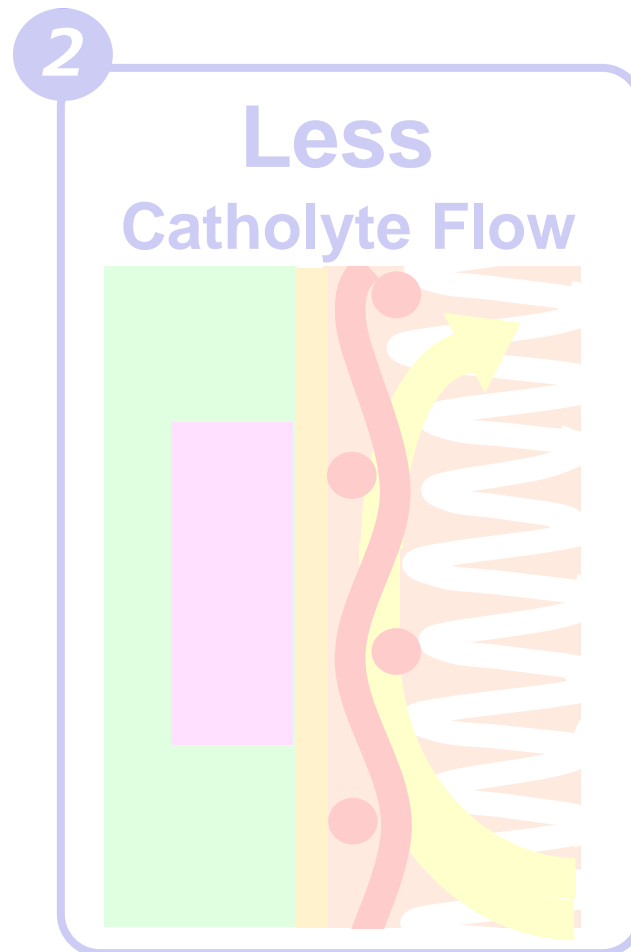


3 Weak brine

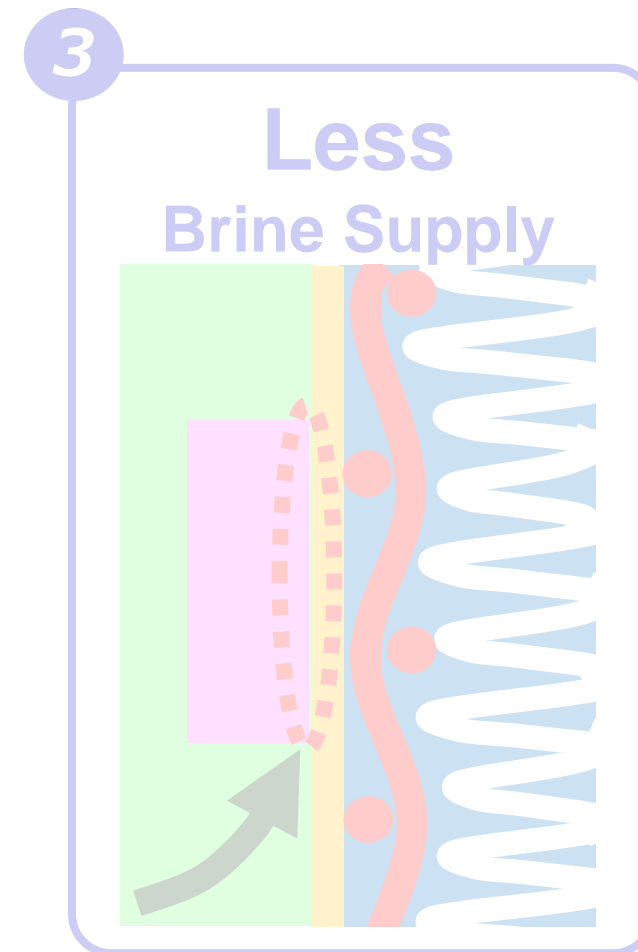
1st Key Point : Ni stain



1 Ni stain



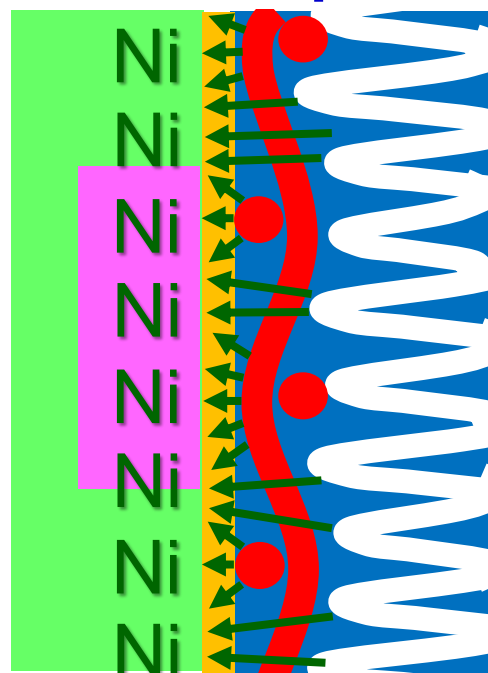
2 High Temperature



3 Weak brine

1

Contacting Cathode parts

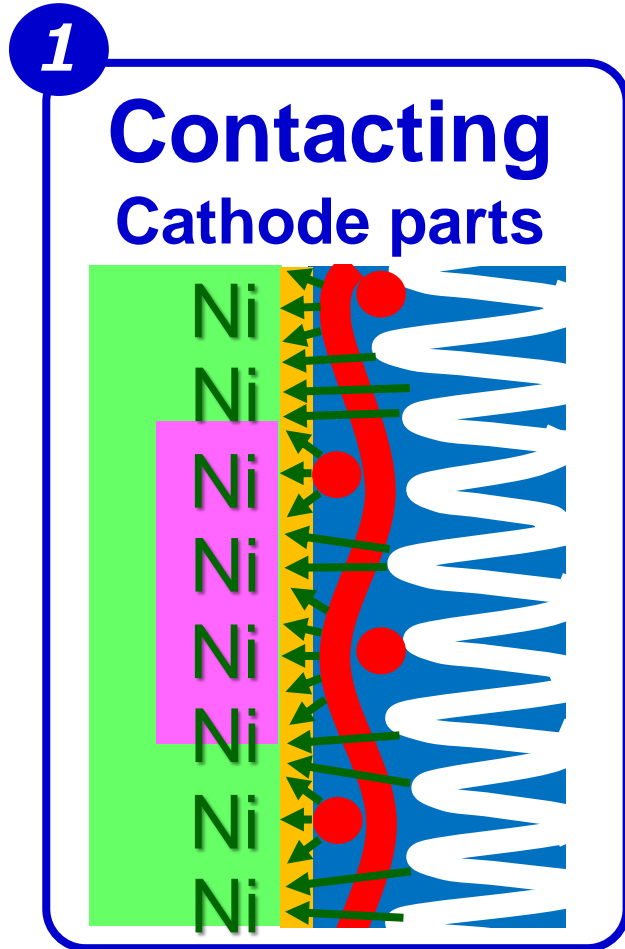


Ni behavior is classified by work

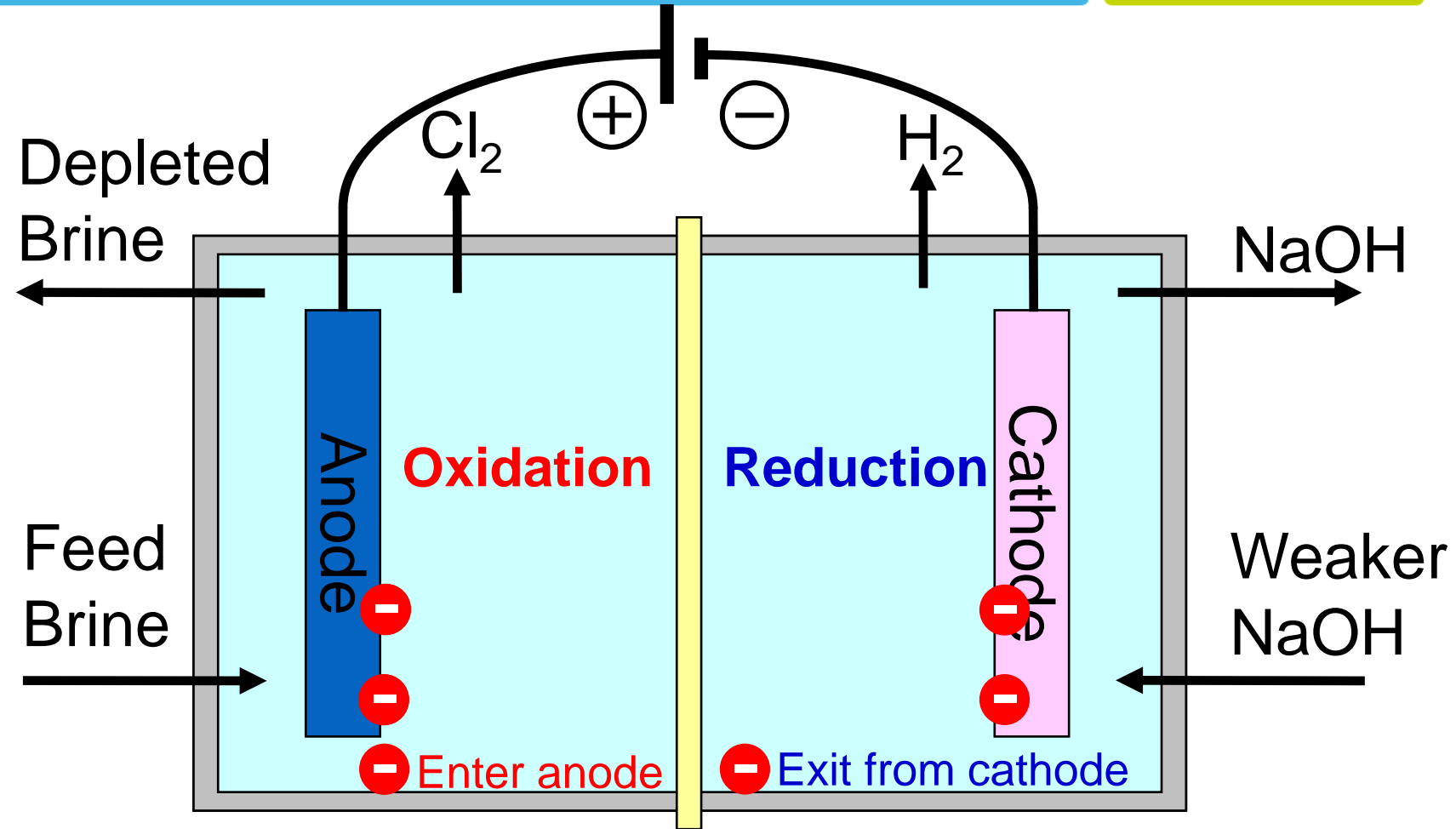
1. Operation
2. Shut down
3. Installation

1 Ni stain

1. Operation



1 Ni stain

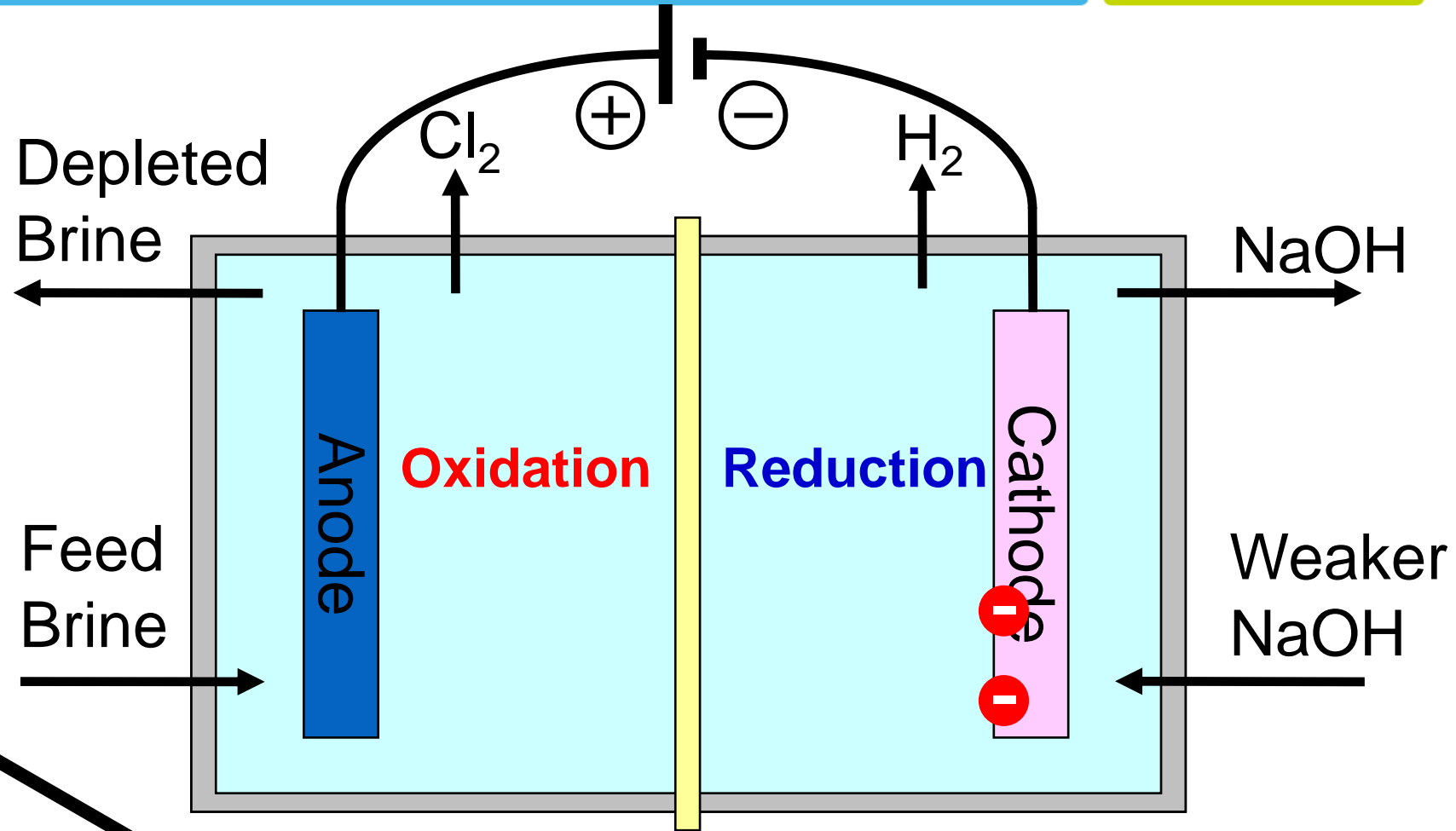
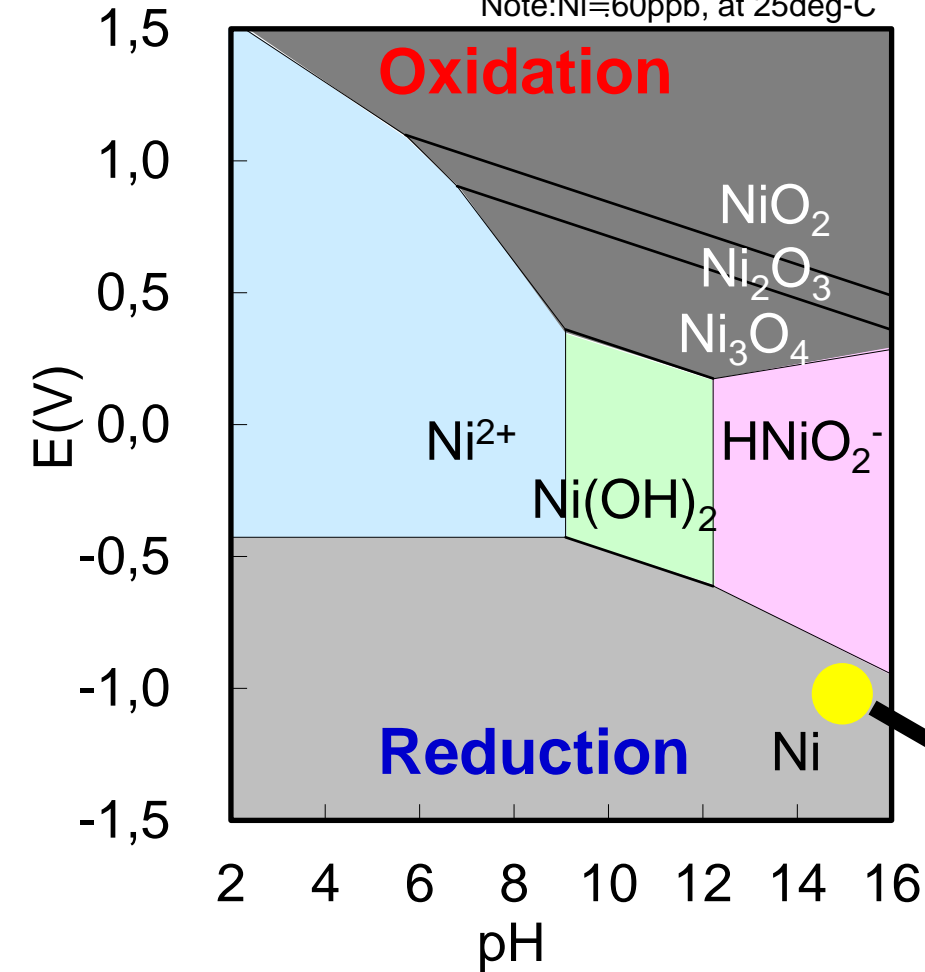


Ni cathode parts are stable
Because cathode reaction is **Reduction**

1. Operation

Pourbaix Diagram of Ni

Note: Ni=60ppb, at 25deg-C

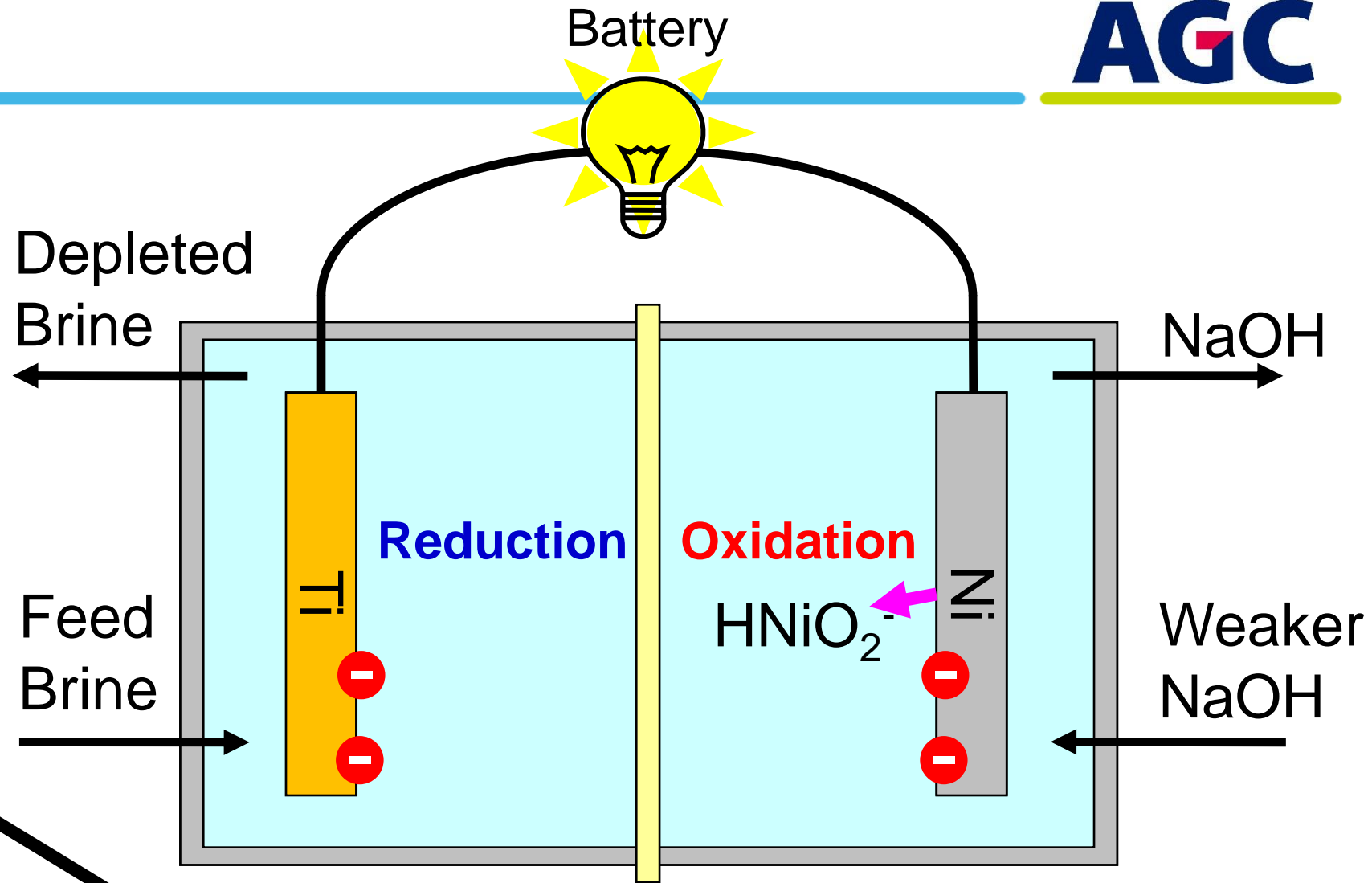
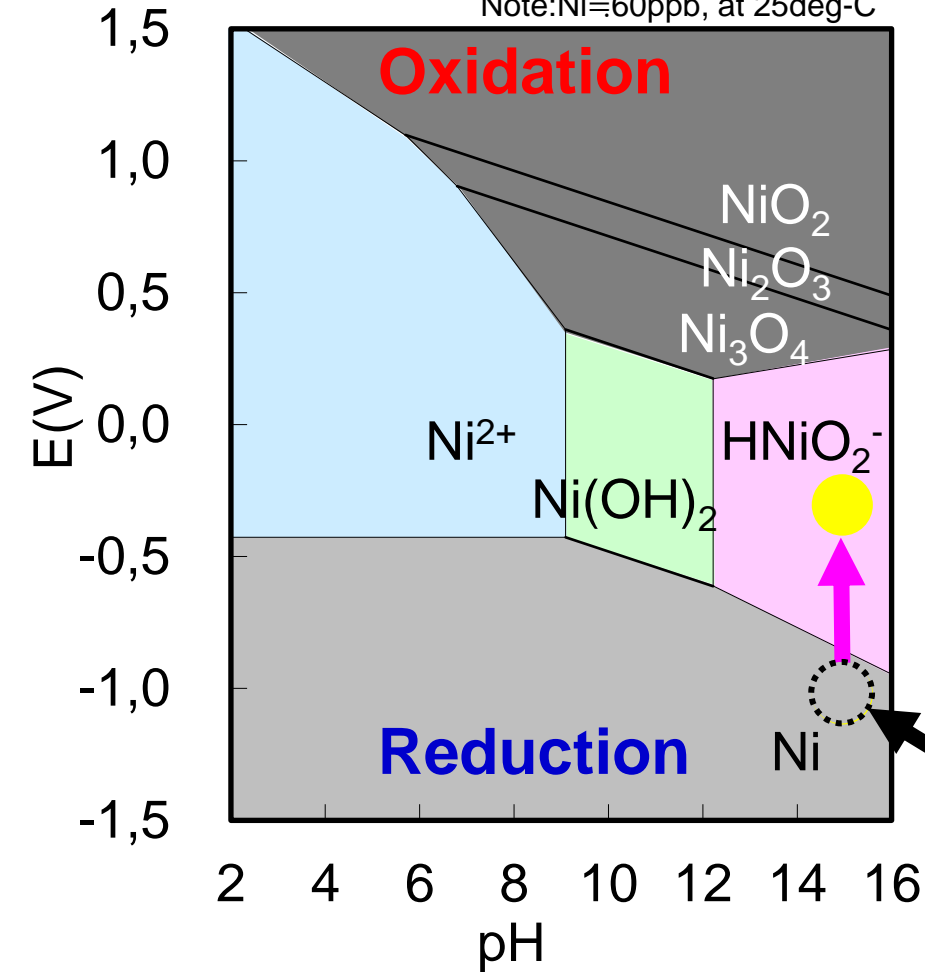


Ni cathode parts are stable
Because cathode reaction is **Reduction**

2. Shut Down (1/2)

Pourbaix Diagram of Ni

Note: Ni=60ppb, at 25deg-C



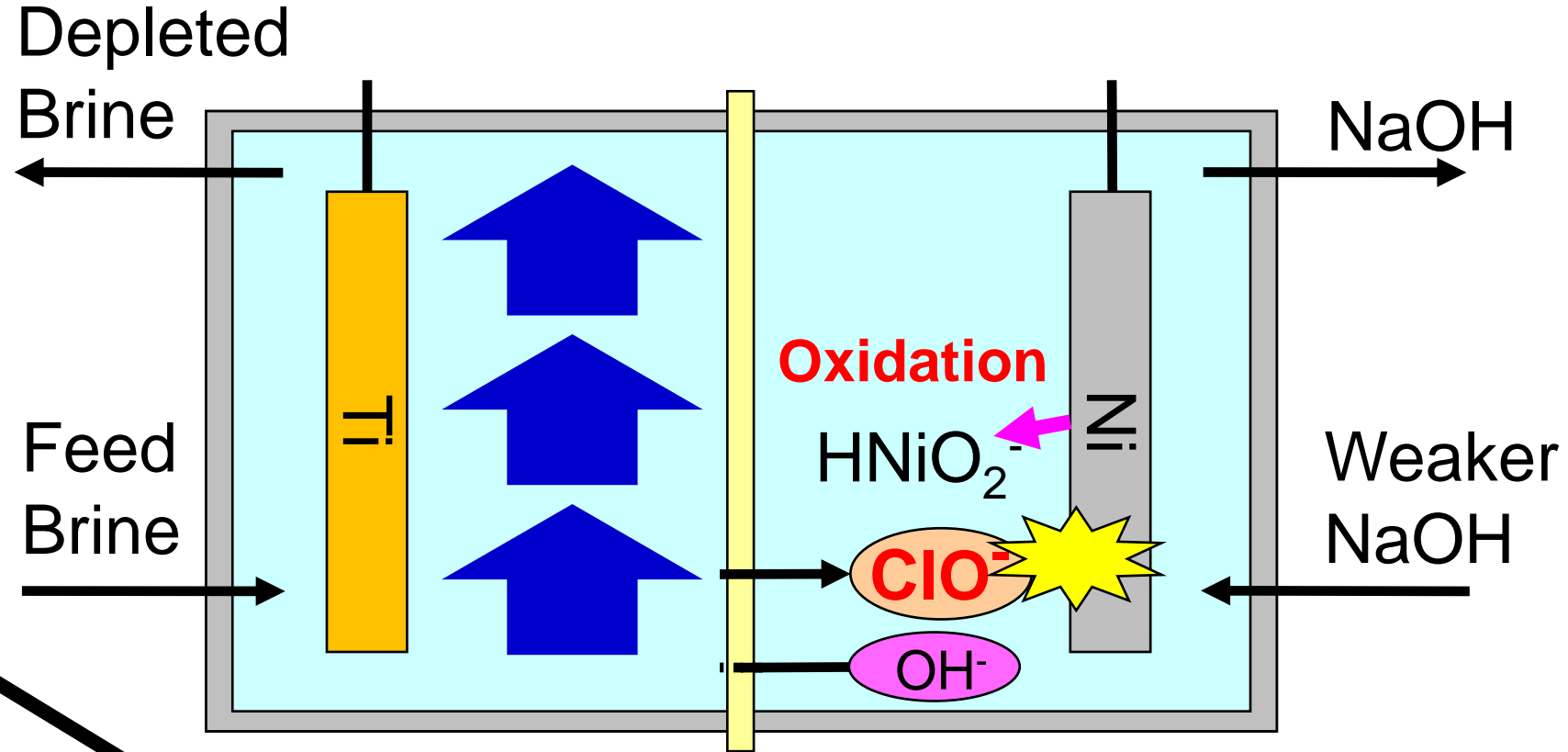
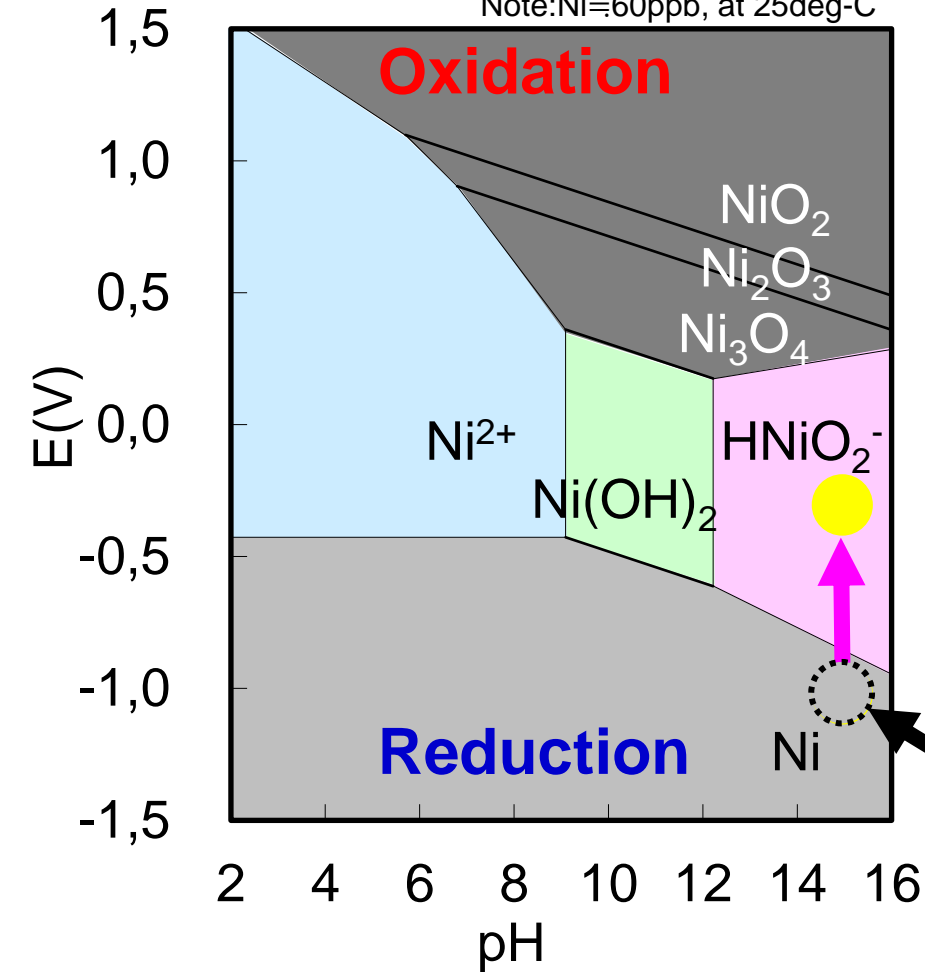
Ni may dissolve as HNiO_2^-

1 Polarization is important after shut down

2. Shut Down (2/2)

Pourbaix Diagram of Ni

Note: Ni=60ppb, at 25deg-C



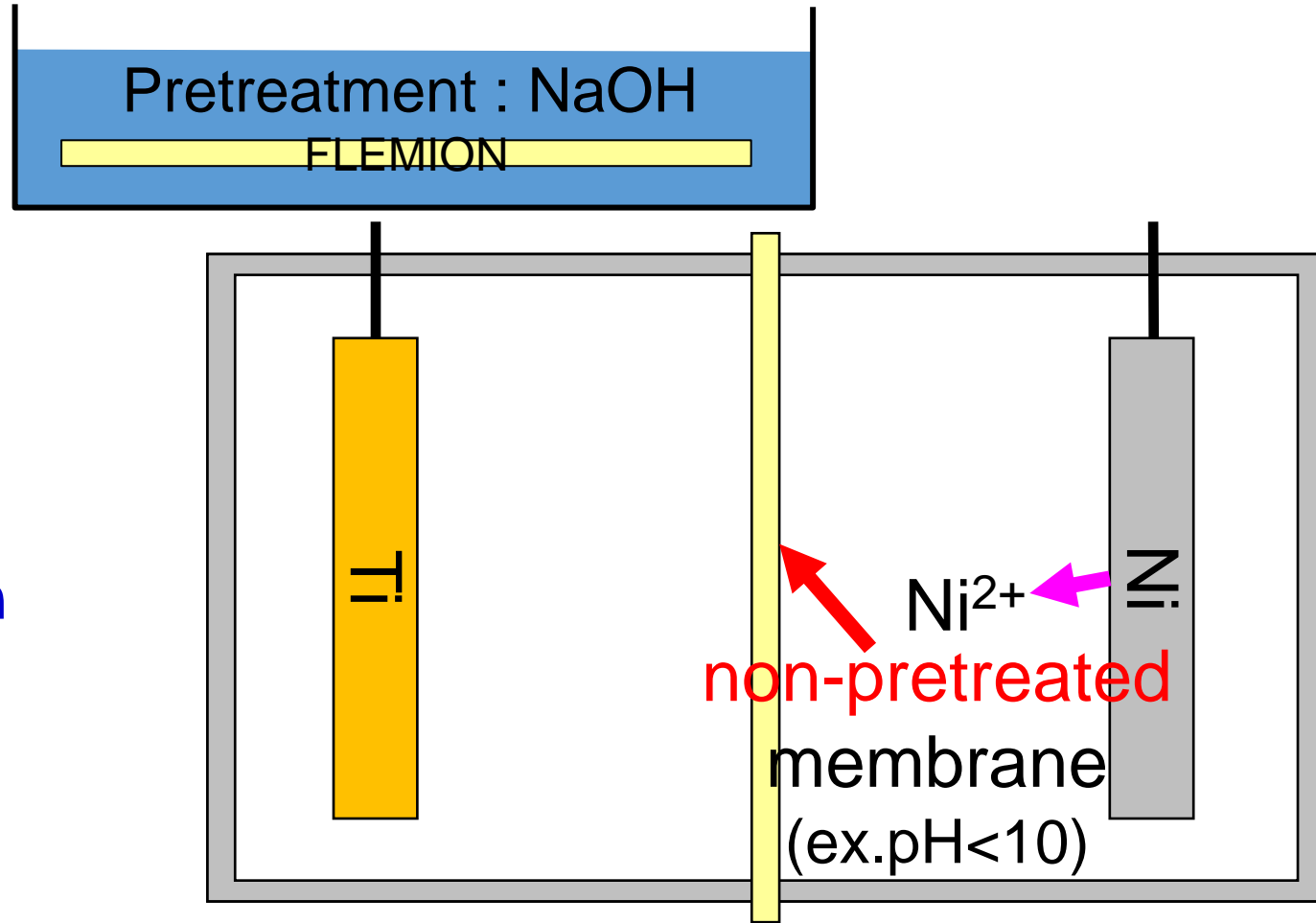
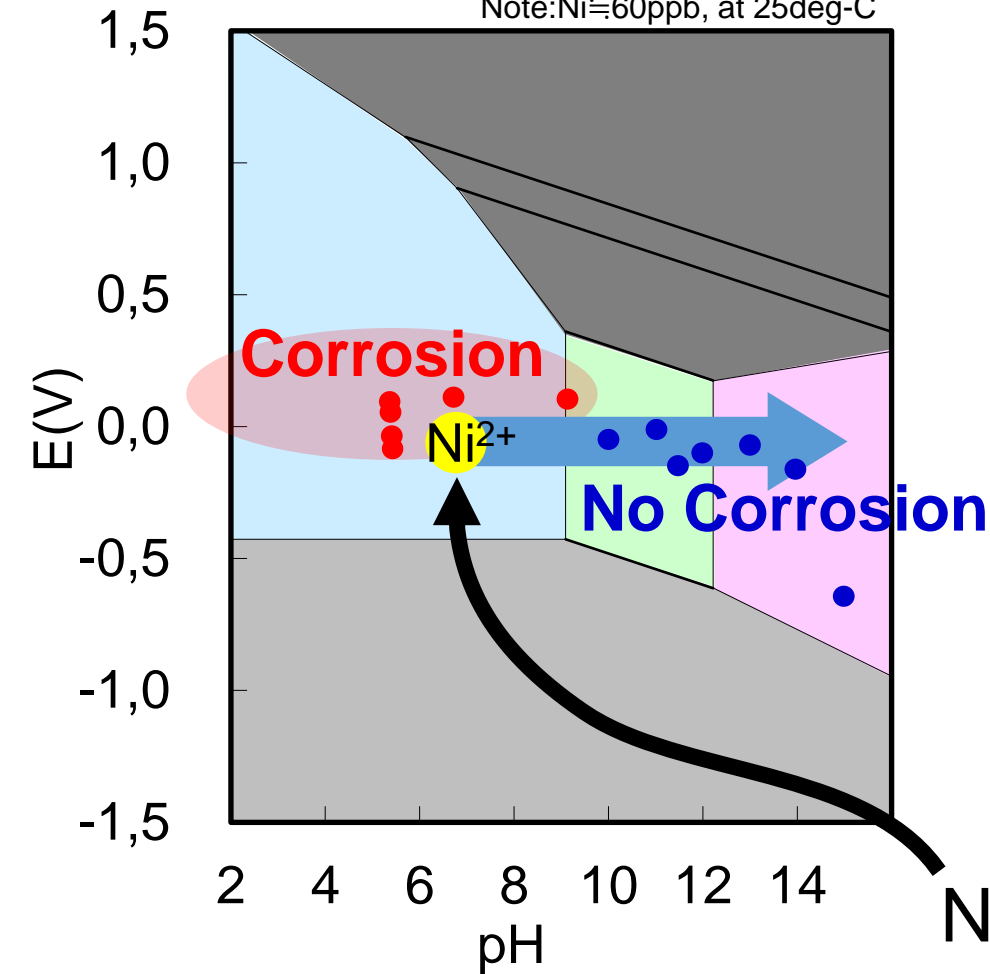
Ni may be corroded by ClO^-

2 Flushing is important after shut down

3. Membrane Installation

Pourbaix Diagram of Ni

Note: Ni=60ppb, at 25deg-C



Ni may be corroded by **non-pretreated** membrane

3 Pretreatment is important before installation

(Example : pretreatment condition 20 g/l NaOH)

Summary : Methods for Preventing Elution of Ni

1. Operation

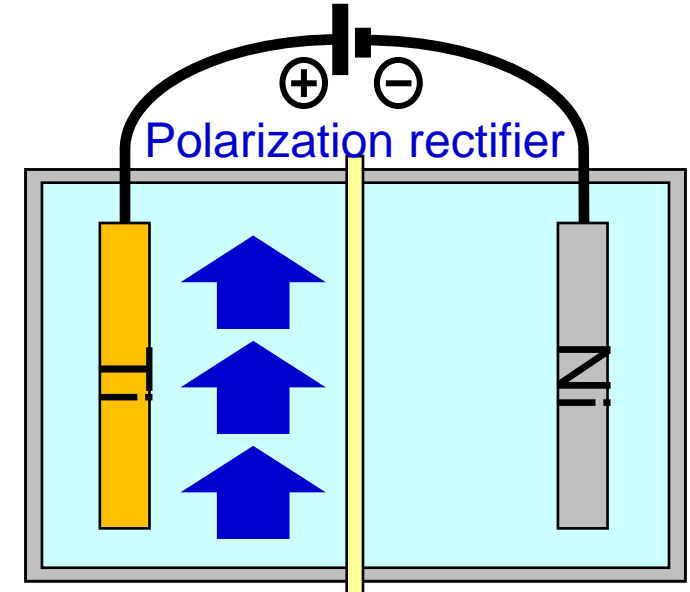
Ni cathode parts are stable

after

2. Shut down

① Polarization

② Flushing



before

3. Installation

③ Pretreatment

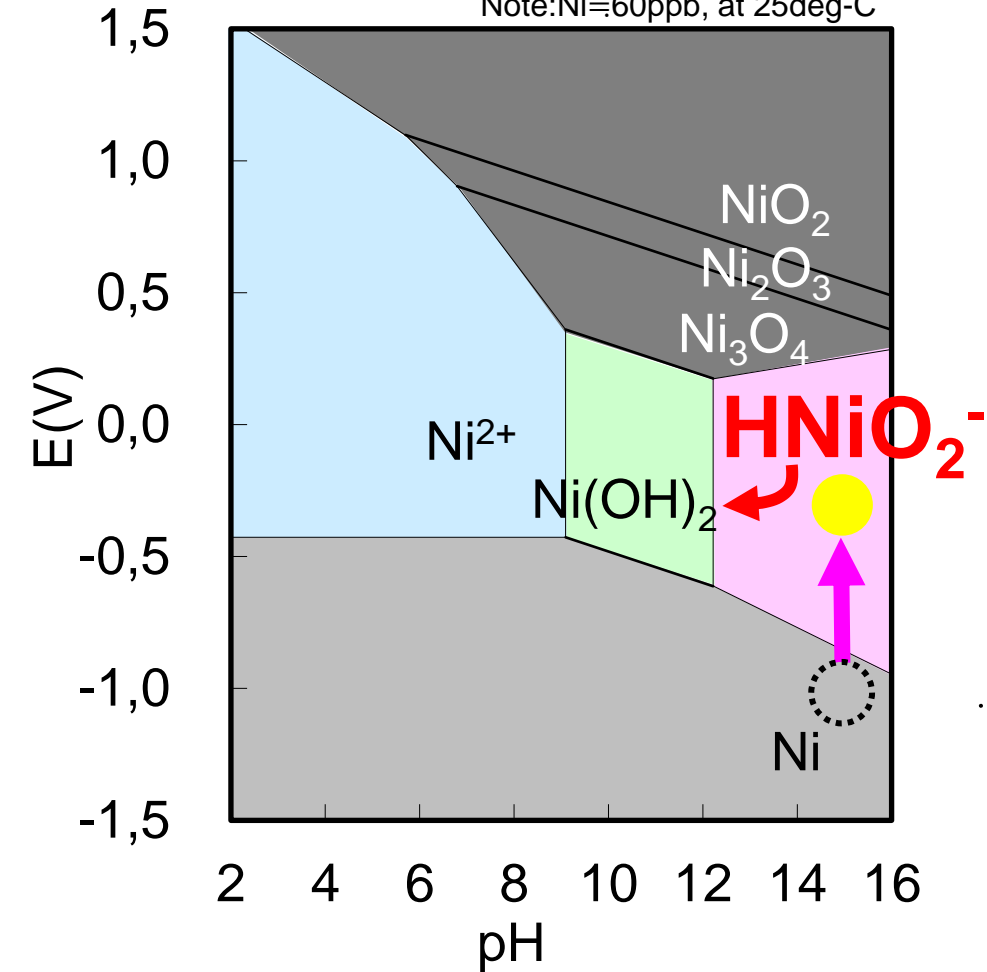


Note) For detail of these methods, refer to each cell licensor

If Ni dissolves...

Pourbaix Diagram of Ni

Note: Ni=60ppb, at 25deg-C



Magnified View

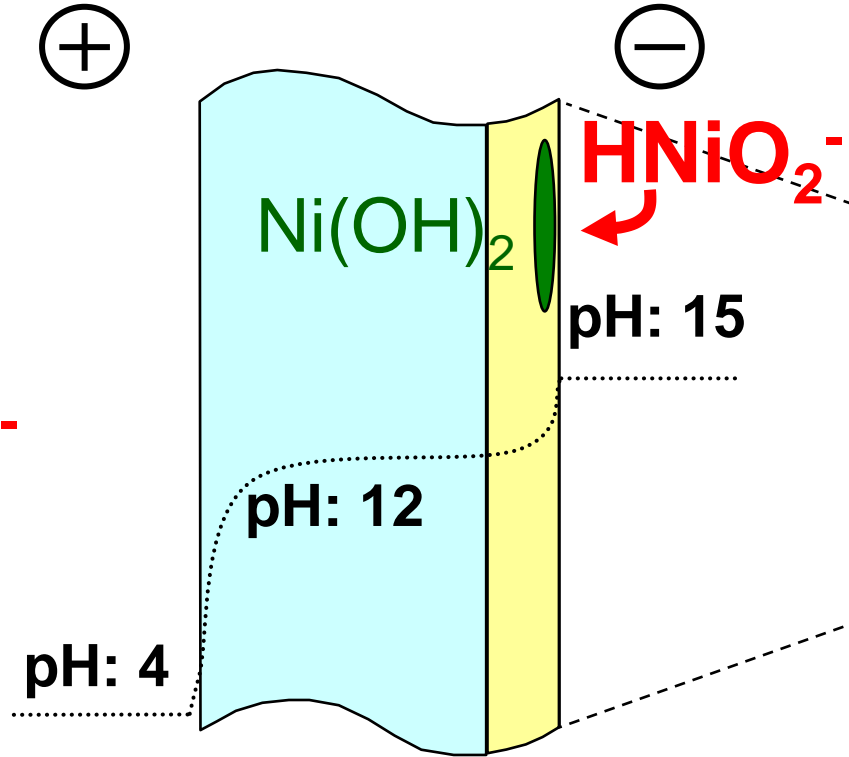
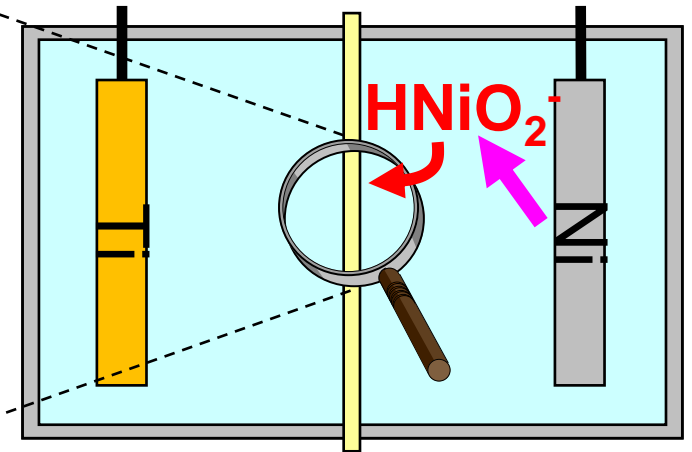


Image of Ni behavior

Ni come from cathode side



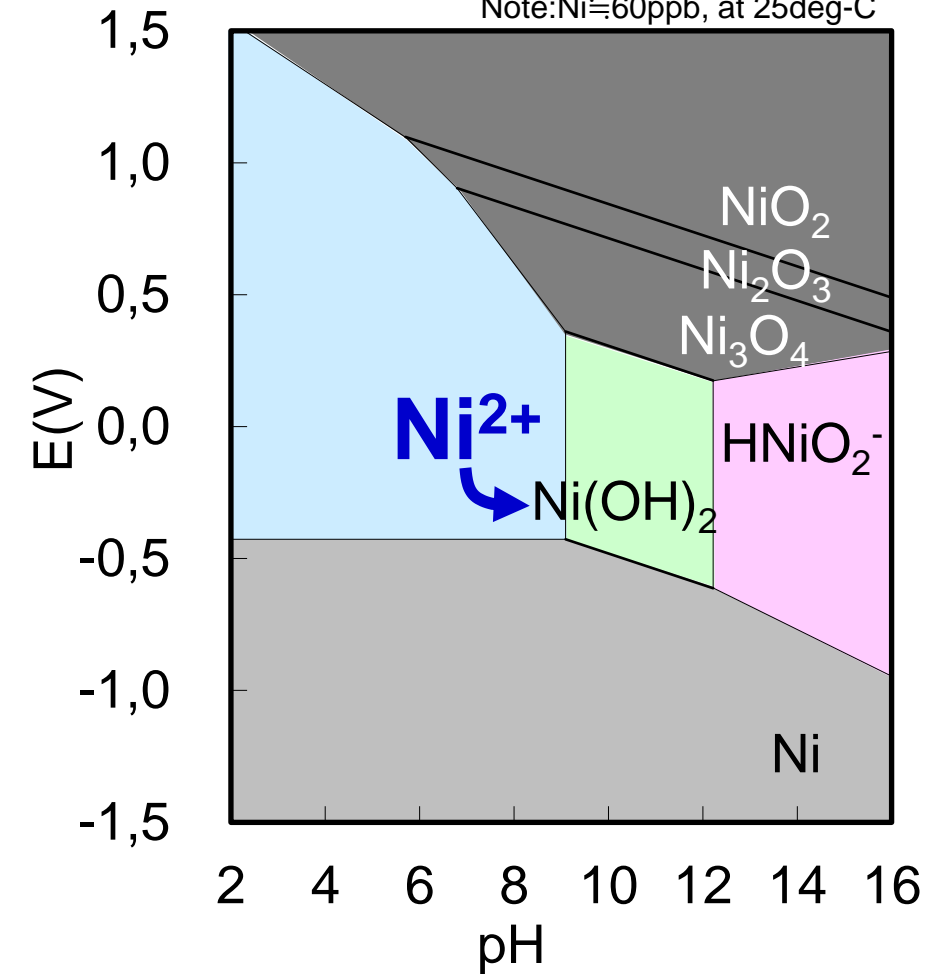
What's the difference from "Brine impurity"

If Ni dissolves... **C.E.** may decline

Brine Impurity : Ni Deposit in S-layer

Pourbaix Diagram of Ni

Note: Ni=60ppb, at 25deg-C



Magnified View

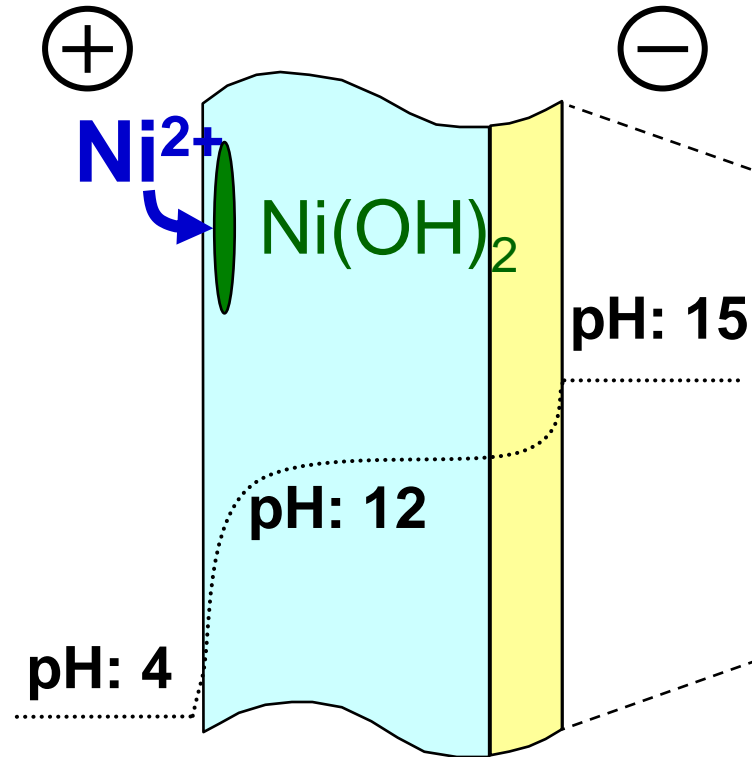
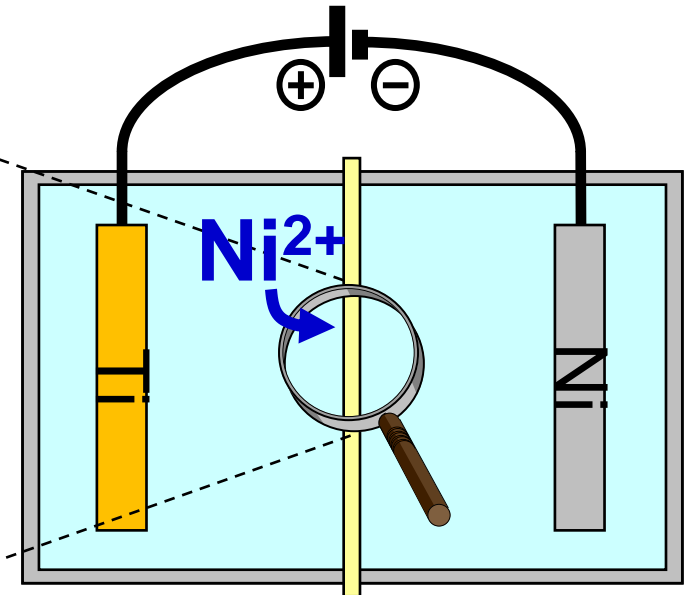


Image of Ni behavior



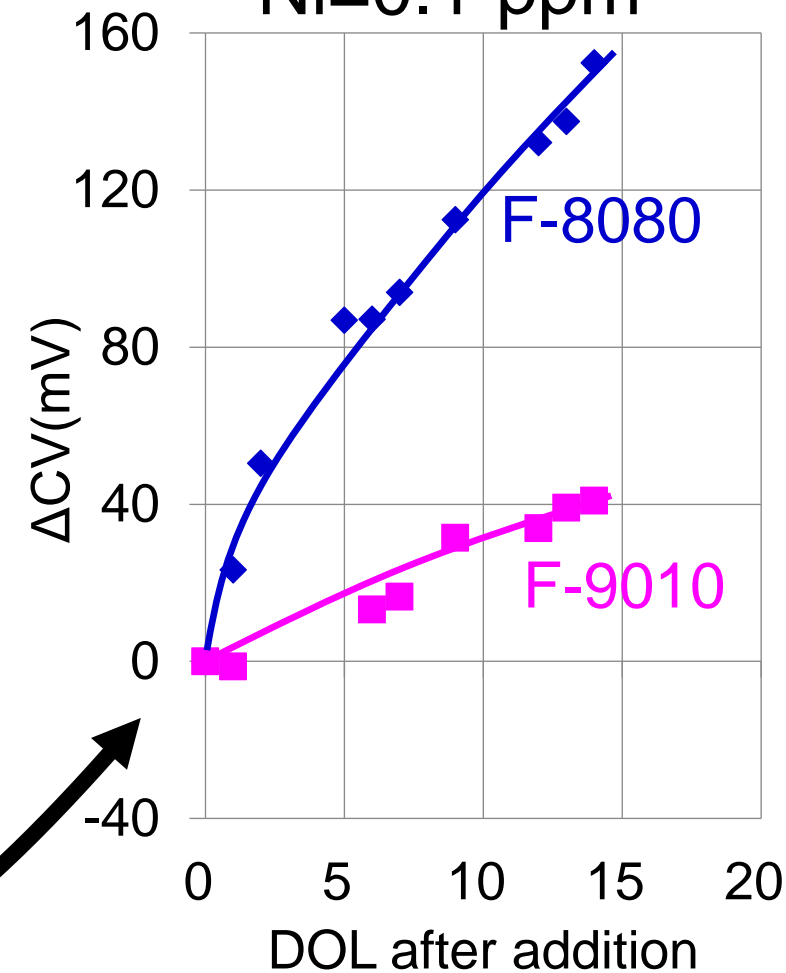
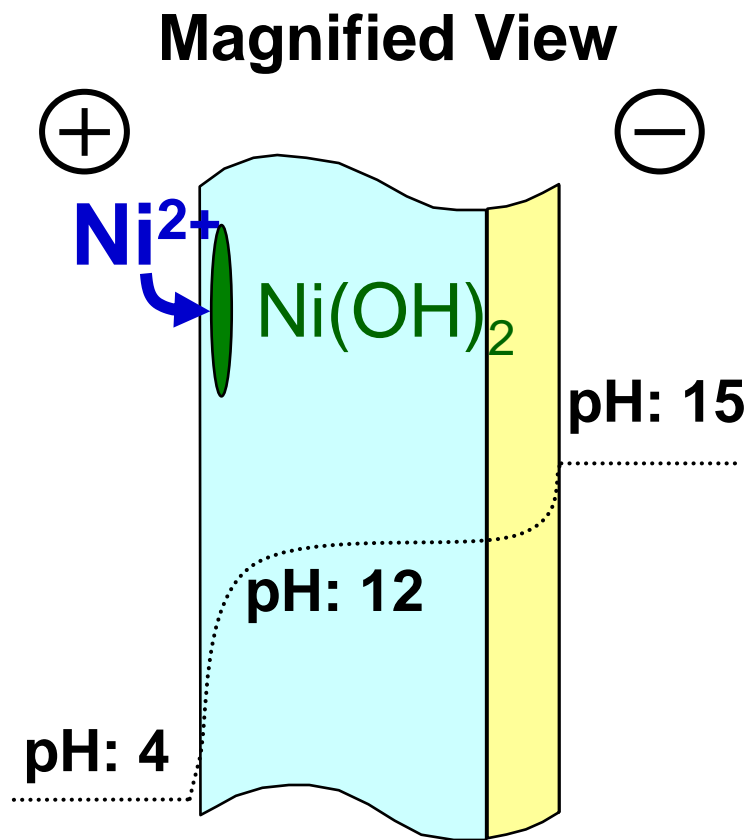
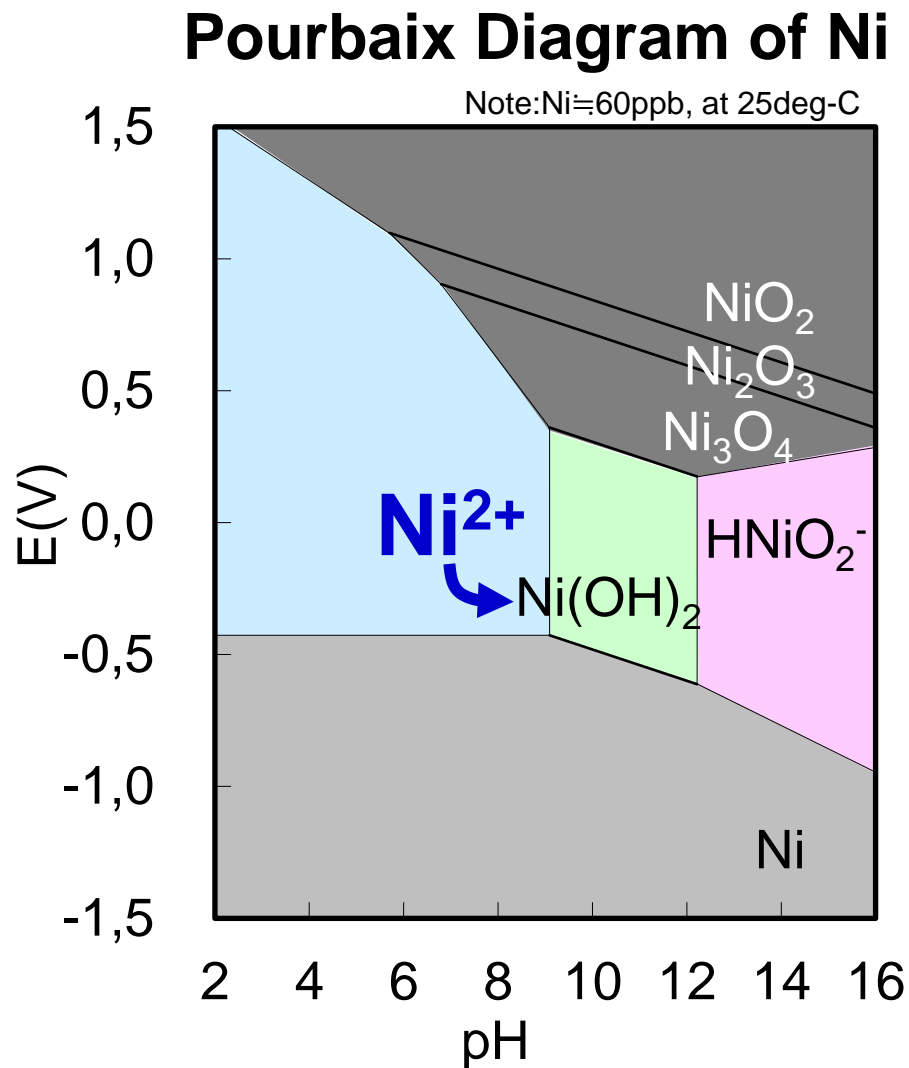
Ni come from anode side

Brine impurity : **C.V.** increase

Brine Impurity : Ni Deposit in S-layer

8 kA/m², 90 °C, 32 wt% NaOH,

Ni=0.1 ppm

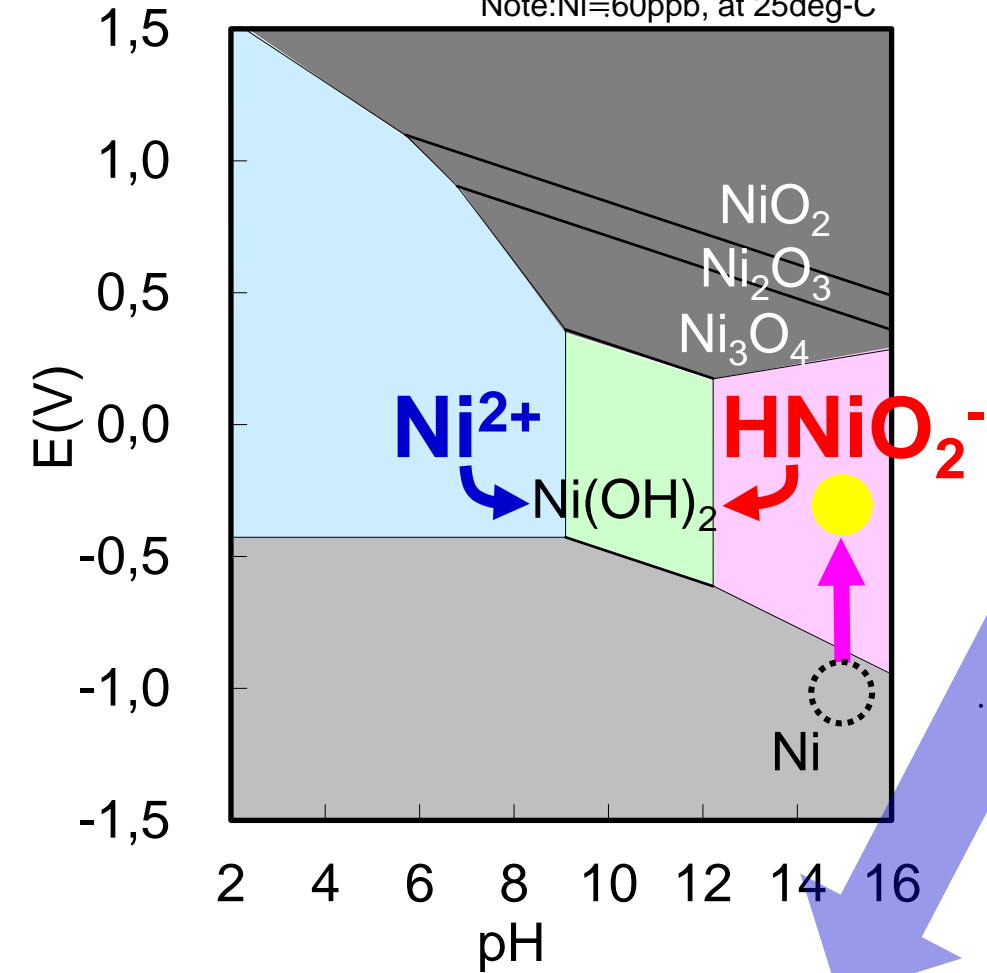


Brine impurity : **C.V.** increase

Ni Behavior : Brine Impurity vs Zero Gap

Pourbaix Diagram of Ni

Note: Ni=60ppb, at 25deg-C



Magnified View

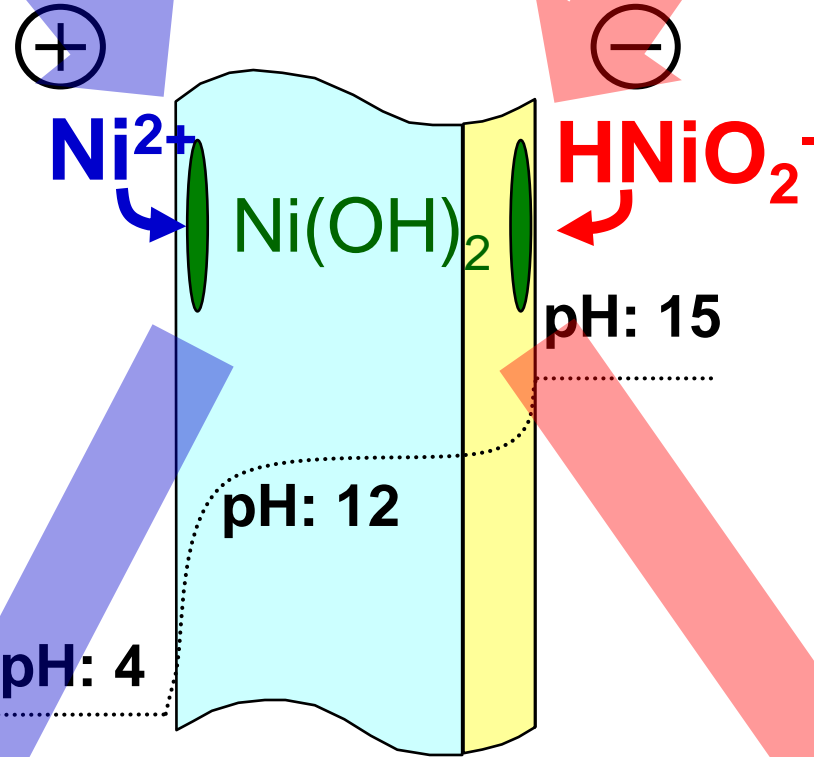
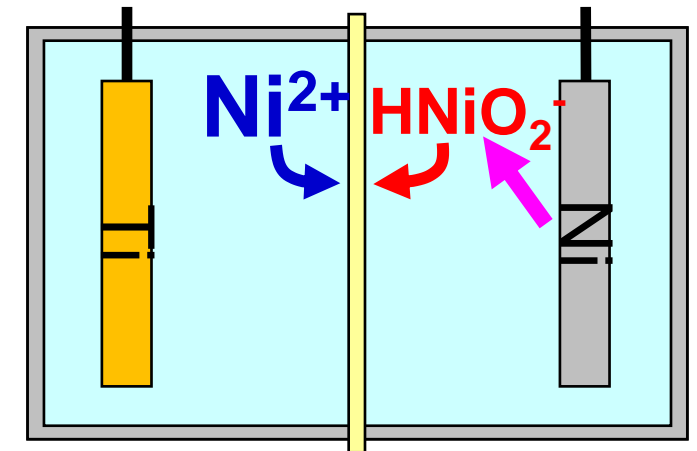


Image of Ni behavior



Brine impurity : **C.V.** increase

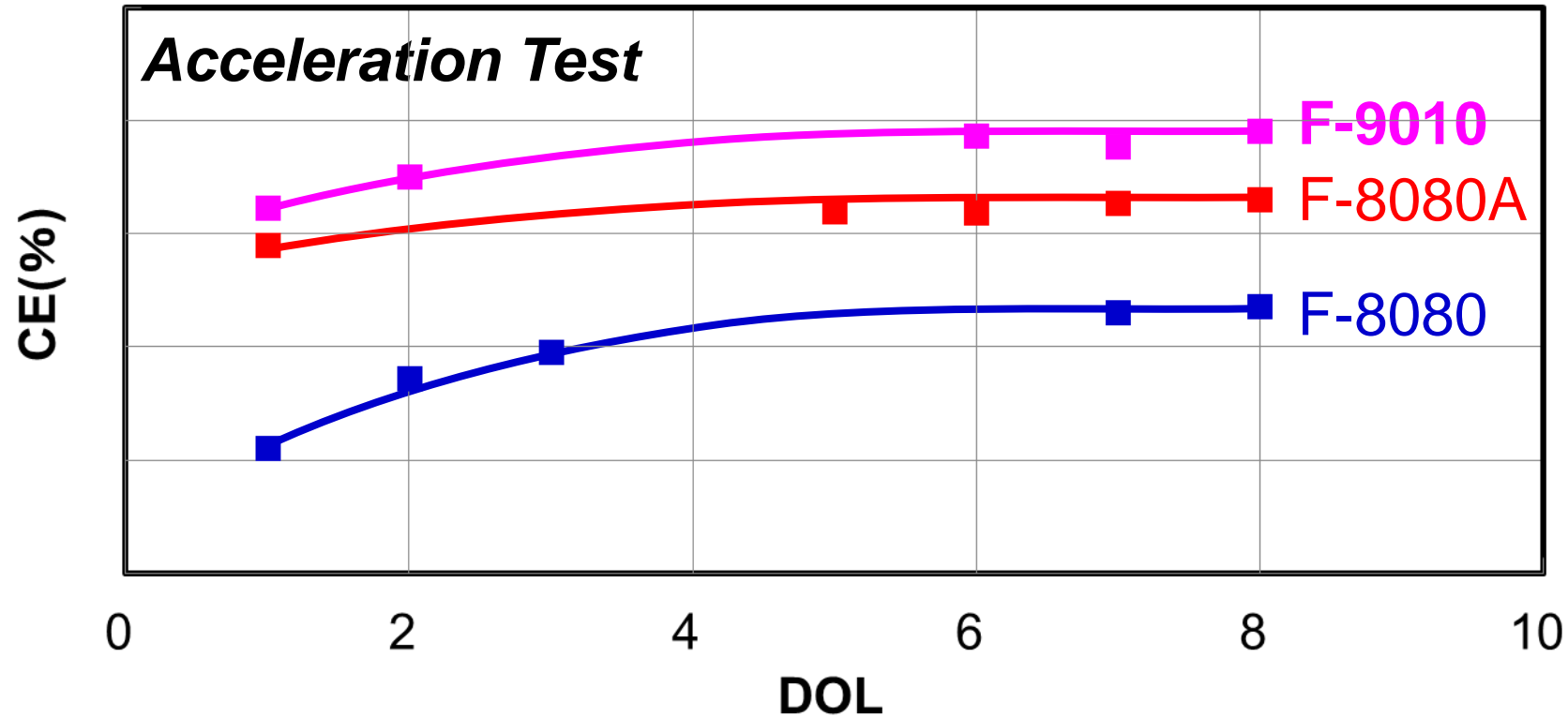
Zero Gap : **C.E.** may decline

Durability against Ni Stain(for Zero Gap)



Note)
Test conditions are confidential

6 kA/m², 90 °C, 32 wt% NaOH,



With understanding Ni behavior, we have been developing membranes with higher Ni resistance for zero gap step by step.

- Influence of Zero Gap on Membrane
- New Generation Membrane
- Technical Service Activity

Table of Initial Performance in Laboratory Cell

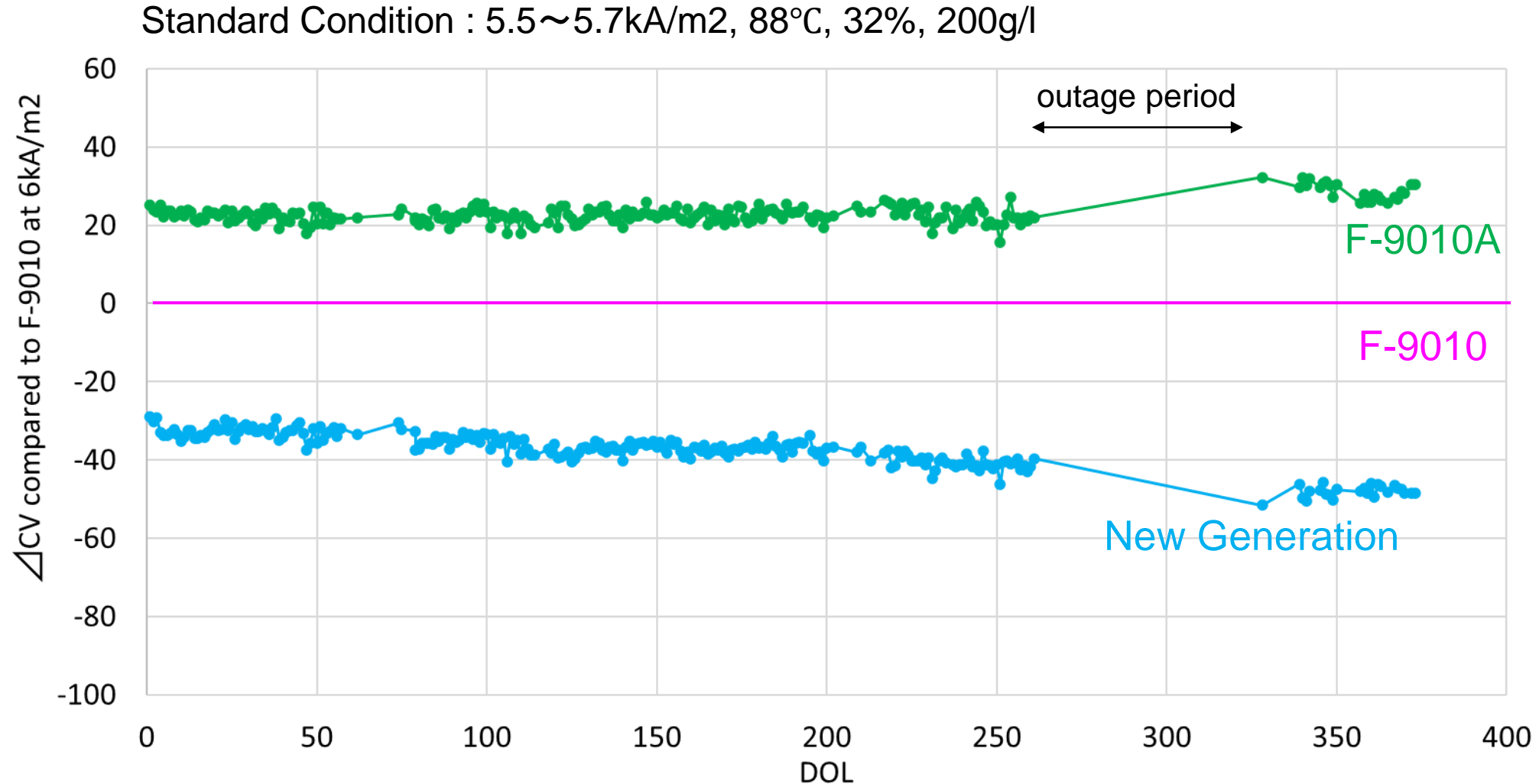


AGC lab cell, 6 kA/m², 90 °C, NaOH 32 wt%, NaCl 200 g/l

	CE	ΔCV	Features
F-8080	≥96.0	+50mV	Previous standard membrane
F-8080A	≥96.5	+50mV	Higher CE than F-8080 suitable for zero gap technology.
F-9010	≥96.8	0mV	Standard Membrane suitable for zero gap technology
F-9010A	≥97.0	+20mV	Higher CE than F-9010 with CV increase suitable for zero gap technology
New Generation	≥97.0	-40mV	<u>the lowest voltage & the highest CE</u> suitable for zero gap technology

New Generation Membrane has both the lowest voltage and the highest CE

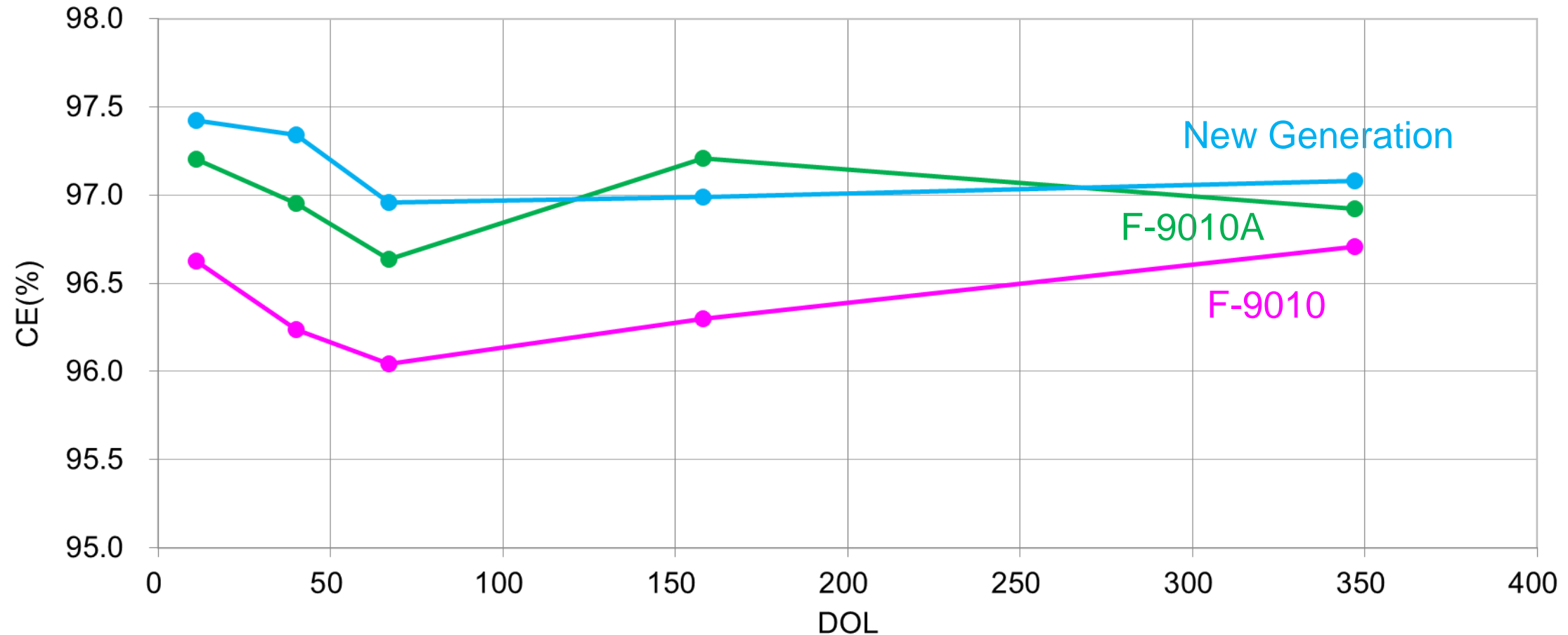
New Generation Performance in AGC Plant (Zero Gap) **AGC**



New Generation Membrane shows about 40mV lower and more stable voltage than F-9010 for around one year.

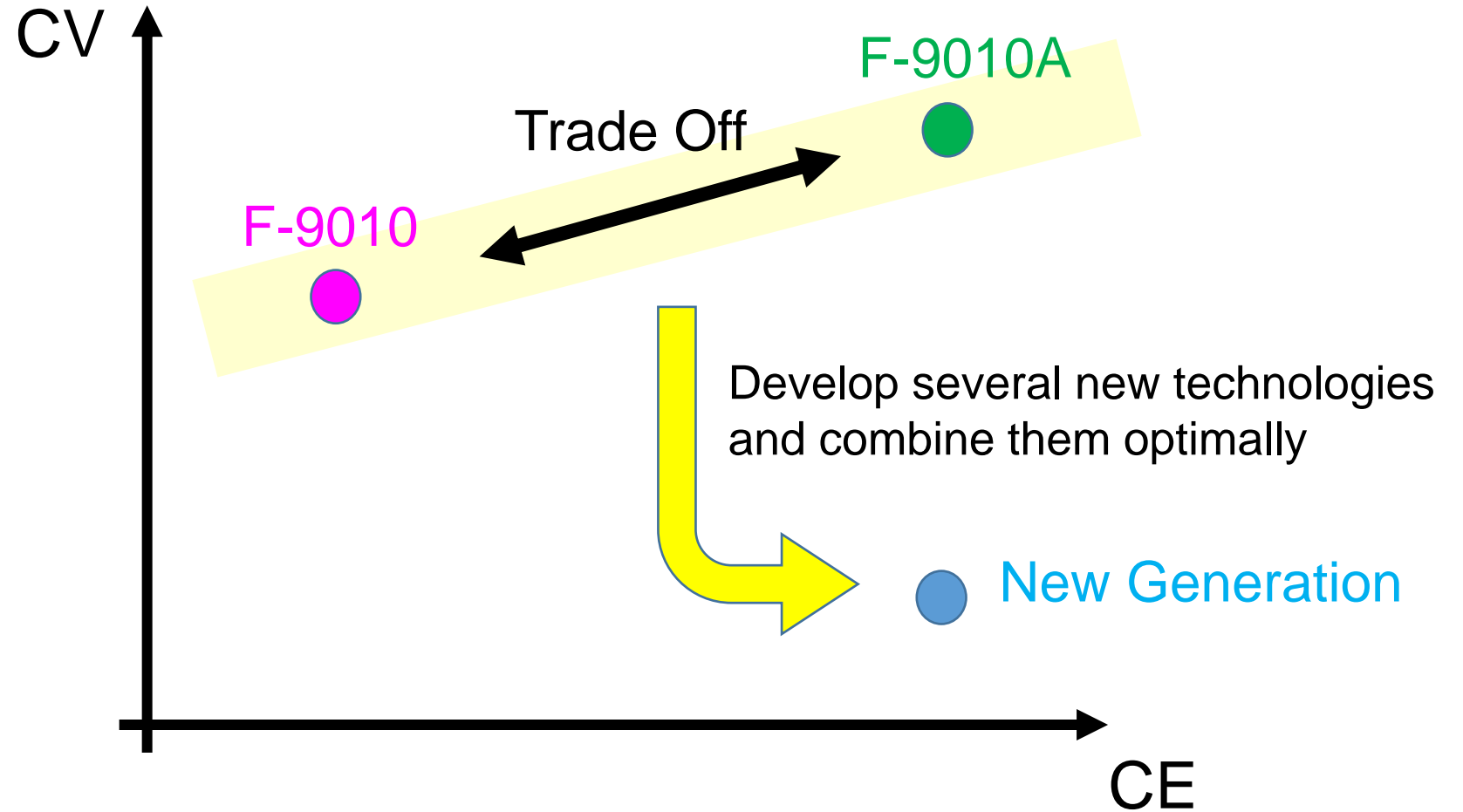
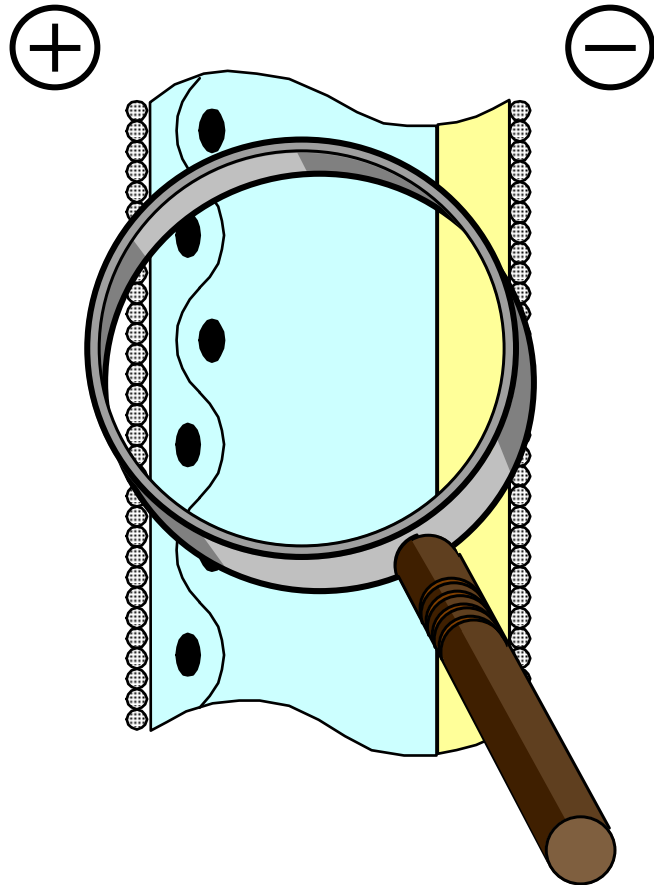
New Generation Performance in AGC Plant (Zero Gap) **AGC**

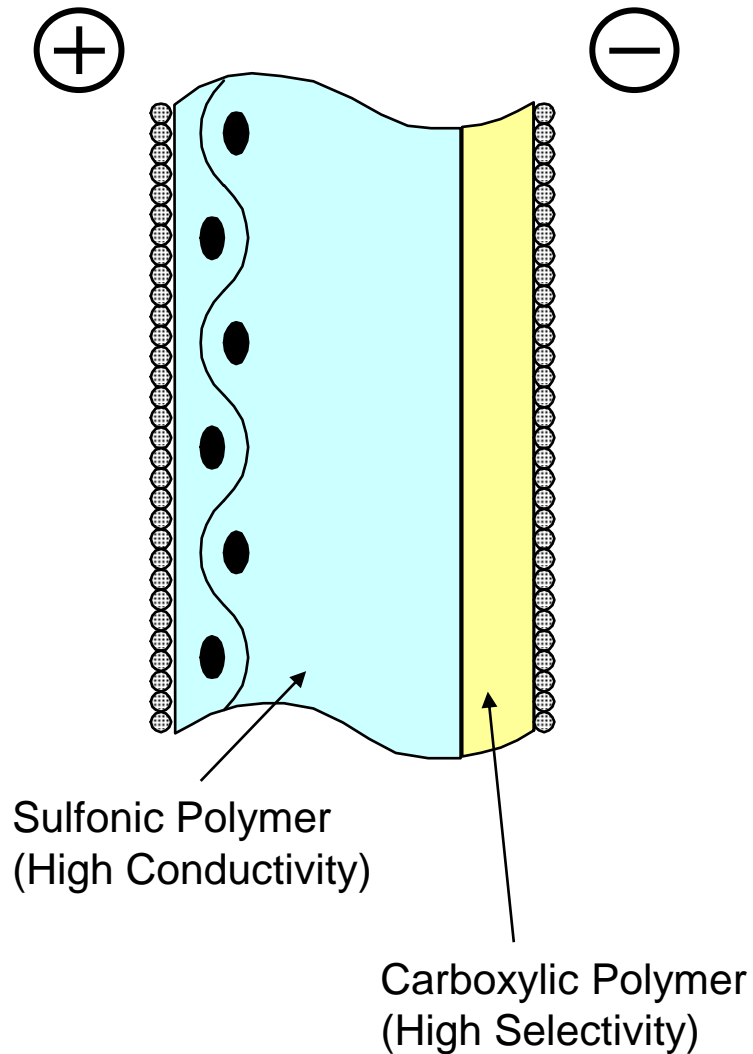
Standard Condition : 5.5~5.7kA/m², 88°C, 32%, 200g/l



New Generation Membrane shows higher CE than F-9010 and nearly the same CE as F-9010A for around one year.

What's new ?

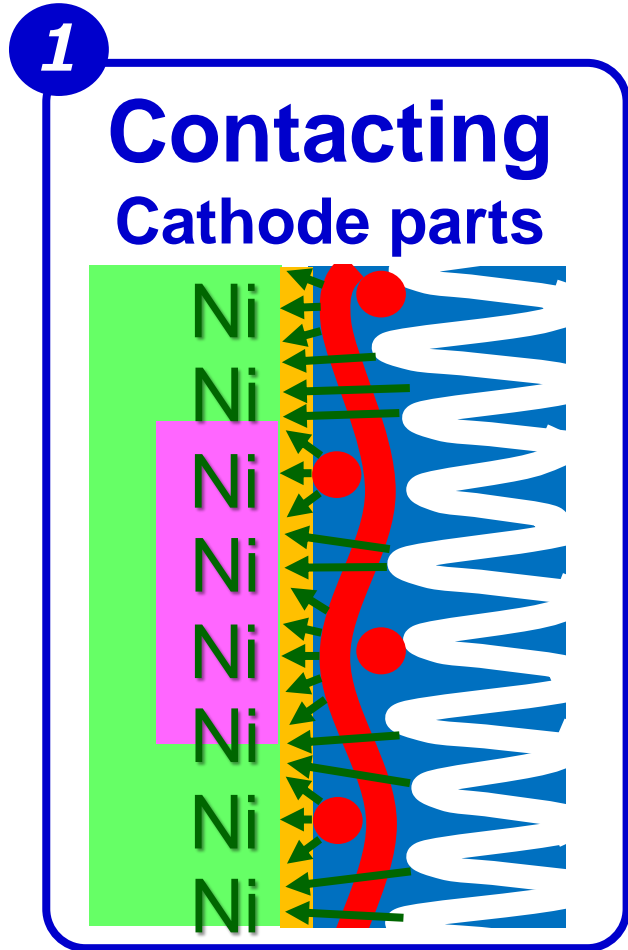




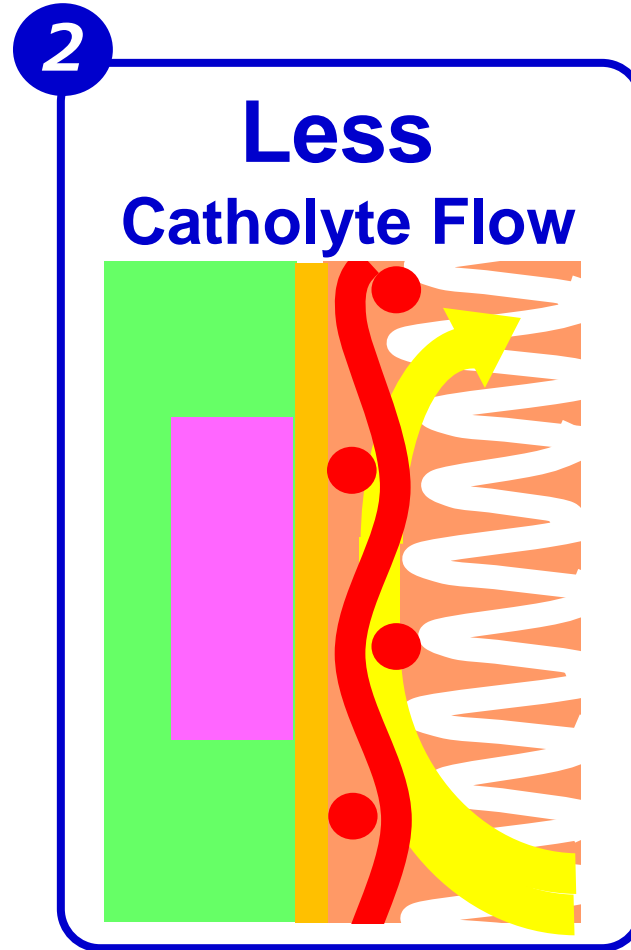
Merit	Key Technology
Lower Voltage	New S Polymer
Higher CE in Zero Gap	New Ion Channel
Stable Performance	Optimized Polymer Layer Configuration

Note) These are a part of applied new technologies

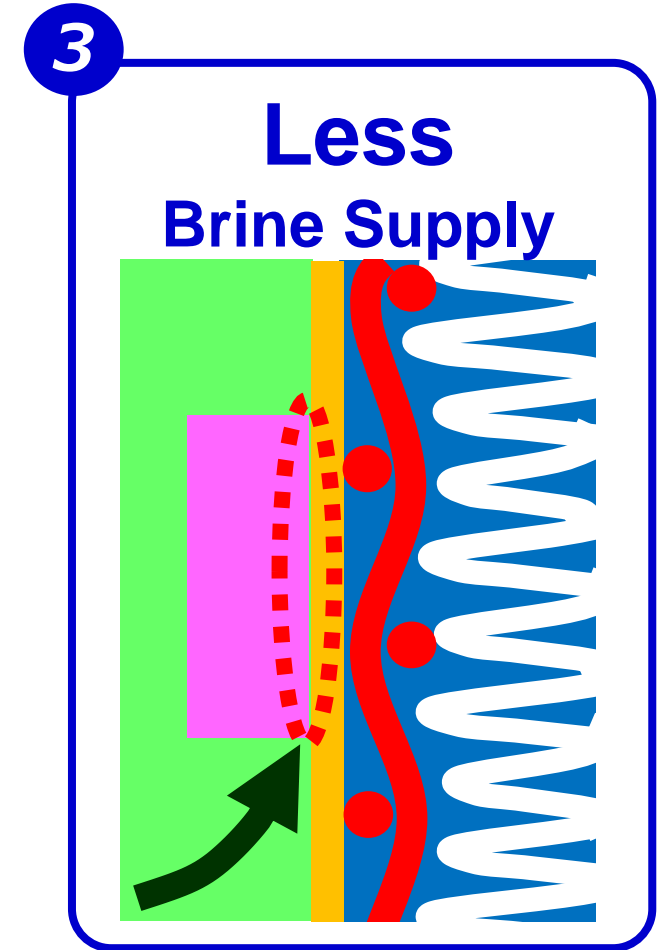
“Zero gap” has **Three** Key Points



1 Ni stain



2 High
Temperature

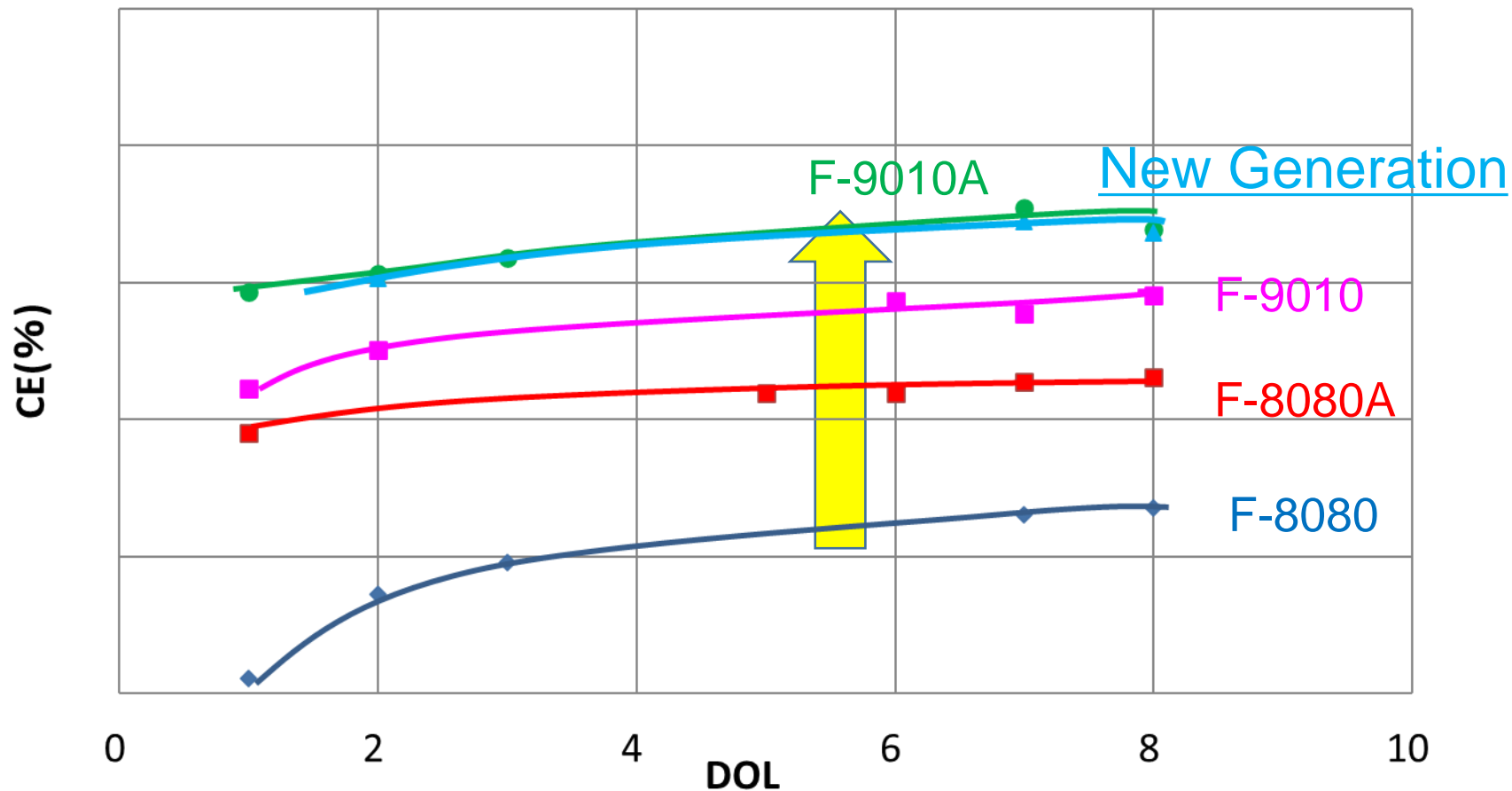


3 Weak brine

New Generation : Resistance to Ni stain

Precondition ; soaked in a Ni solution

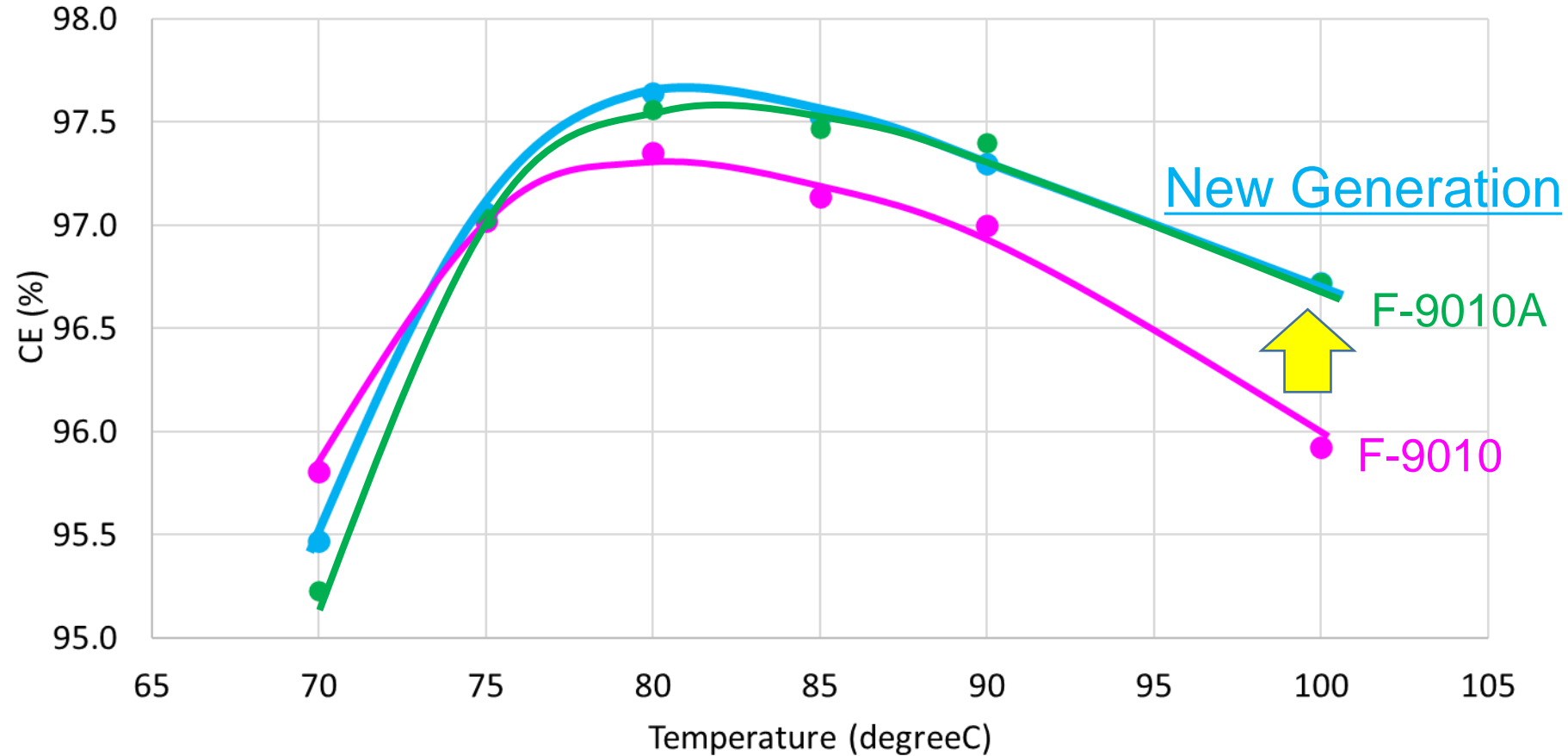
AGC Laboratory cell, 6 kA/m², 90 °C, NaOH 32 wt%, NaCl 200 g/l



New Generation shows the highest resistance to Ni stain

New Generation : Temperature Characteristic

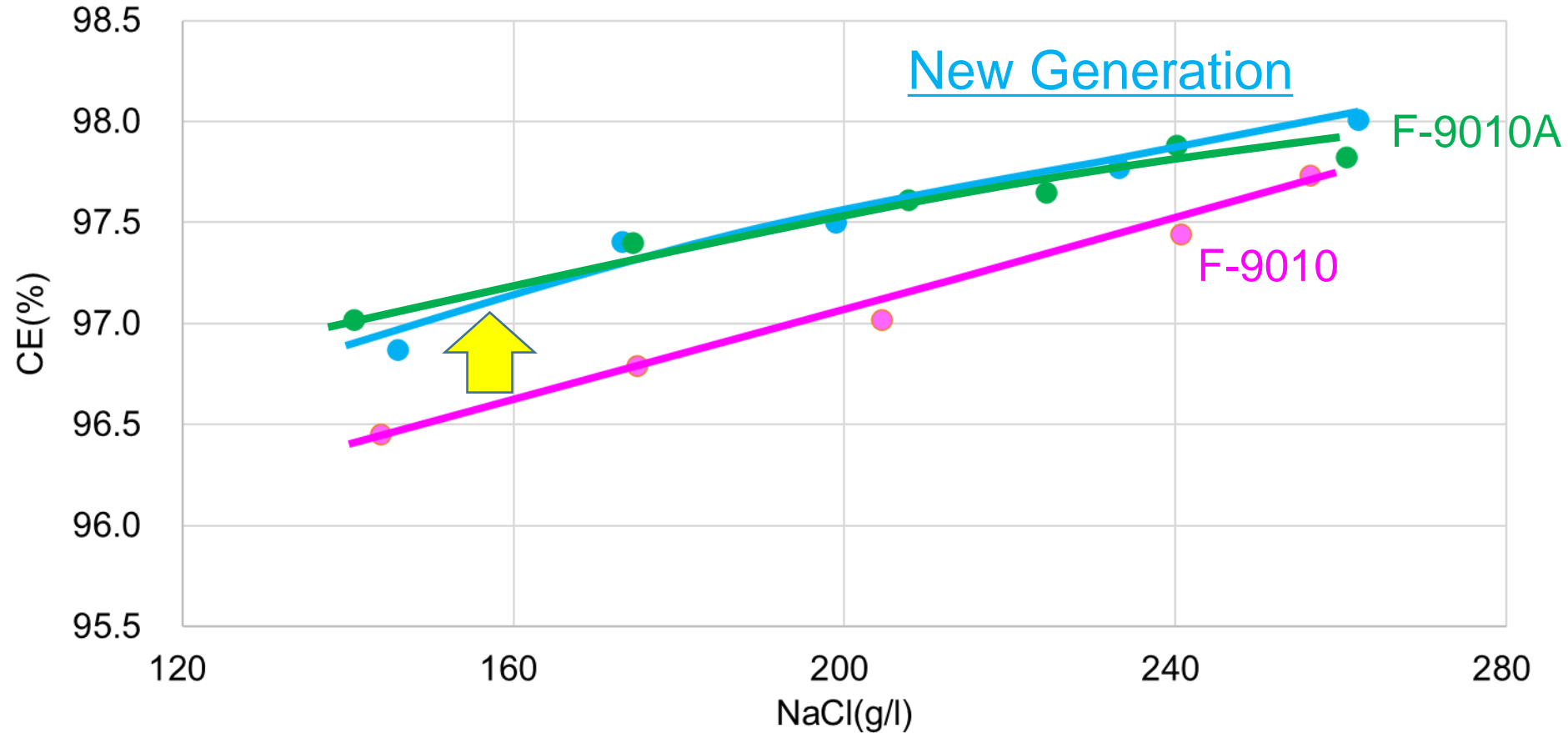
AGC LabCell, 6 kA/m², NaOH 32 wt%, NaCl 200g/l



New Generation shows higher CE at higher temperature

New Generation : NaCl Concentration Characteristic

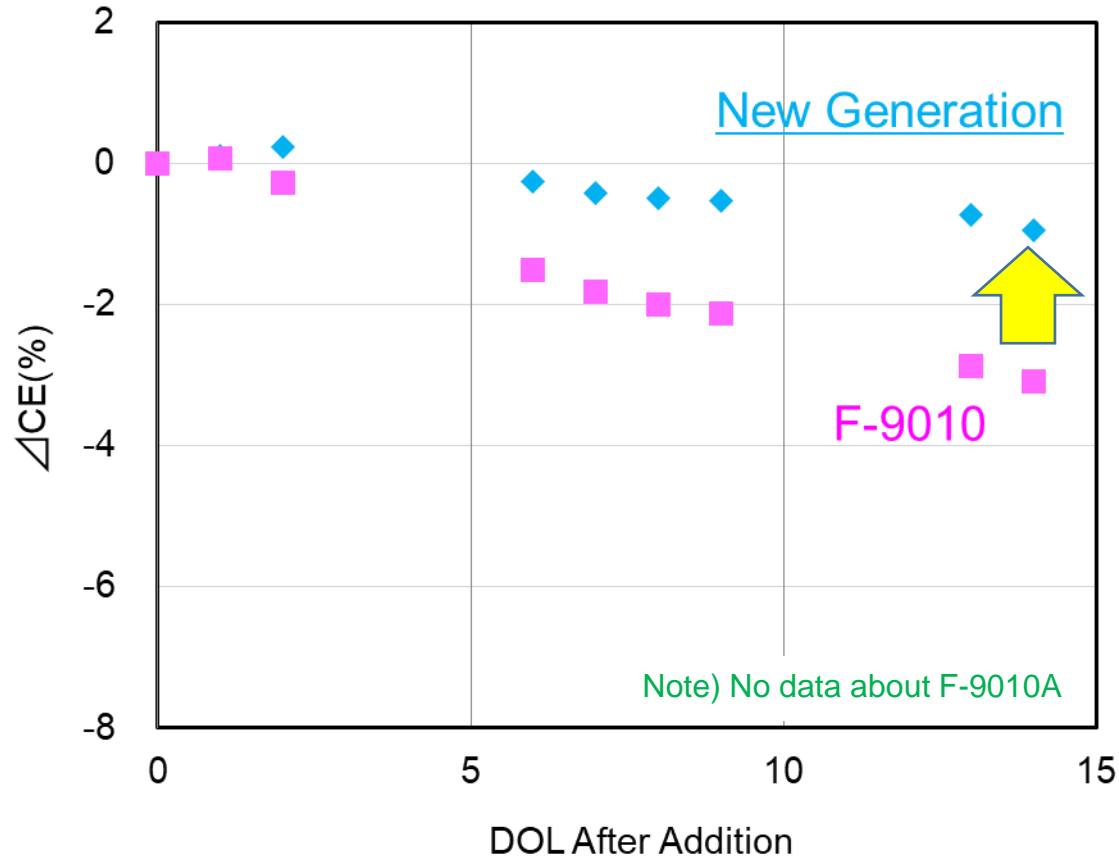
AGC LabCell, 6 kA/m², 90 °C, NaOH 32 wt%



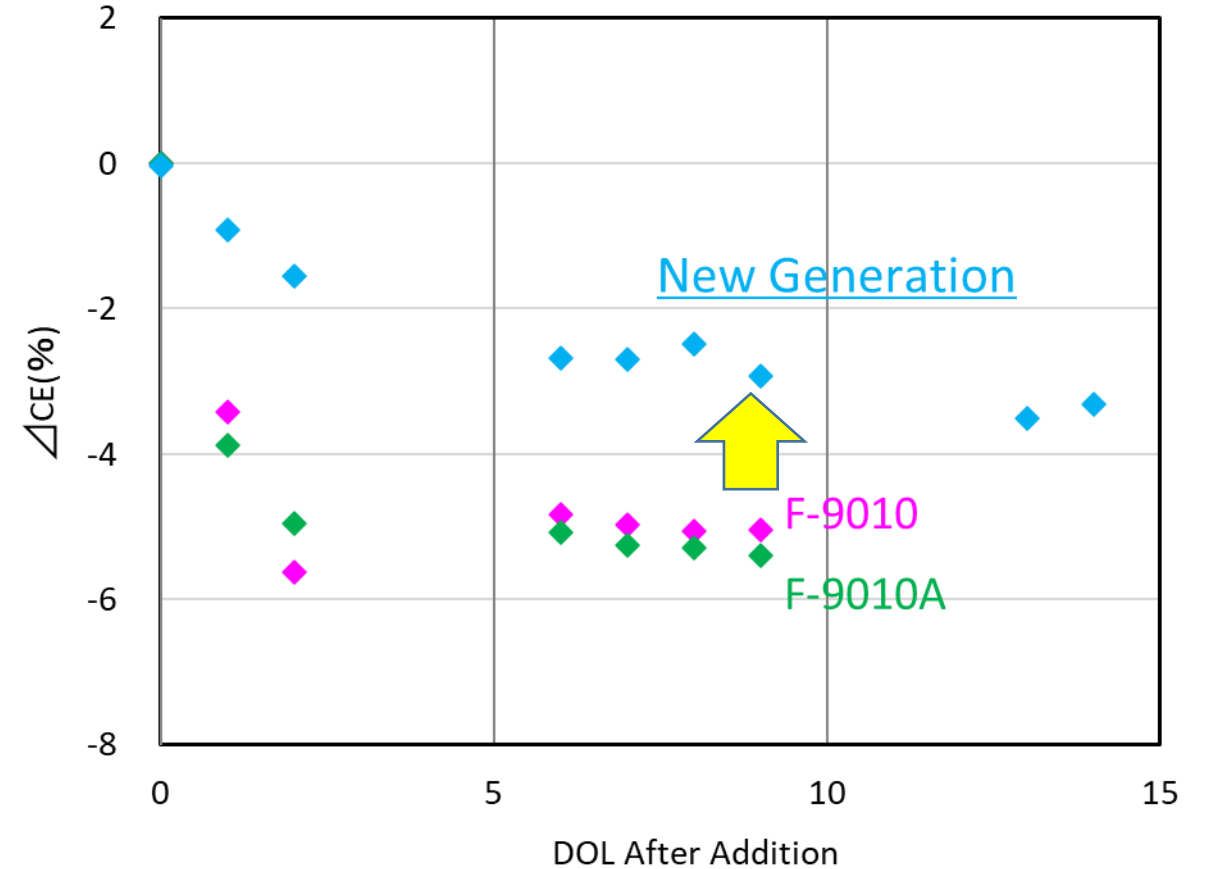
New Generation shows higher CE in weak brine

Durability against Al/SiO₂ and Ca/SiO₂

Al/SiO₂ = 1/30 ppm, 8 kA/m², 85°C, NaOH 32wt%

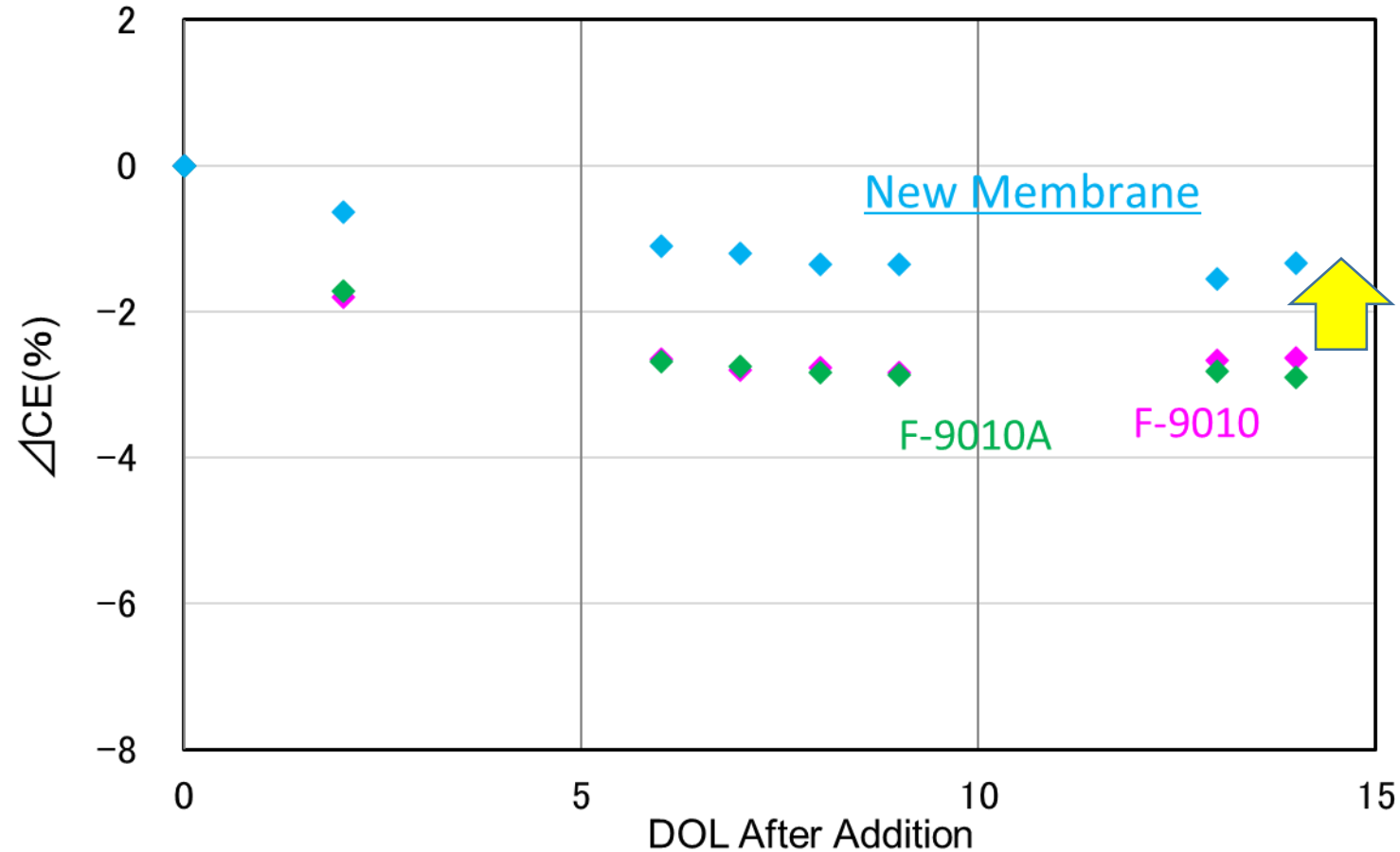


Ca/SiO₂ = 0.05/15 ppm, 8 kA/m², 85°C, NaOH 32wt%





New Generation shows higher durability against Al/SiO₂ and Ca/SiO₂

I/Ca = 10/0.3 ppm, 8 kA/m², 85°C, NaOH 32 wt%



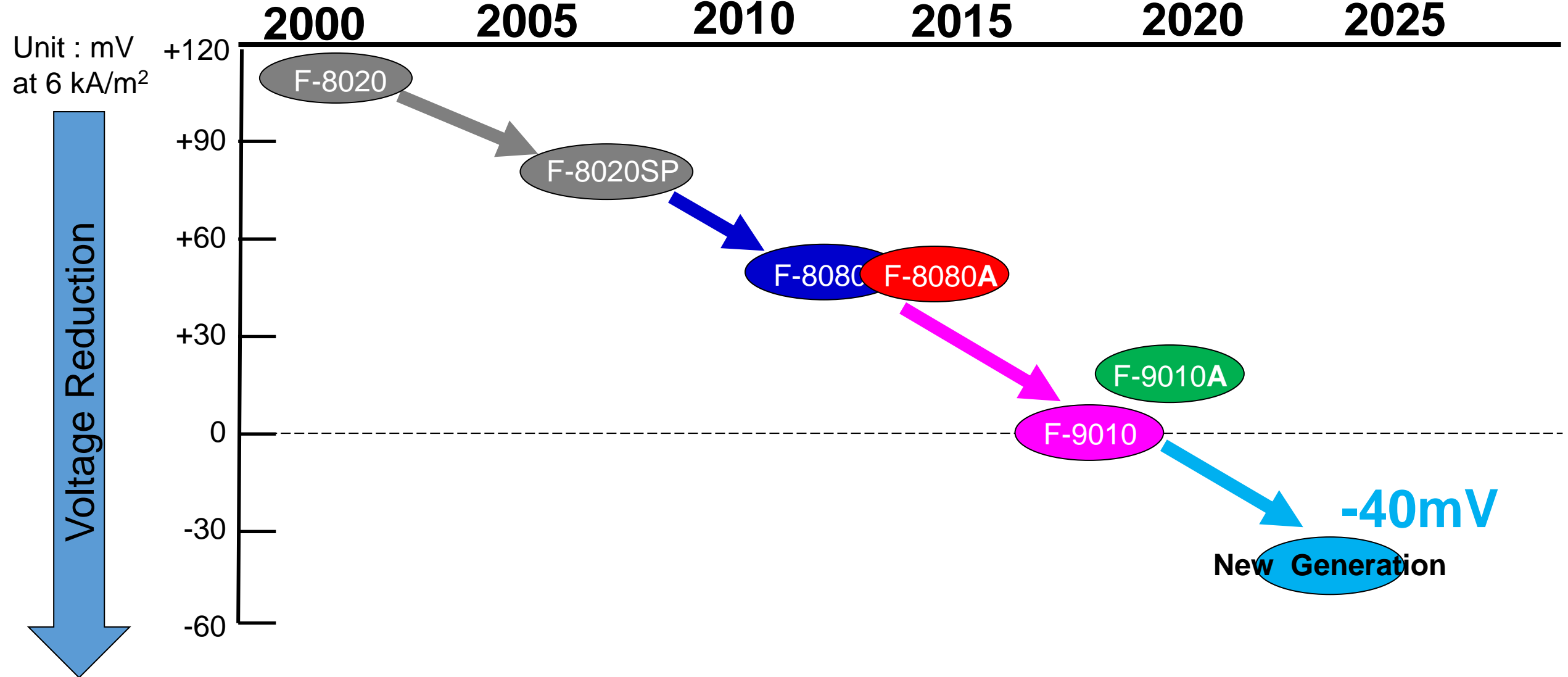
New Generation shows higher durability against I/Ca

Reinforcement Cloth Type	F-8080/F-8080A	F-9010/F-9010A	New Generation
Tensile Strength Elongation (Fiber direction)	Approx. 45 N/cm Approx. 40 %		
Frequent Load Tensile Test (AGC Original Overload Test)	Standard	Better	Standard

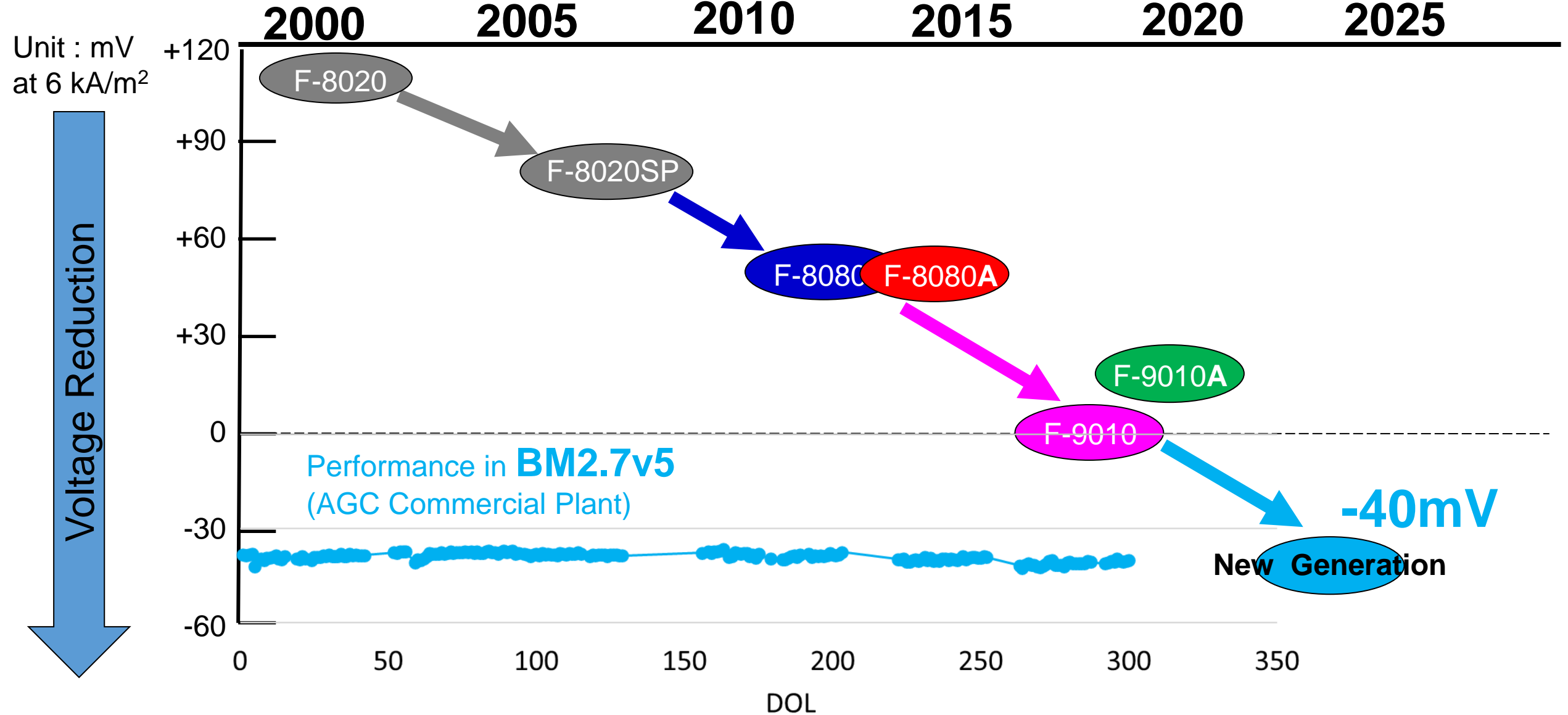
Note) Total number of frequent load tensile test until membrane breaking including fiber direction and 45 degree direction for fiber.

One More Thing

FLEMION™ Voltage Reduction

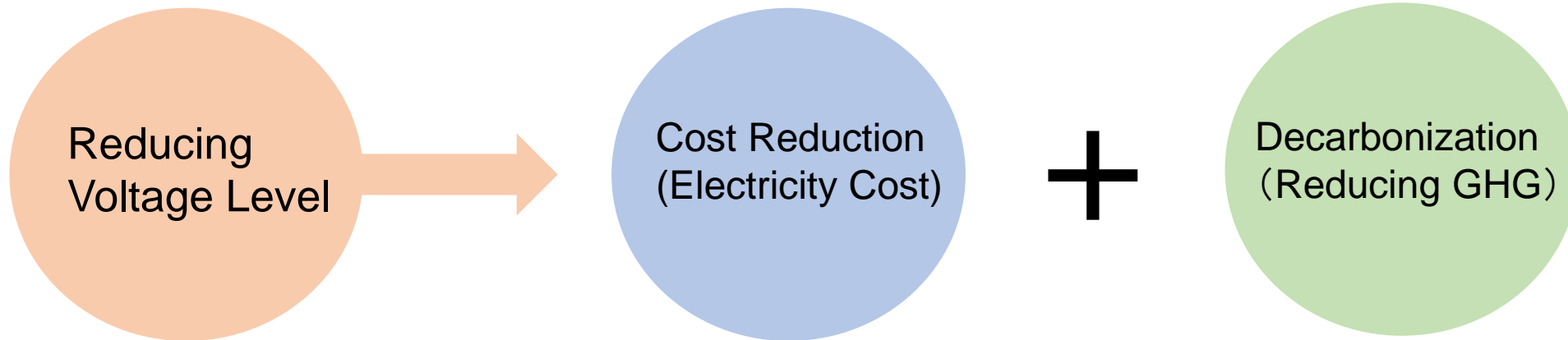


FLEMION™ Voltage Reduction



New Generation keeps stable & low voltage in BM2.7v5 for around 10 months.

Reducing voltage level further would increase not only economical value but also environmental contribution:

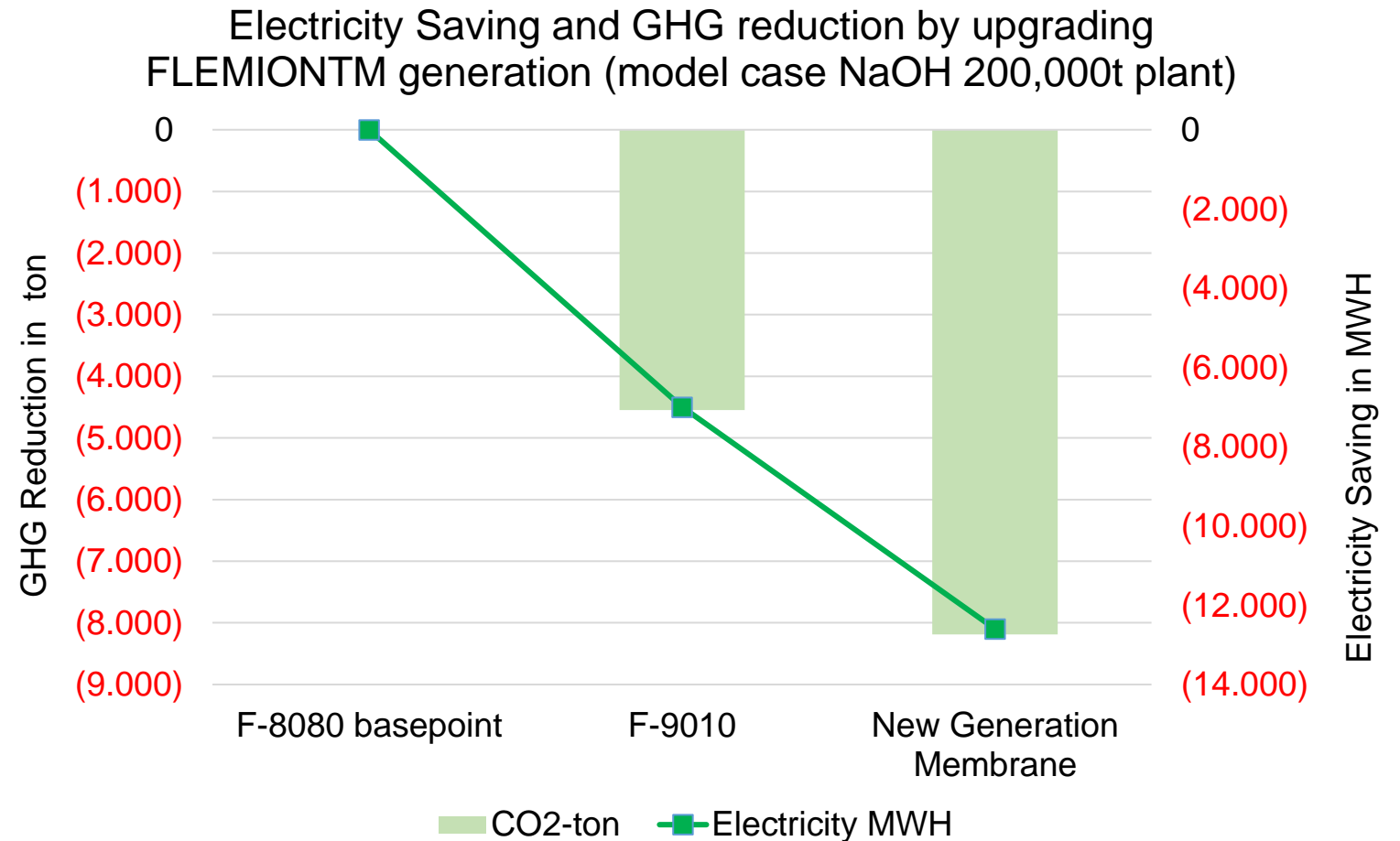


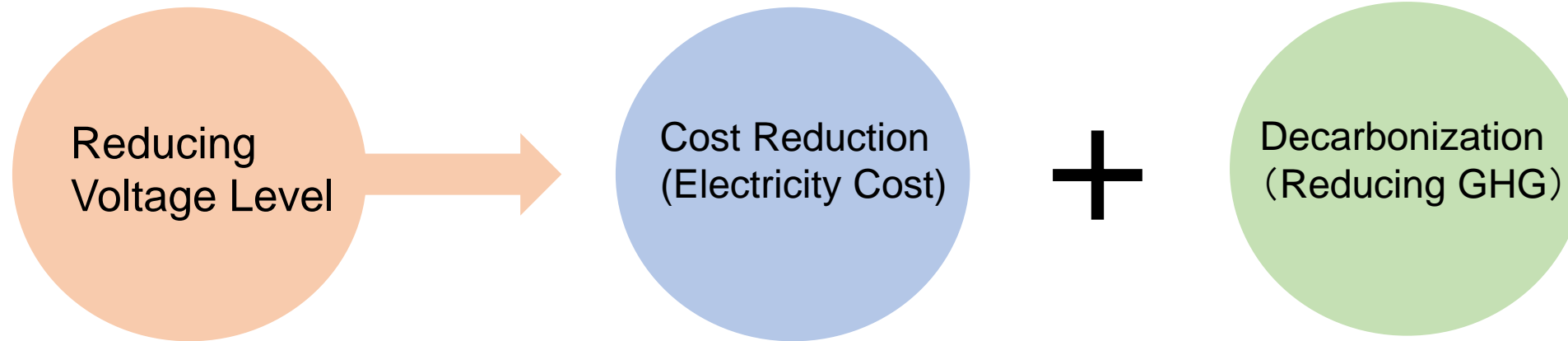
FLEMION™ New Generation Membrane: Value of reducing voltage level **AGC**

By utilizing FLEMION™ new generation membrane and reducing voltage level, chlor-alkali plant can save energy cost and also reduce CO₂ emission

Premises:

- 1.. Consider FLEMION™ F-8080 as base point, calculating the impact of reducing 50mV by using F-9010 and further reducing 40mV by using New Generation Membrane.
- 2.. Consider Chlor-alkali plant with 200,000 ton/Y capacity as a model case
- 3.. Adopting US EPA's average CO₂ emission factor (in electricity, Non-baseload, 2020)





▲40mV voltage reduction:

equivalent to approx. 28kWh/t-NaOH Power Consumption reduction

▲40mV voltage reduction:

equivalent to approx. 0.0182t / t-NaOH^{※1} CO₂ reduction

※1: adopting US EPA's average CO₂ emission factor, Mar 2020
0.00065 t-CO₂/kwh

Economical impact on chlor-alkali plant with 200,000t /Y capacity:

assume electricity cost at 10 cents/kwh, cost reduction impact is roughly \$ 560,000/year

Economical impact on chlor-alkali plant with 200,000t /Y capacity:

assume CO₂ ETS price is 80 euro/CO₂-ton^{※2}
impact is roughly \$ 292,000/year^{※3}

※2: ETS price level in EU as of September 1st, 2022

※3: Currency conversion €/ \$ at 1\$=0.9948€ as of Sep 1st, 2022 (by WSJ online)

- Influence of Zero Gap on Membrane
- New Generation Membrane
- **Technical Service Activity**

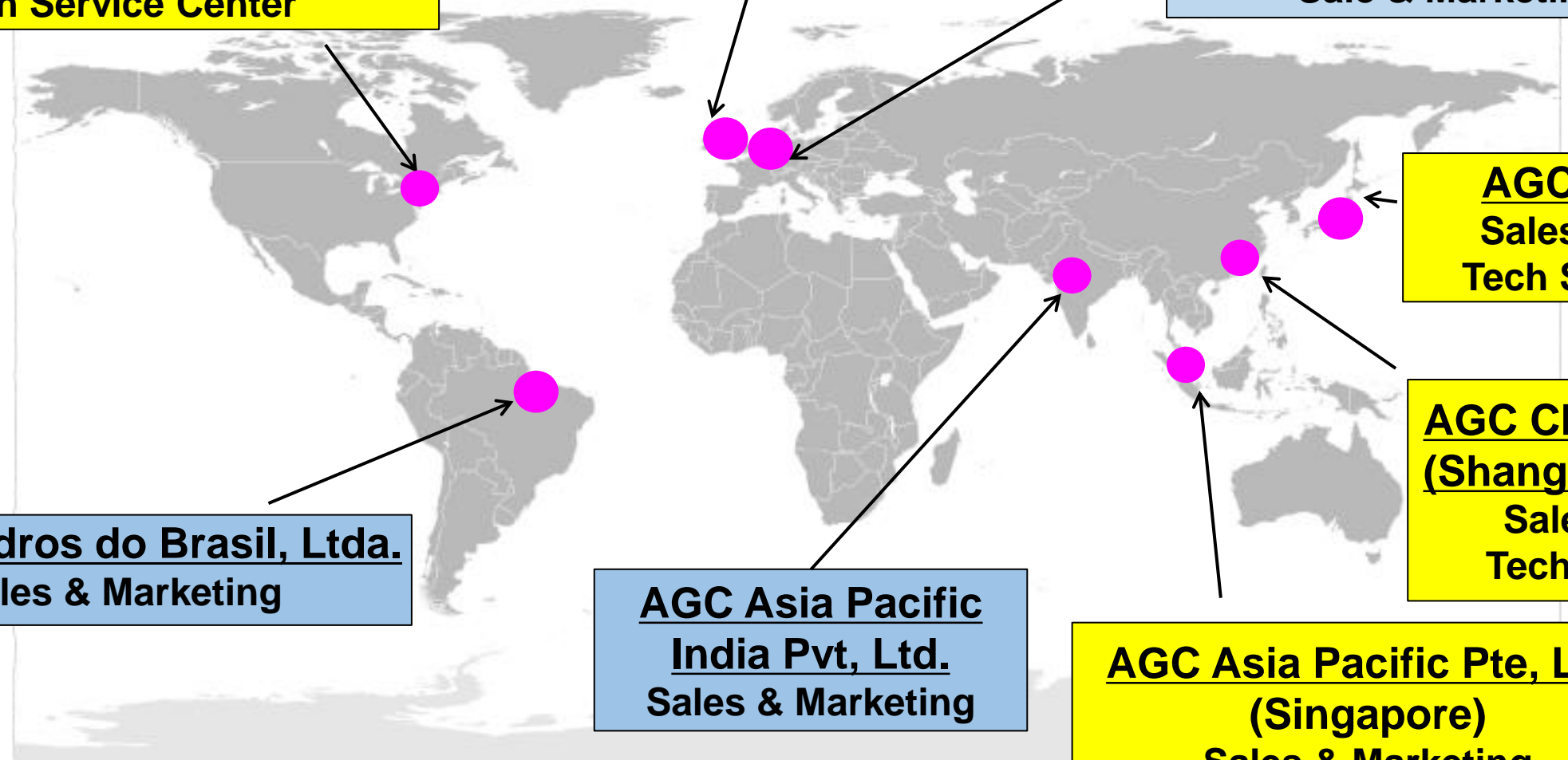
FLEMION™ Business in Worldwide



AGC Chemicals Americas, Inc.
Sales & Marketing
Tech Service Center

AGC Chemicals Europe, Ltd.
Sales & Marketing

**AGC Chemicals Europe
Commercial Centre.**
Sale & Marketing



AGC Inc. Japan
Sales & Marketing
Tech Service Center

AGC Vidros do Brasil, Ltda.
Sales & Marketing

**AGC Asia Pacific
India Pvt, Ltd.**
Sales & Marketing

**AGC Chemicals Trading
(Shanghai) Co., Ltd.**
Sales & Marketing
Tech Service Center

**AGC Asia Pacific Pte, Ltd.
(Singapore)**
Sales & Marketing
Tech Service Center



AGC Japan

All site

Membrane Analysis

Brine Analysis

Pinhole or Blister Evaluation

Influence of Impurities

Brine & Salt

Visual Analysis

- Sketch
- Photograph

Damage Type

- Optical Microscope
- SEM (Scanning Electronic Microscope)

Amount & Position of Impurities

- ICP, SEM-EDX

Electrolysis Evaluation

- Zero Gap lab cell

Amount of Impurities

- ICP, IC, TOC

Causes of Damage on the Membranes

- Amount of Impurities
- Type and Position of Impurities
- Cause of CV increase
- Cause of the CE Decrease

Crosscheck with customer's lab results

Full Investigation & Informative Report of Analysis

▶ **Just send your brine or salt sample** by using provided sample kit and shipping label

→ **We will analyze your sample and report back to you!**

▶ Please use our service to:

- Analyze solid salt, raw brine, filtered brine, purified brine, or other brine sample
- Obtain results from AGCCA to compare your own analysis
- Utilize the results to track historical performance etc

→ **Available for any purpose!**

Brine Sample Label and Sampling Kit



- ▶ What is the Cost? **Nothing!**
- ▶ Why does AGC offer this service? **Just for you!**

In order to be responsive to your needs and to recommend process improvements.

- ▶ How long will the analysis take?

Brine or Salt sample: 4 Weeks; Membrane sample: 3 Months

Depending on the situation, it may take a little more



AGC



For AGC's FORBLUE™ FLEMION™ Technical Symposium

October 24-26, 2023

Join us as our guests to
learn about our latest
innovations and have
some fun!



Scan Me



Your Dreams, Our Challenge


AGC



New Orleans



Where?

**New Orleans,
Louisiana**

“The Big Easy”

**AGC's FORBLUE™ FLEMION™
Technical Symposium**



Scan Me

FORBLUE™

● Influence of Zero Gap on Membrane

- Three Key Points of Zero Gap : Ni stain, High temperature, Weak brine
- Methods of preventing Ni dissolution with Pourbaix Diagram

● New Generation Membrane

1. Lowest voltage

40mV lower voltage than F-9010 at 6kA/m²

2. Higher CE stability in zero gap

Higher resistance to Ni stain and high temperature operation and weak brine

3. Higher brine durability against Al/SiO₂, Ca/SiO₂ and I/Ca

4. Good impact on not only electricity cost reduction but also GHG reduction

● Technical Service Activity

Please use our technical service for keeping good membrane performance

A tropical landscape featuring a body of water in the foreground, a line of palm trees on a small island in the middle ground, and a blue sky with scattered white clouds. A large, semi-transparent yellow shape is overlaid on the left and bottom portions of the image.

Thank you for your attention