



The development of Insoluble CNT Anode for Electroplating Using ARIP

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Problem Issue

[Development of Anode for Electroplating Process using CNT coating layer]

- The anode is dissolved by electrochemical reaction at electroplating process

→ Insoluble anode required

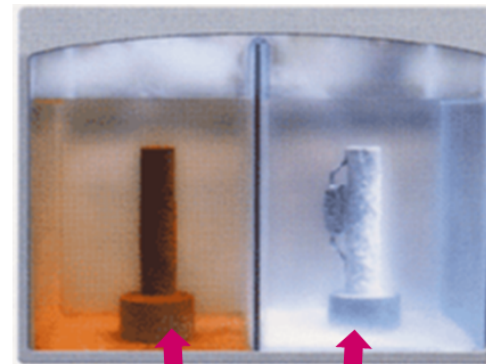
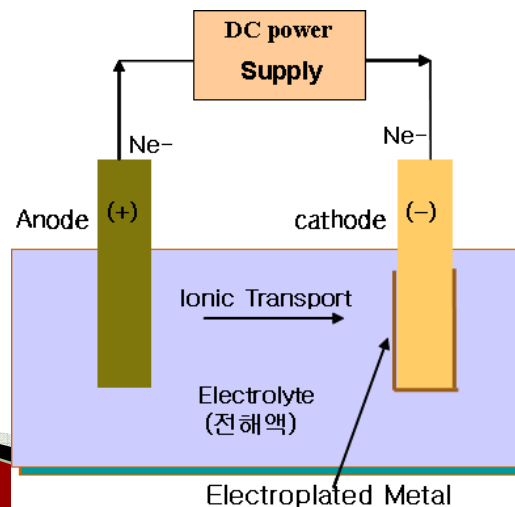
(1) Platinum-based anode used in order to prevent dissolution (Useful) /conventional method

(2) Platinum elements are very expensive (Cost up) : (harmful)

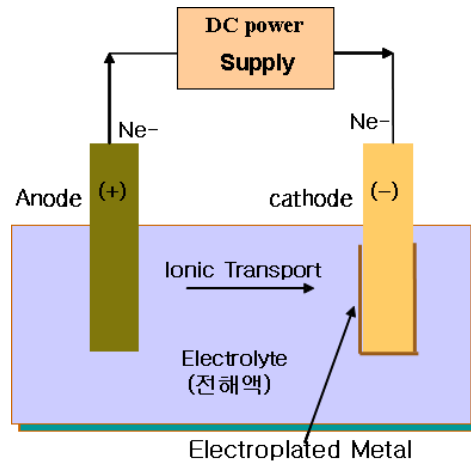
★ IrO₂ price: more than 1200\$/oz , manufacturing process is repeated more than 40 times (brushing), Curing temp: >650℃



The anode should not be used platinum element and dissolution



Anode : 용해 / Cathode: 부착



● Problem Issue :

- Electroplating anode should not be use platinum elements.
- The fabrication process is simple rather than conventional process
- Need Long life time (more than 6month, currently 2~4month)



Replace the required electrical and chemical properties of the platinum

Conventional method for solving problem

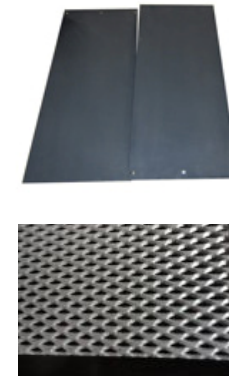
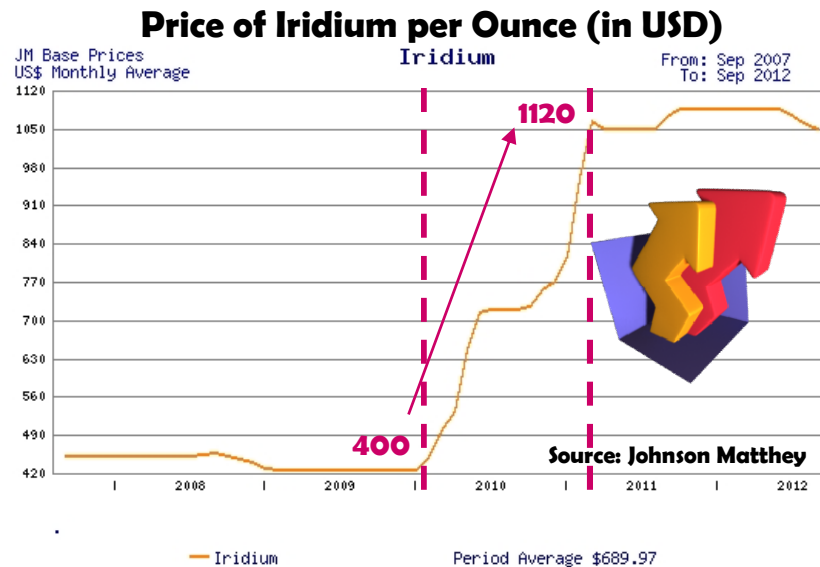
- Using the Lead (Pb) anode → Environmental problems caused
- Using the Platinum elements (Pt, Ta, Ir(IrO₂)) coating anode (Currently in use)
→ Insoluble / High cost . Complex process for making anode

useful

Harmful

Problem Define

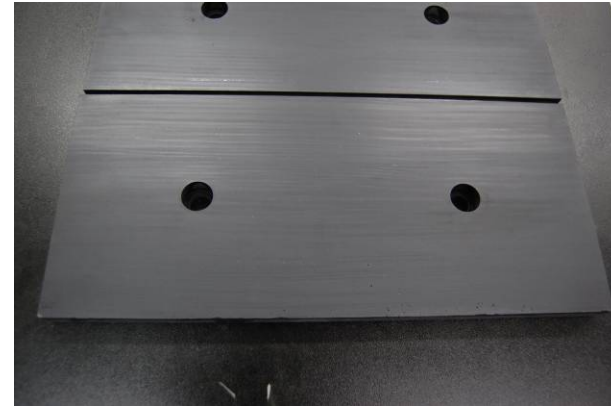
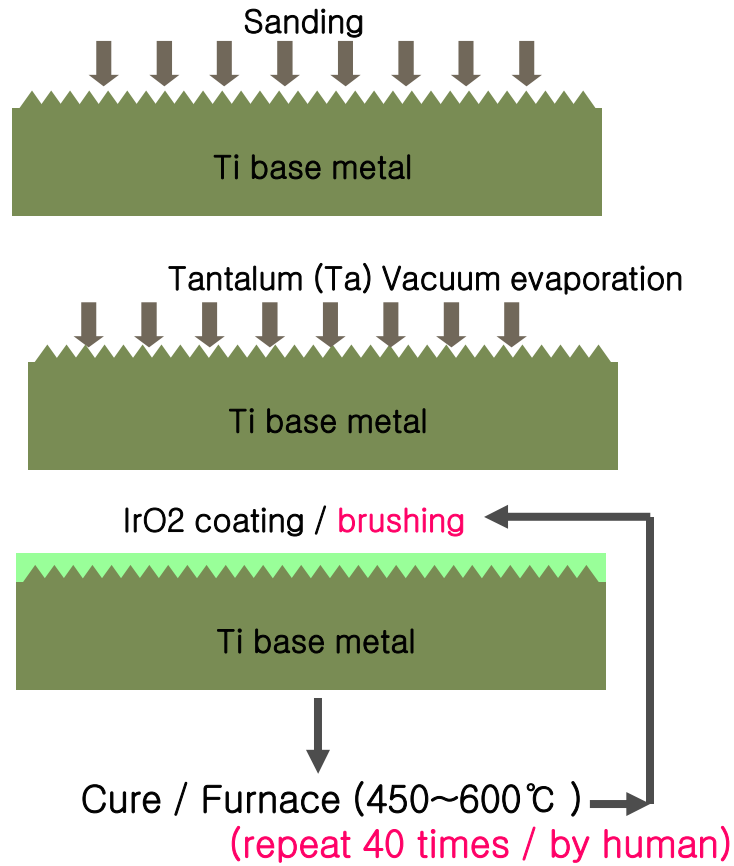
Using the Platinum-based element (IrO_2) coating layer (about 10um)
 -Base metal : Titanium (Ti) plate (10mm)



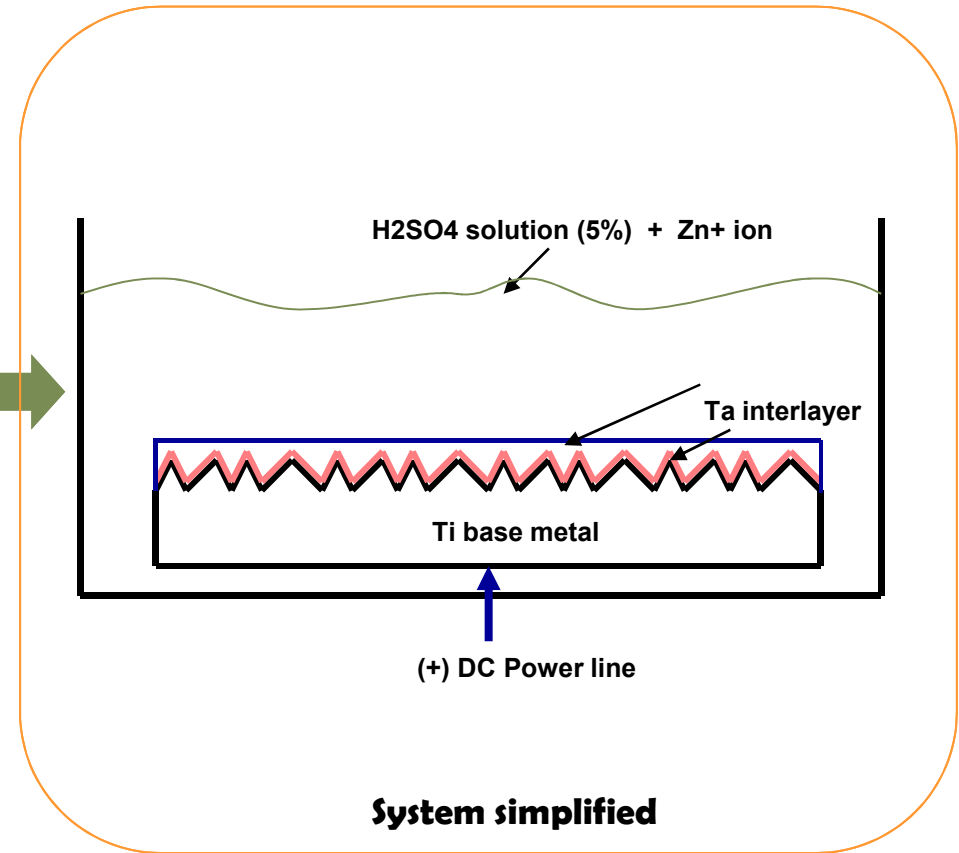
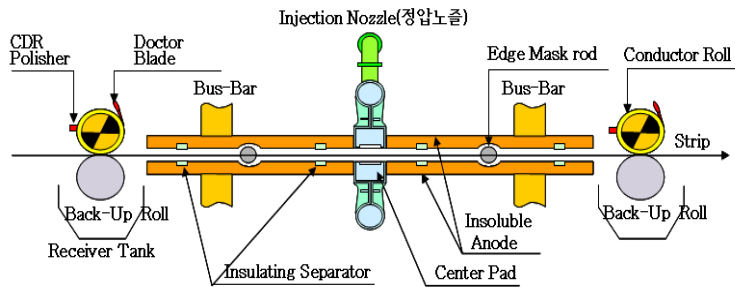
The iridium price is depend on Rapid increasing in market of Smart phone and IT display

Problem Define

● Conventional Process of Electroplating Anode (using IrO₂)



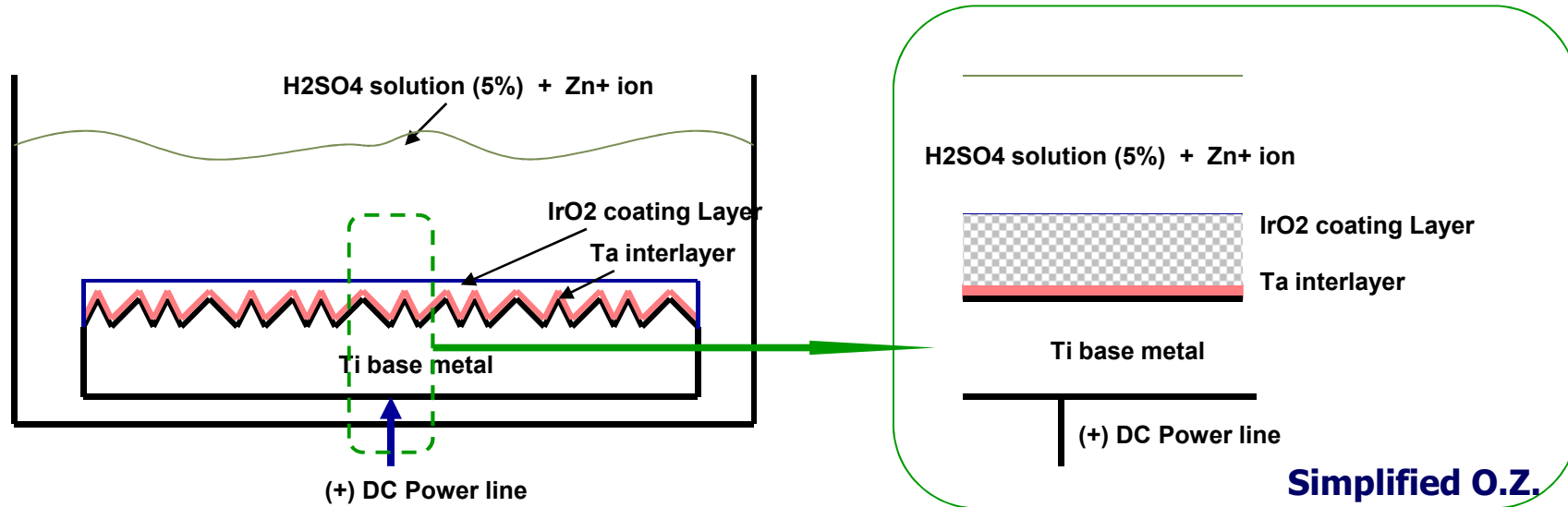
● Simplifying the system / Part of the Interaction only



Changing the Coating Layer Material

Operation Zone

● Operation Zone (O.Z.) : Where the problem occurs?

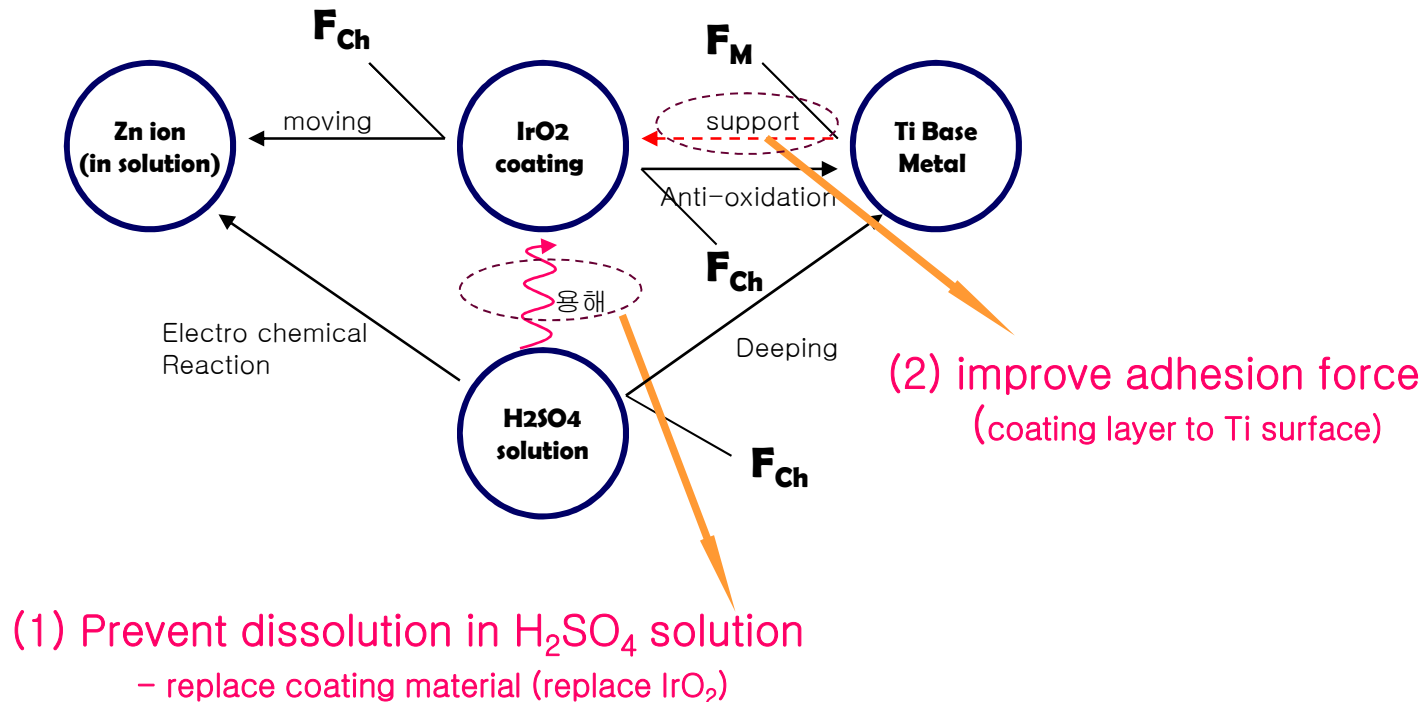


Resource Analysis

Substance	Field
H ₂ SO ₄	Temperature
Water	Electric energy
Iridium coating layer	Pressure (solution)
Titanium (base plate)	Conductivity (surface)
Tantalum (interlayer)	Friction (solution to surface)

Su-Field Model Analysis

● Su-Field model / Inadequate or harmful factors to improve



Ideal Final Result :

Replace the required electrical and chemical properties of the platinum.

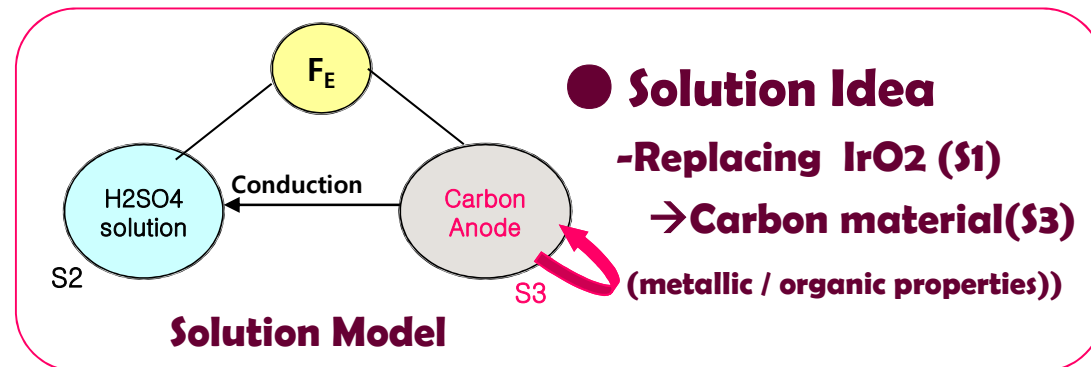
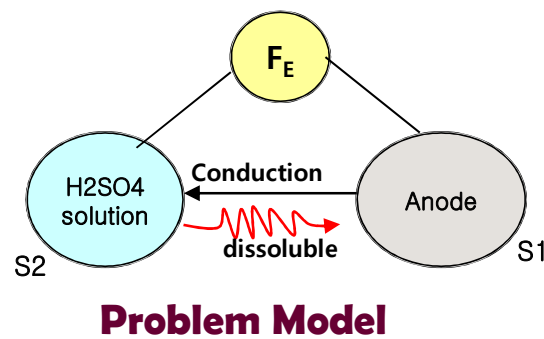
- Chemically Insoluble
- Mechanically high adhesion to surface
- Electrically Low surface potential (Low resistance)

Solution idea ?

● Solution concept

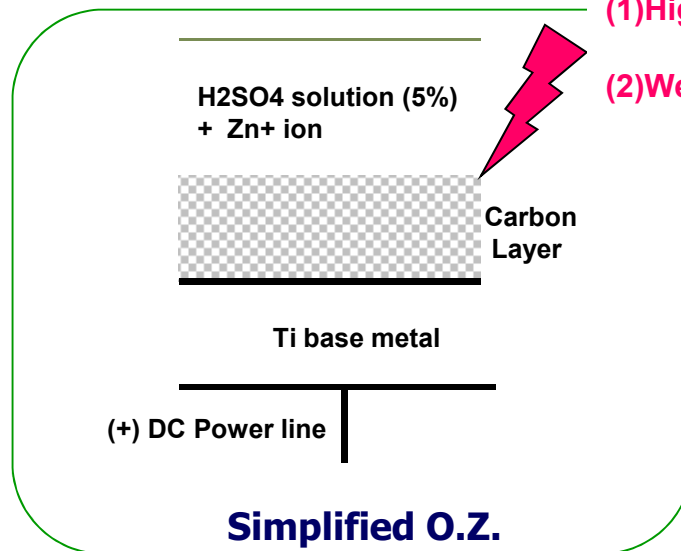
● Contradiction

- Low surface potential (solution – surface) / Metallic properties)
- Anti - dissolution (Insoluble) in acid (Organic properties)

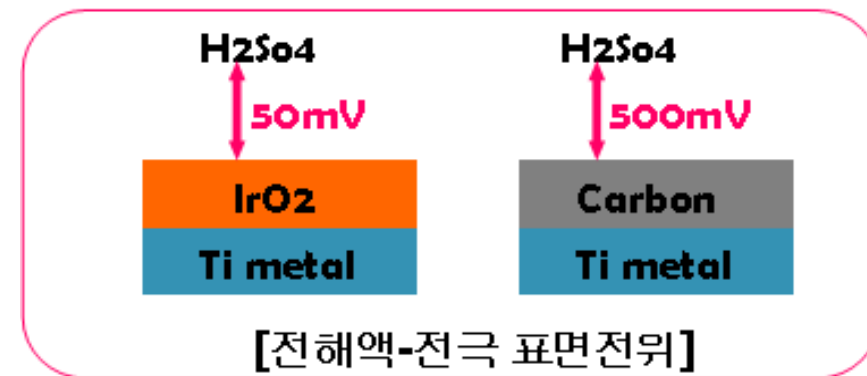


Solution Concept Evaluation

● Operation Zone for solution concept 1

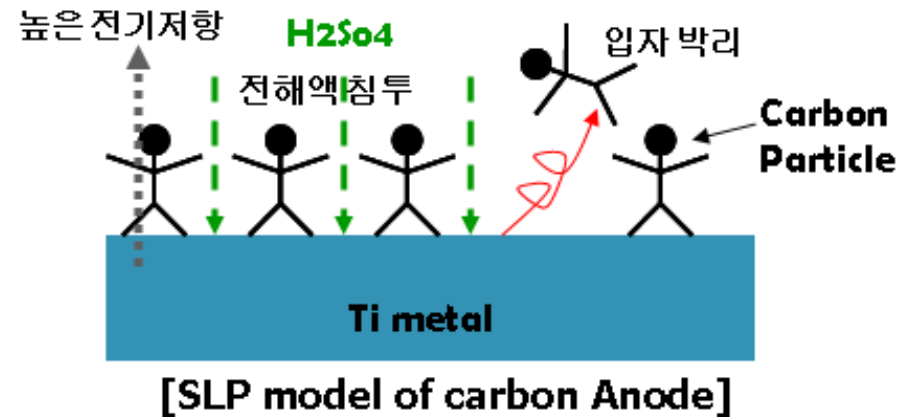


- (1) High surface potential rater than metal elements
(Metal → about 50mV , but carbon about 500mV)
- (2) Weak binding force (particle to particle)
(Brittle , Hydrophilic)



Solution Concept Evaluation

● SLP model for solution concept 1



- Carbon : Carbon powder molding fabrication process
 - **hydrophilic properties, Porous surface** (micro pore, inter granular)
- Contact at Ti metal surface to H₂SO₄ solution → Increasing oxidation layer
 - **The occurrence of insulating layer (TiO)**
 - (Bad electric performance, increasing surface potential)

Final Solution

■ Physical Contradiction

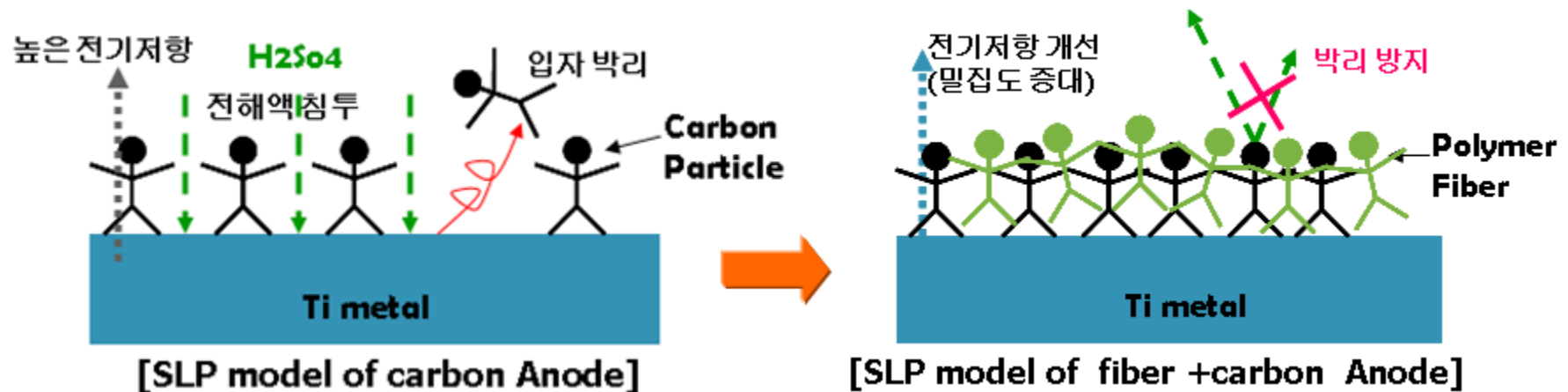
- Electrically : High conductivity → Metal properties
- Chemically : Insoluble
- Mechanically : connected particle (such as Polymers or wire)



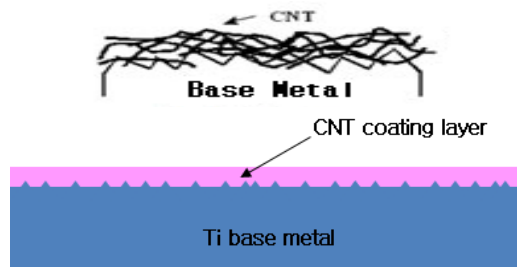
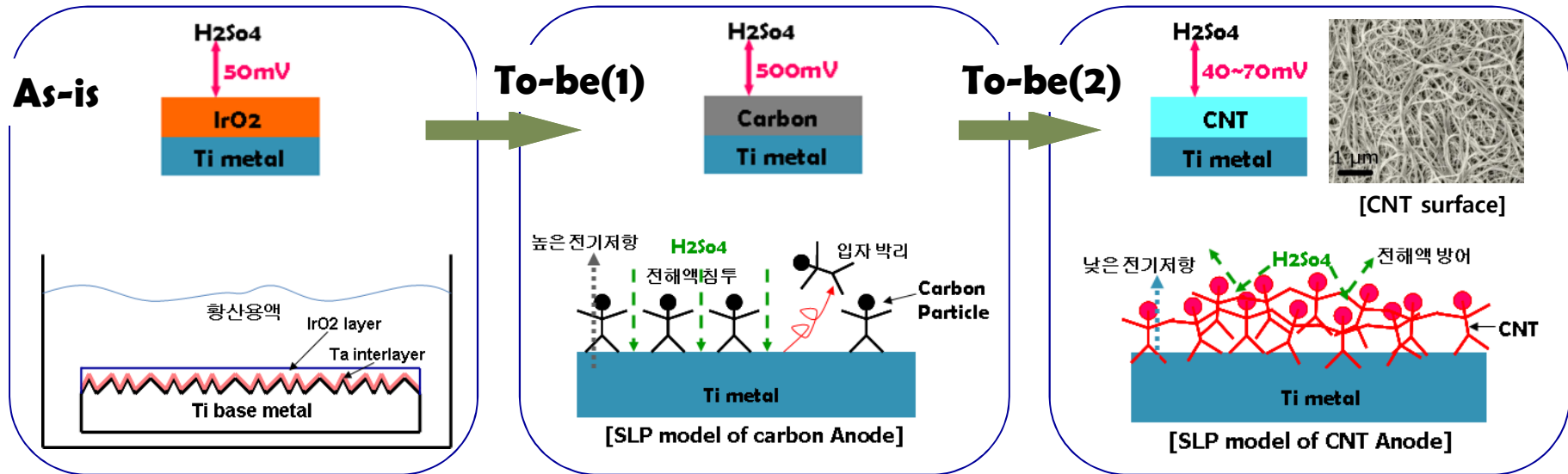
● Physical contradiction / Separation of conflict properties in space (condition)

- electrical conductivity condition : carbon particle
- improving binding force condition : polymer fiber

- *CNT (Carbon Nano Tube) → electrically : metal performance (very low resistance)
- Structure : like polymer fiber (nano size wire)



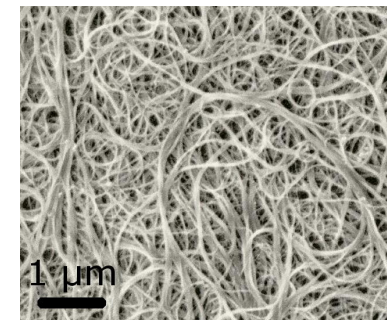
Final Solution



[structure of CNT-Ti Anode / Intl. patent pending]



[CNT anode / 150 x 150 mm²]



[CNT anode surface]

Improving the Adhesion of Coating Layer

Problem Define

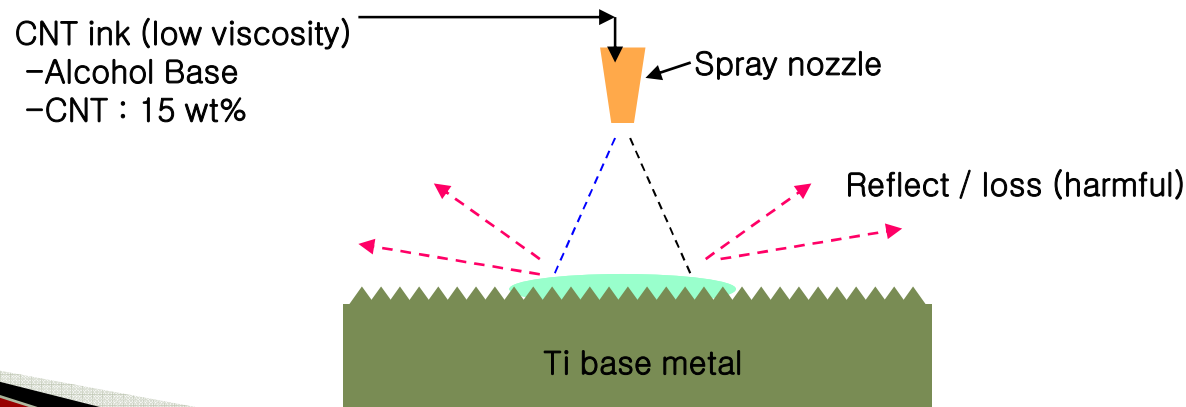
- **Require a strong adhesion of Ti base metal and CNT coating layer**
 - in coating process (spray coating)

Problem 1 : There many loss of CNT in spray coating process (about 40%)
(using CNT ink (low viscosity, CNT 15 wt%))

Problem 2 : Weak adhesion force and bad dispersion at Ti surface

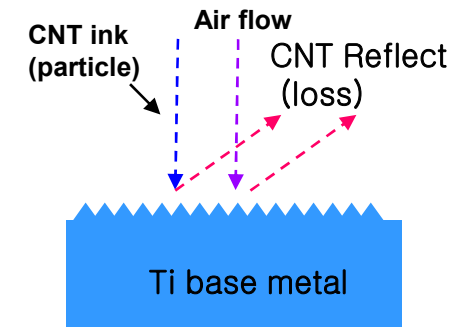
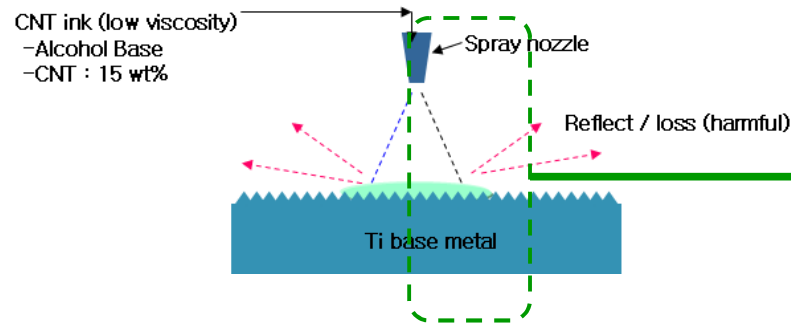


What I want ? : In the coating process, require reducing CNT loss and increasing adhesion force



Operation Zone

● Operation Zone (O.Z.) : Where the problem occurs?



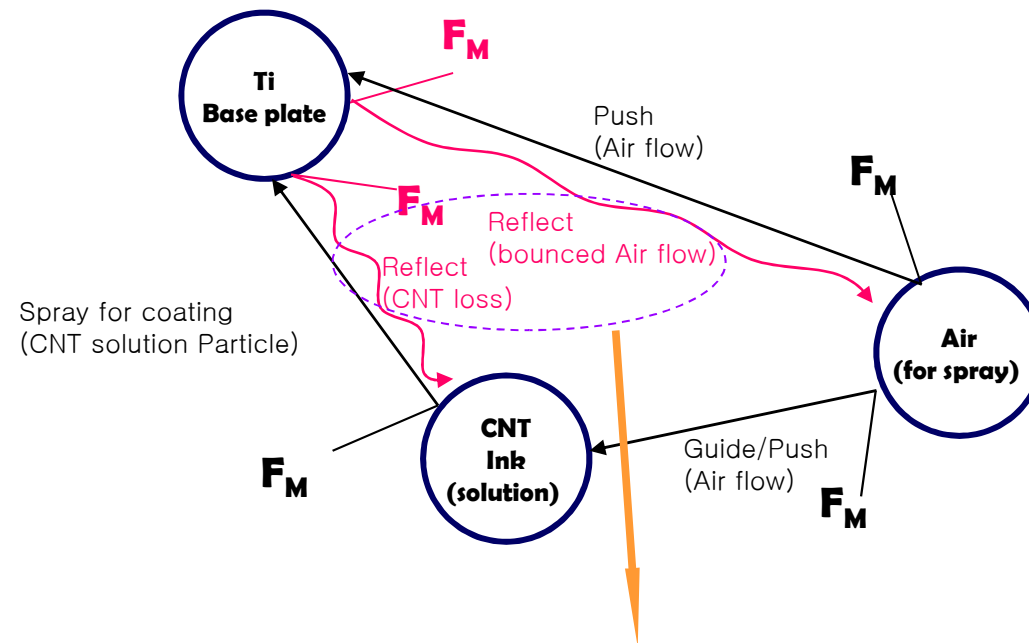
Simplified O.Z.

Resource Analysis

Sub.	Field
CNT ink (particle)	Pressure
Air (for spray pressure)	Gravity
Ti base plate	Mechanical force (impact energy)
Air (environment)	Friction (sprayed material to metal surface)

Su-Field Model Analysis

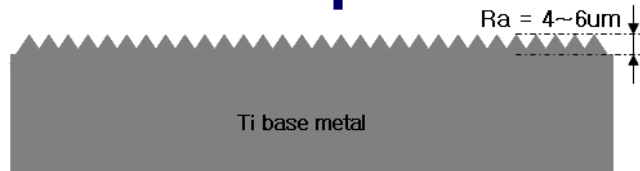
● Su-Field model / Inadequate or harmful factors to improve



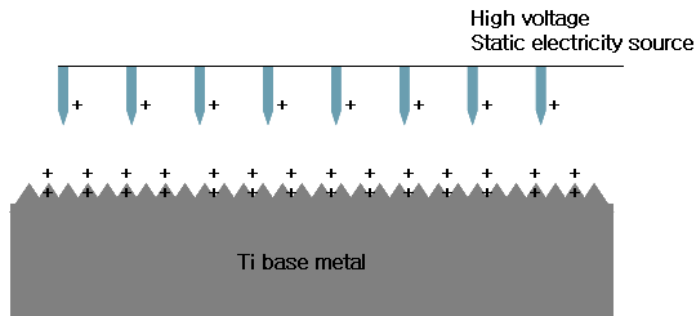
- ★ Need to reducing reflection force at pressure of spray
 - required more adhesion force (CNT to surface) rather than reflecting force (air bounce)

Final Solution

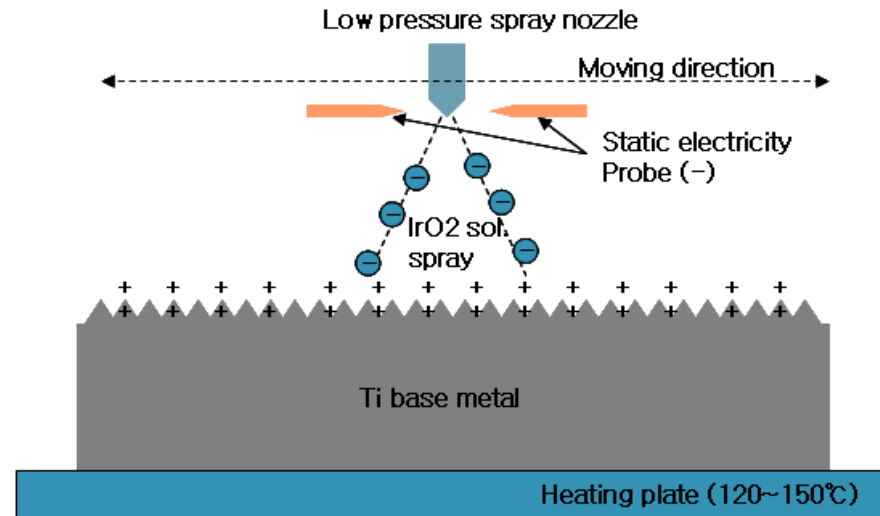
● Solution concept



(1) Making surface roughness (4~6um)



(2) Static electricity process



(3) spray coating process

■ **Base metal (Ti) : +) electrostatically charge** (about +1000V)
and heating pre-cure temperature (about 120°C)

■ **CNT sprayed particle : -) electrostatically charge** (about -1000V)

→ +) -) using the electrostatic voltage → increasing adhesion force

(Minimizing CNT material losses)

→ pre-curing (baking) is possible in spray coating process

(additional adhesion force)