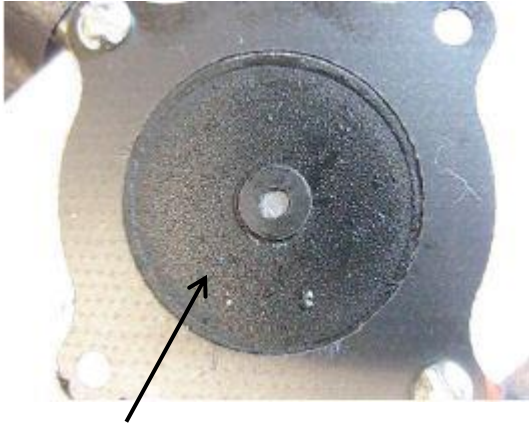


# Film Coater Device selection and coating process

Atsuo Orita

# About electrode of EAP

Before Collaboration



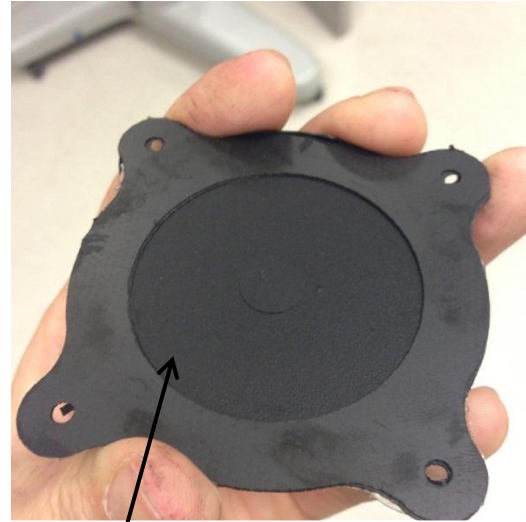
Compliant Electrode Using Air Spray

{ Carbon black powder  
Silicone oil  
hexanes

- Very easy to breakdown
- Maximum 6kV
- Easy to be peeled off



After Collaboration



Compliant Electrode Using Air Spray

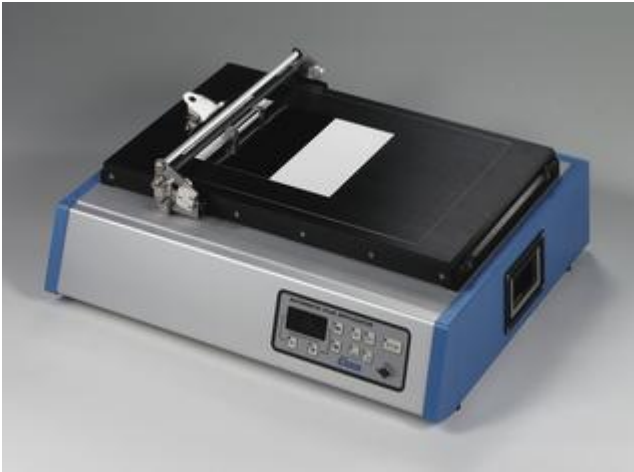
{ Carbon black powder  
Silicone rubber  
Toluene

- Maximum 7.5kV
- Cured Electrode not being peeled off

Thin Electrode make EAP maximize the performance.  
However it is also needed for EAP to get uniform, thin, and compliant electrode.

We should use auto coating device to solve this problem.

Starting from Auto-Film Applicator



## Features

- Precise application speed settable in 10 mm/s increments from 50 to 500 mm/s
- Wide range of operating speeds allowing optimum settings of shear rate
- Real time display of application speed
- Memory function to store commonly used speeds
- Constant downward force applied to coated surface
- A wide variety of film Applicator can be accommodated
- Applicator may be used side by side for comparison tests
- Wire bar coater attachment included
- Solvent resistant touch key panel that is easily cleaned
- Two stroke lengths

<http://www.worldoftest.com/automaticfilmapplicator.htm>

## Elcometer 4340 Motorised / Automatic Film Applicator



<http://www.gtech.com.vn/?f=Product&p=314&id=585>

<http://www.minex.ro/en/product-lines/Wet-Film-Applicators/75/Automatic-Film-Applicators-4340>

## Byko-drive



[http://www.gardco.com/pages/application/dp/byko\\_drive.cfm](http://www.gardco.com/pages/application/dp/byko_drive.cfm)

|                                      |   |                      |
|--------------------------------------|---|----------------------|
| <b>Platform:</b>                     | with vacuum plate<br>with glass plate and clamp | Cost about<br>\$4000 |
| <b>Voltage:</b>                      | 100 - 240V/50 - 60 Hz                           |                      |
| <b>Traverse Speeds:</b>              | 10 mm/sec or 1 in/sec                           |                      |
| <b>Traverse Speed Accuracy:</b>      | ±5%   |                      |
| <b>Wire Bar Diameter Limits:</b>     | 6 - 19 mm (0.25 - 0.75 in)                      |                      |
| <b>Wire Bar Test Length Maximum:</b> | 406 mm (16 in)                                  |                      |
| <b>Stroke Length:</b>                | 25 - 235 mm (1 - 9.25 in)                       |                      |
| <b>Weight:</b>                       | 6 kg (13 lbs)                                   |                      |
| <b>Test Panel Size Maximum:</b>      | 229 x 305 mm (9 x 12 in)                        |                      |
| <b>Dimensions:</b>                   | 365 x 229 x 127 mm (14.38 x 9 x 5 in)           |                      |

## Automatic Film Applicator AB3110-3120-3210-3220-3310-3320



### <Features>

- Automatic test chart clamp
- Easy to clean ultra plane glass bed
- Vacuum bed with built in vacuum pump
- Removable bed for easy cleaning and maintenance
- Automatic bar coaters storage device
- Flexible
- Wide speed range
- Extensive operator safety features
- Solid support feet

<http://www.obsnap.com/coating-paint-ink-testing/automatic-film-applicator-ab3110-3120-3210>

## Wire-Bar Coater



TQC Spiral bar applicator with a film width of 310 mm and available in ranges from 4 to 200  $\mu\text{m}$ . The Spiral bar or wire wound / drawdown rod applicator is ideal for applying a film on thin materials such as sheets or plastic. Also works on flexible substrates, and with motorized film applicators\*.

Totale length: 440 mm

Length application area: 320 mm

## Baker Applicator



## Bird Applicator



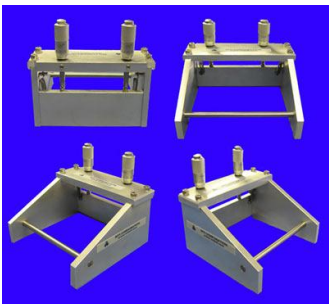
## Film Applicator



Cylindrical film applicator with 4 application sides for applying paint-films of 4 different pre-defined thicknesses. The Baker applicator's are available in film width 60 mm and 80 mm and are suitable for applying a host of different products onto flat and relatively solid substrates. Since it's made out of high-grade stainless steel, the Baker Film Applicator will not be affected by acid or base elements.

The TQC Film Applicator (Quadruplex) has four application sides for applying paint films with four different predefined thicknesses, in film width 60 or 80 mm. One side of the applicator is supplied with a guidance support for straight application. This support may be removed as well. The high grade stainless steel will not be affected by acid or base elements.

## Adjustable film applicator



100 mm standard width






Make wet film thickness between 0 - 3500 microns

Micrometer head's controllable accuracy is 10 microns

Made of SS304 stainless steel



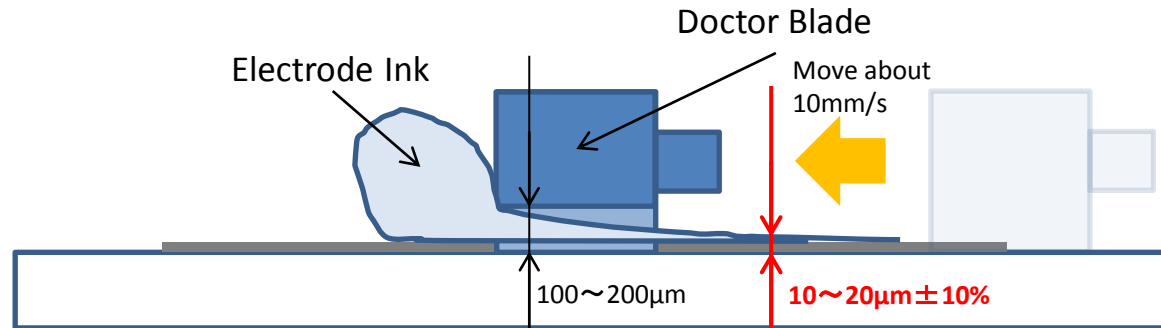
## Compare List

|                         |  |  |  |  |  |
|-------------------------|---|--|---|---|---|
|                         | PA-2101   | Elcometer4340  | Byko-drive  | TQC AFA   | EGPI-1210   |
| Traverse Speed          | 50-500 mm/s   | 0.5-10 mm/s  | 10 mm/s   | 2-500 mm/s  | 10-200 mm/s   |
| Traverse Speed Accuracy | 10 mm/s   |  | ±5% mm/s  | ±1% mm/s  |   |
| Wire Bar Diameter       | 10 – 13 mm  |  | 6 – 19 mm   | Max 7 mm  |   |
| Wire Bar Test Length    | 320 mm max.   |  | 406 mm  | 300 mm max.   |   |
| Wire Bar Minimum Length | 407 mm  |  |   |   |   |
| Stroke Length           | 170,340 mm  |  | 25-235 mm   | 50-400 mm   | 330 mm  |
| Test Panel Size         | 420 x 300 mm  |  | 305 x 229 mm  | 420 x 297 mm  | Option<br>420 x297mm  |
| Power Supply            | 230/115V 50/60Hz  |  | 240-100V 50/60Hz  | 230/115V 50/60Hz  |   |
| Weight                  | 45 kg   | 29 kg  | 6 kg  | 31 kg   | 21 kg   |
| Cost                    | ----  | \$12311  | \$3200  | \$8100-   | \$11000   |
| Time of Delivery        |   |  |   | 1.5 month   |   |

## The summaries of asking know how of using auto-film-coater

I had a hearing about film coater for making thin electrode film in the fuel cell research of HondaR&D

### Basics



Notice Blade does not contact with coated film.

Thickness of ink is dependent on it's viscosity, blade height, and blade moving speed.

- Viscosity of ink should be measured before coating test. However it's not easy. Experimentally by considering solution/solvent viscosity ratio as ink's viscosity they can adjust auto film coater, and then get a proper thickness of ink.
- Current making electrode film for fuel cell is done at 2-10mm/s speed, and 200μm Doctor Blade with 50% solution/solvent viscosity ratio.
- Whether thin film coated is good or not, is very easy to be determined in eyesight. To analyze the uniformity of film, scanning electron microscope or micrometer is usually used.
- In experimentally opinion the circle shape of Blade often causes wider dispersion.
- Variable height blade and variable speed of film coater should be careful in precision.
- As smaller quantity of solvent as possible is better for us to handle future problem in fabrication.
- Adjusting procedure of this device  
decide solution/solvent ratio  $\Rightarrow$  adjust variable height with constant speed  
if unable to get proper film  $\Rightarrow$  change solution/solvent ratio  $\Rightarrow$  change coater speed

## Wire-Bar Coater



TQC Spiral bar applicator with a film width of 310 mm and available in ranges from 4 to 200  $\mu\text{m}$ . The Spiral bar or wire wound / drawdown rod applicator is ideal for applying a film on thin materials such as sheets or plastic. Also works on flexible substrates, and with motorized film applicators\*.

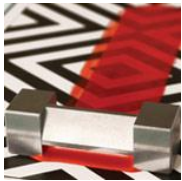
Total length: 440 mm

Length application area: 320 mm

## Baker Applicator



## Bird Applicator



## Film Applicator



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## Recommended

### Adjustable film applicator



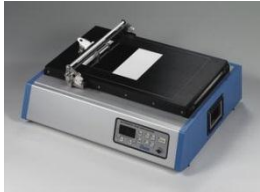



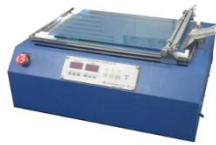
100 mm standard width

Make wet film thickness between 0 - 3500 microns

Micrometer head's controllable accuracy is 10 microns

Made of SS304 stainless steel

## Compare List

|                                |  |  |  | <b>Recommended</b><br> |  |
|--------------------------------|---|--|---|---|---|
|                                | PA-2101   | Elcometer4340  | Byko-drive  | TQC AFA   | EGPI-1210   |
| Traverse Speed                 | 50-500 mm/s   | 0.5-10 mm/s  | 10 mm/s   | 2-500 mm/s  | 10-200 mm/s   |
| Traverse Speed Accuracy        | 10 mm/s   |  | ±5% mm/s  | ±1% mm/s  |   |
| Wire Bar Diameter              | 10 – 13 mm  |  | 6 – 19 mm   | Max 7 mm  |   |
| Wire Bar Test Length           | 320 mm max.   |  | 406 mm  | 300 mm max.   |   |
| Wire Bar Minimum Length        | 407 mm  |  |   |   |   |
| Stroke Length                  | 170,340 mm  |  | 25-235 mm   | 50-400 mm   | 330 mm  |
| Test Panel Size                | 420 x 300 mm  |  | 305 x 229 mm  | 420 x 297 mm  | Option<br>420 x297mm  |
| Power Supply                   | 230/115V 50/60Hz  |  | 240-100V 50/60Hz  | 230/115V 50/60Hz  |   |
| Weight                         | 45 kg   | 29 kg  | 6 kg  | 31 kg   | 21 kg   |
| Cost                           | ----  | \$12311  | \$3200  | \$8100-   | \$11000   |
| Time of Delivery               |   |  |   | immediately   |   |
| However masking is the problem |   |  |   |   |   |

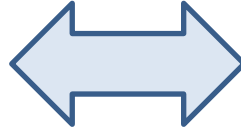
Thinking coating method  
with auto-film coater  
and  
screen printing

# Our electrode coating on EAP

## Requirements

We want to get

- Uniformity
- Low dispersion
- Thin film under  $20\mu\text{m}$
- Good masking

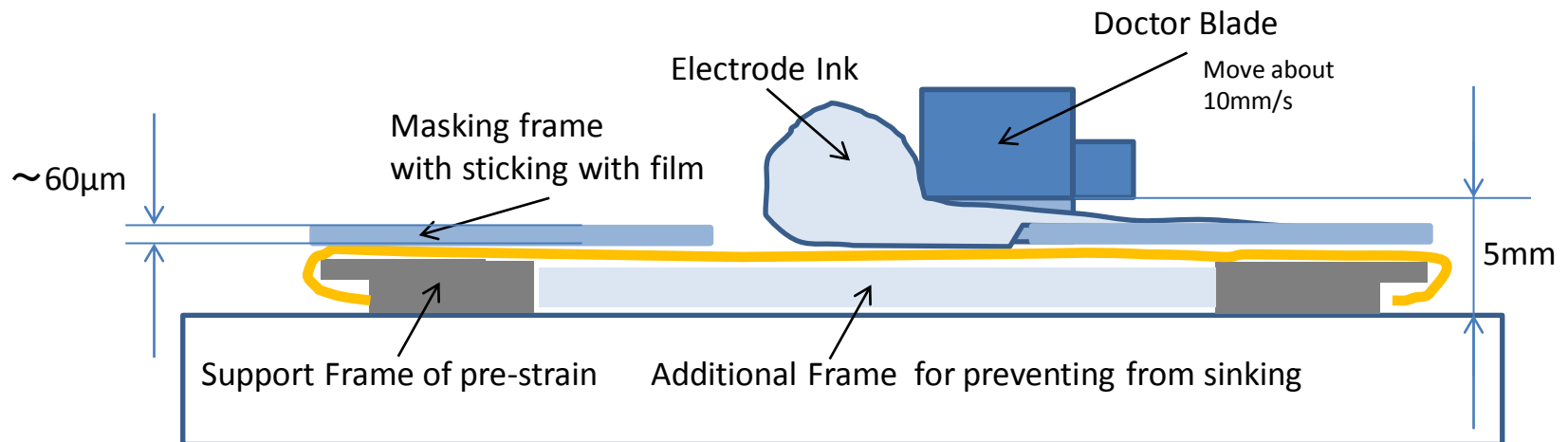


We should be careful for

- Sticky film
- High Viscosity ink
- Damaged by masking
- EAP tearing by shear force

## Idea ①

### Bar-coater with masking



### <Merits>

- Low cost
- Easy to change masking

### <De-merits>

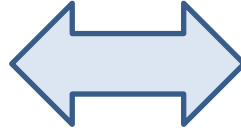
- Unique-way
- film tearing by masking edge
- Thickness might not be thin

## Our electrode coating on EAP

### Requirements

We want to get

- Uniformity
- Low dispersion
- Thin film under  $20\mu\text{m}$
- Good masking

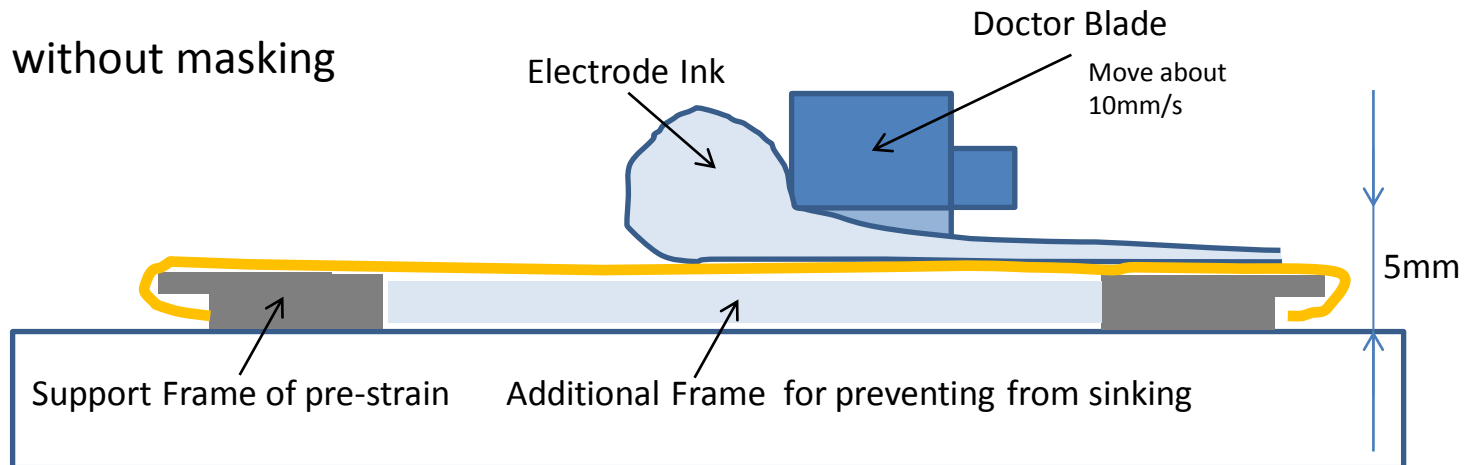


We should be careful for

- Sticky film
- High Viscosity ink
- Damaged by masking
- EAP tearing by shear force

### Idea ②

#### Bar-coater without masking



#### <Merits>

Normal way to use  
Thin film coated  
Low cost

#### <De-merits>

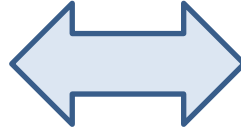
All area coated

## Our electrode coating on EAP

### Requirements

We want to get

- Uniformity
- Low dispersion
- Thin film under  $20\mu\text{m}$
- Good masking

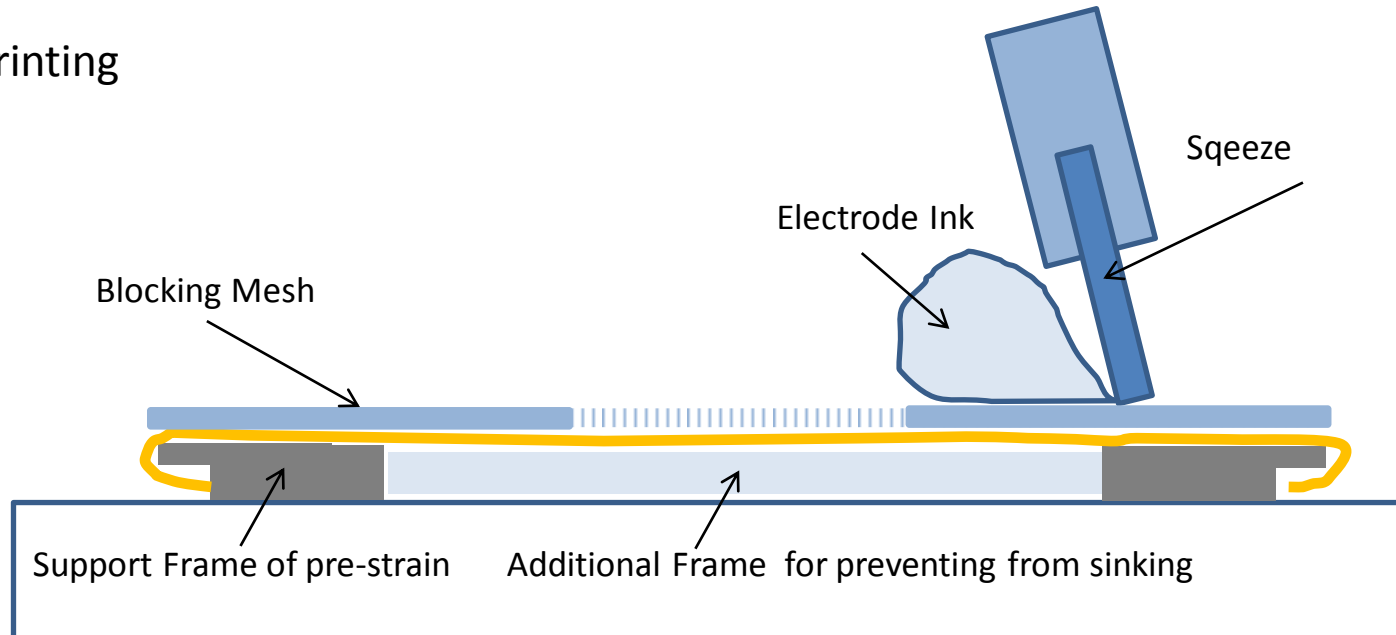


We should be careful for

- Sticky film
- High Viscosity ink
- Damaged by masking
- EAP tearing by shear force

### Idea ③

#### Screen printing



#### <Merits>

Normal Way of coating  
soft mesh  
thin film coated

#### <De-merits>

Auto-device is expensive  
Not so easy to change masking  
Mesh must be treated cleanly

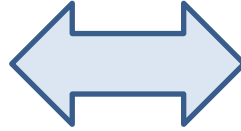


## Our electrode coating on EAP

### Requirements

We want to get

- Uniformity
- Low dispersion
- Thin film under  $20\mu\text{m}$
- Good masking

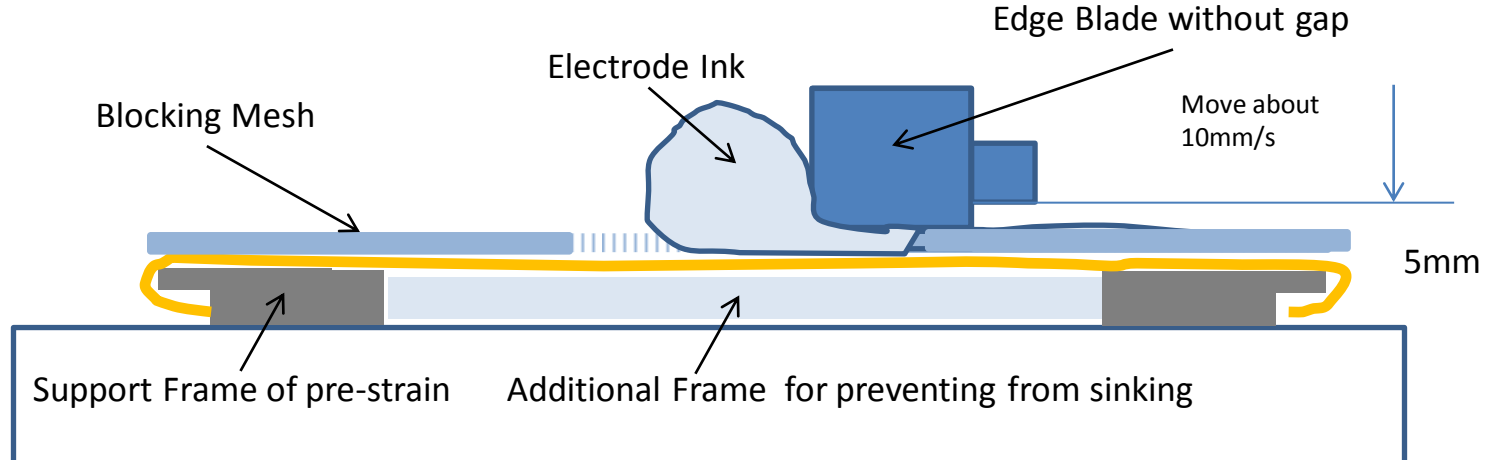


We should be careful for

- Sticky film
- High Viscosity ink
- Damaged by masking
- EAP tearing by shear force

### Idea ④

#### Screen printing with bar-coater

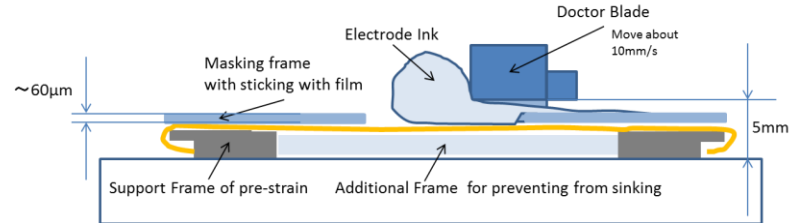
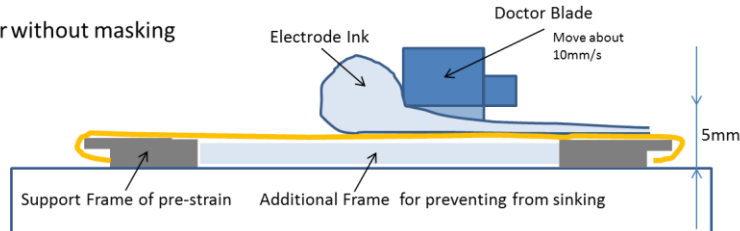
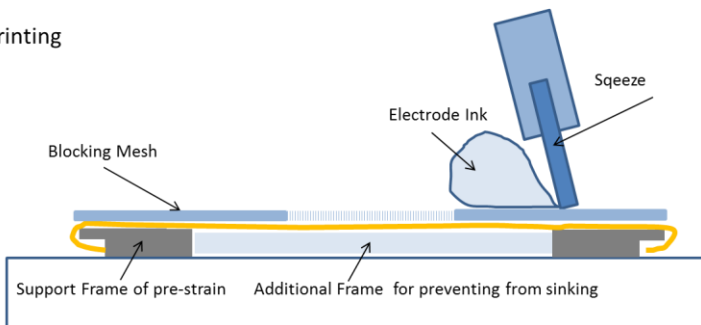
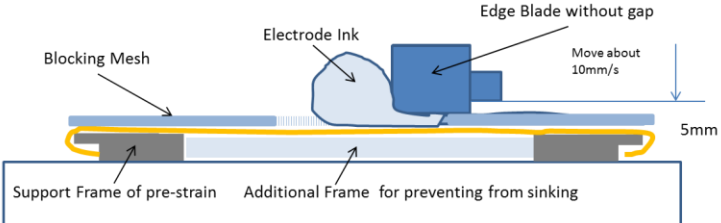


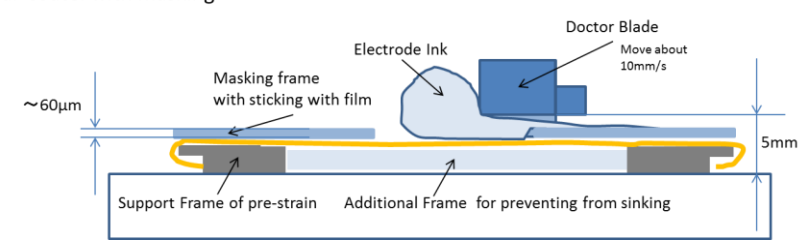
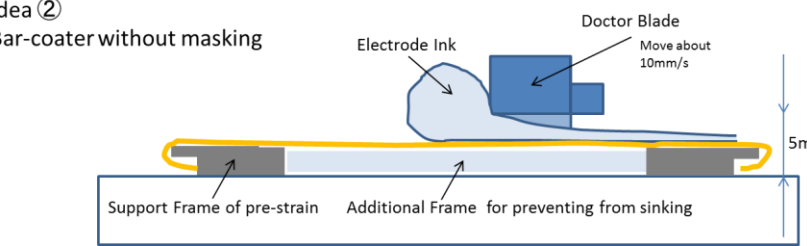
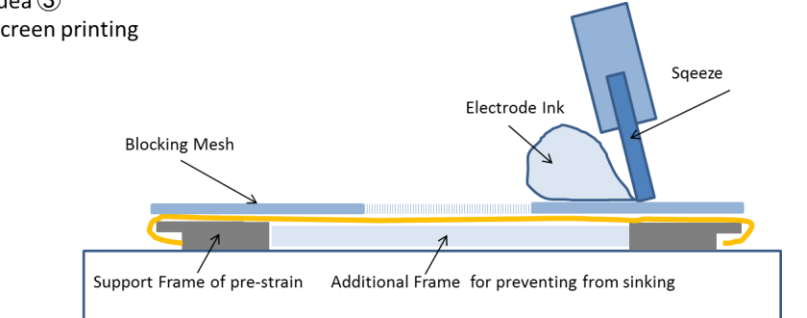
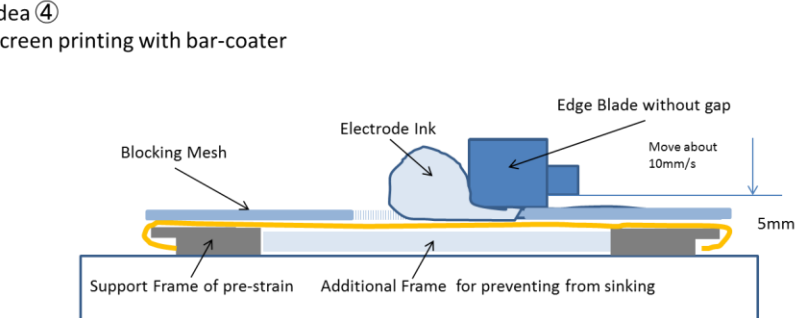
#### <Merits>

Soft mesh  
Low cost

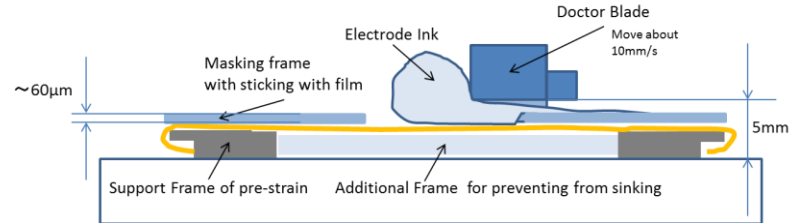
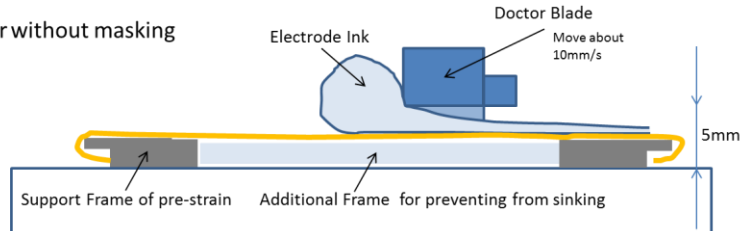
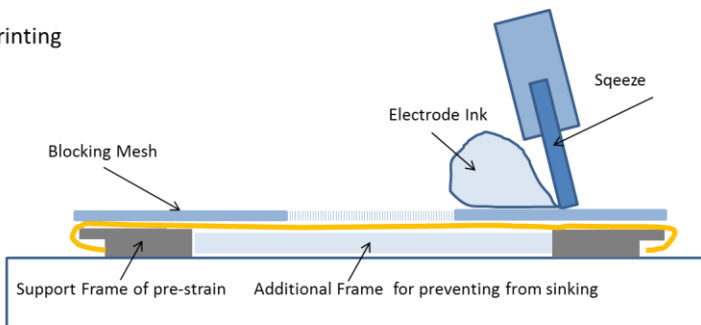
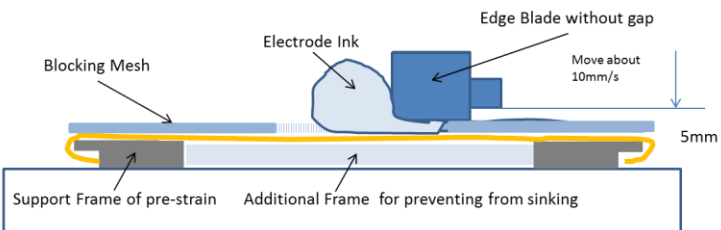
#### <De-merits>

Film might not be thin by unique way  
Not so easy to change masking  
Mesh must be treated cleanly

|  | Merit   | De-merit  |
|--|---|---|
| <p>Idea ①<br/>Bar-coater with masking</p>            | <p>Low cost<br/>Easy to change masking</p>                      | <p>Unusual-way<br/>Film tearing by masking edge<br/>Thickness might not be thin</p>                                   |
| <p>Idea ②<br/>Bar-coater without masking</p>        | <p>Normal way to use<br/>Thin film coated<br/>Low cost</p>      | <p>All area coated</p>  |
| <p>Idea ③<br/>Screen printing</p>                   | <p>Normal Way of coating<br/>Soft mesh<br/>Thin film coated</p> | <p>Auto-device is expensive<br/>Not so easy to change masking<br/>Mesh must be treated cleanly</p>                    |
| <p>Idea ④<br/>Screen printing with bar-coater</p>  | <p>Soft mesh<br/>Low cost</p>                                   | <p>Thickness might not be thin<br/>Not so easy to change masking<br/>Mesh must be treated cleanly<br/>Unusual-way</p> |

|  | Merit   | De-merit  |
|--|---|---|
| <p>Idea ①<br/>Bar-coater with masking</p>            | <p>Low cost<br/>Easy to change masking</p>                      | <p>Unusual-way<br/>Film tearing by masking edge<br/>Thickness might not be thin</p>                                   |
| <p>Idea ②<br/>Bar-coater without masking</p>         | <p>Normal way to use<br/>Thin film coated<br/>Low cost</p>      | <p>All area coated</p>  |
| <p>Idea ③<br/>Screen printing</p>                   | <p>Normal Way of coating<br/>Soft mesh<br/>Thin film coated</p> | <p>Auto-device is expensive<br/>Not so easy to change masking<br/>Mesh must be treated cleanly</p>                    |
| <p>Idea ④<br/>Screen printing with bar-coater</p>  | <p>Soft mesh<br/>Low cost</p>                                   | <p>Thickness might not be thin<br/>Not so easy to change masking<br/>Mesh must be treated cleanly<br/>Unusual-way</p> |

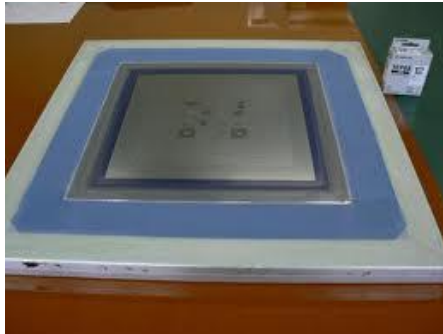
Normal Coating is better

|  | Merit   | De-merit  |
|--|---|---|
| <p>Idea ①<br/>Bar-coater with masking</p>            | <p>Low cost<br/>Easy to change masking</p>                      | <p>Unusual-way<br/>Film tearing by masking edge<br/>Thickness might not be thin</p>                                   |
| <p>Idea ②<br/>Bar-coater without masking</p>        | <p>Normal way to use<br/>Thin film coated<br/>Low cost</p>      | <p>All area coated</p>  |
| <p>Idea ③<br/>Screen printing</p>                   | <p>Normal Way of coating<br/>Soft mesh<br/>Thin film coated</p> | <p>Auto-device is expensive<br/>Not so easy to change masking<br/>Mesh must be treated cleanly</p>                    |
| <p>Idea ④<br/>Screen printing with bar-coater</p>  | <p>Soft mesh<br/>Low cost</p>                                   | <p>Thickness might not be thin<br/>Not so easy to change masking<br/>Mesh must be treated cleanly<br/>Unusual-way</p> |

I choose it without auto-system

# Handy Screen Printing

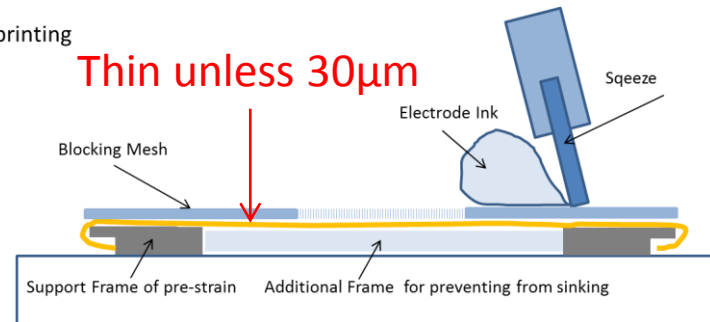
Stainless steel mesh



Blocking mesh with emulsion

Idea ③  
Screen printing

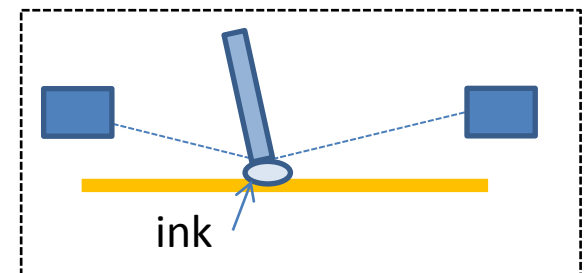
Thin unless  $30\mu\text{m}$



Handy printing with  
Squeezer



This process will not damage  
EAP film surface

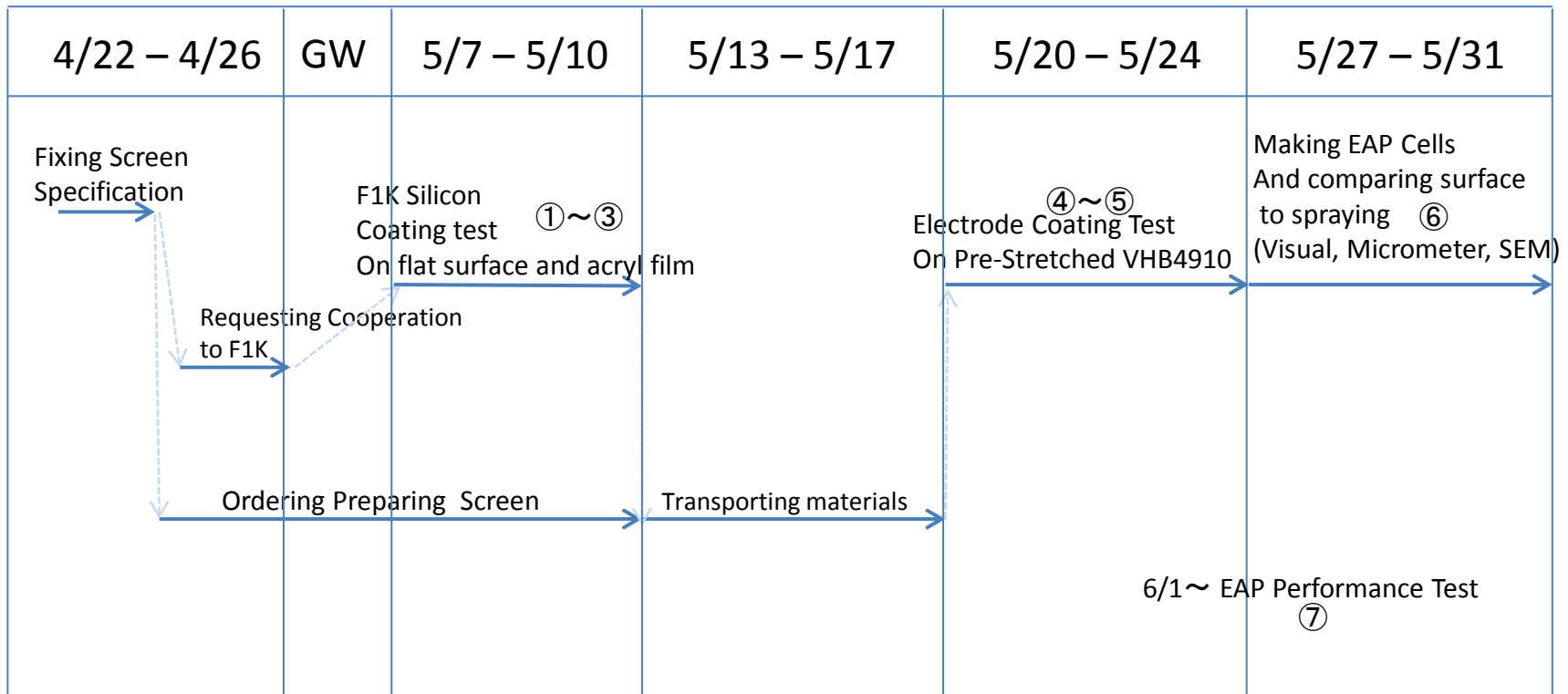


A4 size

# Checking list for using it for fabrication

- silicon ink with solvent might damage the screen blocking
- silicon ink might block the screen mesh with getting hard in printing
- Can silicon ink can be printed uniformly, thinly.
- Can electrode ink can be printed uniformly, thinly too.
- Can screen printing be used for pre-stretched EAP film without tearing propagation?
- Is Electrode film by screen printing better than spraying in terms of thickness and uniformity?
- Is Electrode film by screen printing better performance than spraying ,such as Variable Stiffness, break down, force durability in soft and electrical durability?

# Schedule for installation



## Problems to be solved

- ① silicon ink with solvent might damage the screen blocking
- ② silicon ink might block the screen mesh with getting hard in printing
- ③ Can silicon ink can be printed uniformly, thinly.
- ④ Can electrode ink can be printed uniformly, thinly too.
- ⑤ Can screen printing be used for pre-stretched EAP film without tearing propagation?
- ⑥ Is Electrode film by screen printing better than spraying in terms of thickness and uniformity?
- ⑦ Is Electrode film by screen printing better performance than spraying ,such as Variable Stiffness, break down, force durability in soft and electrical durability?

## Appendix



## F1K 吉澤さん打ち合わせ

Auto Film Coater及びドクターブレードの選定、及び望みの薄膜生成のプロセスについて  
F1K吉澤さんにヒアリングした

- ・ 粘性係数からFilm Coaterの高さと速さを決定すべきだが、F1Kにおいては粘性係数測定装置がないので、溶媒/溶質比を仮に粘性としてFilm Coaterの設定を実施
- ・ 現状燃料電池用の電極生成は、2-10mm/s ぐらいの速度である  
(調整するためには可変速度のFilm Coaterが必要だが、その場合は速度誤差を考慮しなければいけない。)
- ・ できた薄膜の良し悪しは、ほぼ目視で判断できる。(薄すぎると地肌が見える)
- ・ 可能な限り溶媒を少なくして薄膜生成した方が、後々の問題に対処しやすい  
(生成面積等を広くし易い)
- ・ ブレードは、円形のものはバラツキが出やすい。高さ可変のものは、その精度に注意するひつようがある。
- ・ ドクターブレードの実施要領  
溶媒比を決定⇒厚み、速度を仮決定⇒薄膜生成試行

うまくできない場合 : 厚みを変更⇒溶媒比変更⇒移動速度の変更

## 実施方法について

Auto Film Coater自体はオランダ製であるので、USAで在庫があるかもしれないが現状日本の代理店が在庫を持っていて即納可能である。  
(購入依頼後数日で払い出し可能な状況)

### 日本で購入⇒輸出

設備稟議⇒購入依頼⇒検収⇒輸出申請⇒スタンフォード到着⇒研究開始  
(パラメタシート)

備考:毎年設備の棚卸しがある

### スタンフォードが購入

代理店が日本のため  
HRI-USが代理購入 ⇒ 代理店から直接スタンフォードへ ⇒ 研究開始

備考:スタンフォードからHRI-USへ立て替え金を送付する必要がある

# Checking list for using it for fabrication

These checks can be done in Honda, Japan with negotiation.

- silicon ink with solvent might damage the screen blocking
- silicon ink might block the screen mesh with getting hard in printing
- Can silicon ink can be printed uniformly, thinly.
- Can electrode ink can be printed uniformly, thinly too.
- Can screen printing be used for pre-stretched EAP film without tearing propagation?
- Is Electrode film by screen printing better than spraying in terms of thickness and uniformity?
- Is Electrode film by screen printing better performance than spraying ,such as Variable Stiffness, break down, force durability in soft and electrical durability?

1. I would like to discuss about the needed devices for this process.  
( Screen Mesh, Squeezer, Screen Printing Device etc )
2. What checks should be done in Japan before checking in Stanford?
3. Is there measuring thickness devices such as micrometer and SEM in Stanford?