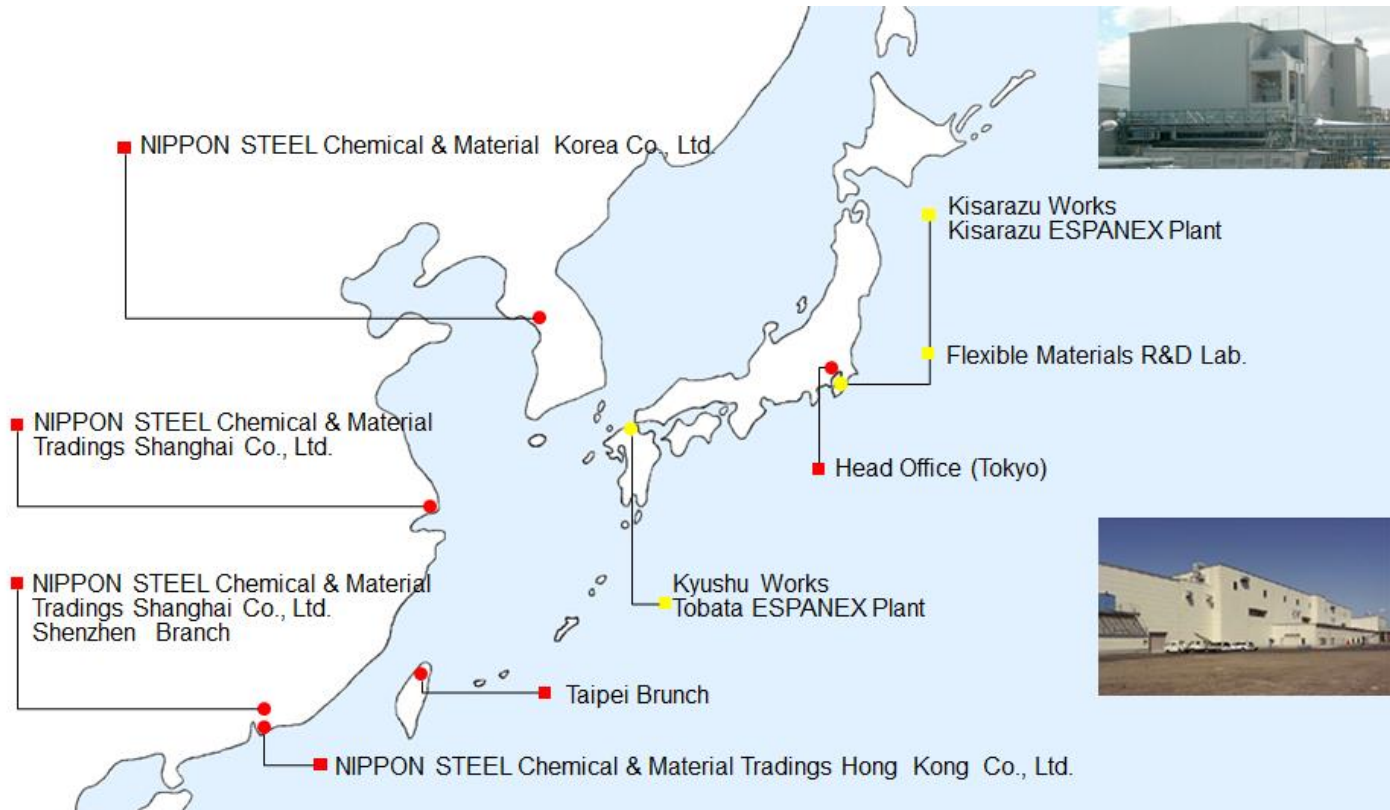


## Offices & Manufacturing Location and Line-up

我們日鐵化學材料遵照客戶多方面的需求、提供產品優勢給客戶。

We provide the benefit for our customer with various line-up.

### 據點 Location



### 產品類 Features of FCCL Product Family

#### Standard type "ESPANEX® M Series"

- ✓ Excellent Dimensional Stability
- ✓ Lower Dielectric Properties ( $D_k=3.3[xy]$  /  $2.9[z]$ ,  $D_f=0.006@10GHz$ )
- ✓ In Preparation for Thin Polyimide Grade ( $5\mu m$ ), ( $9\mu m \sim 38\mu m$ )

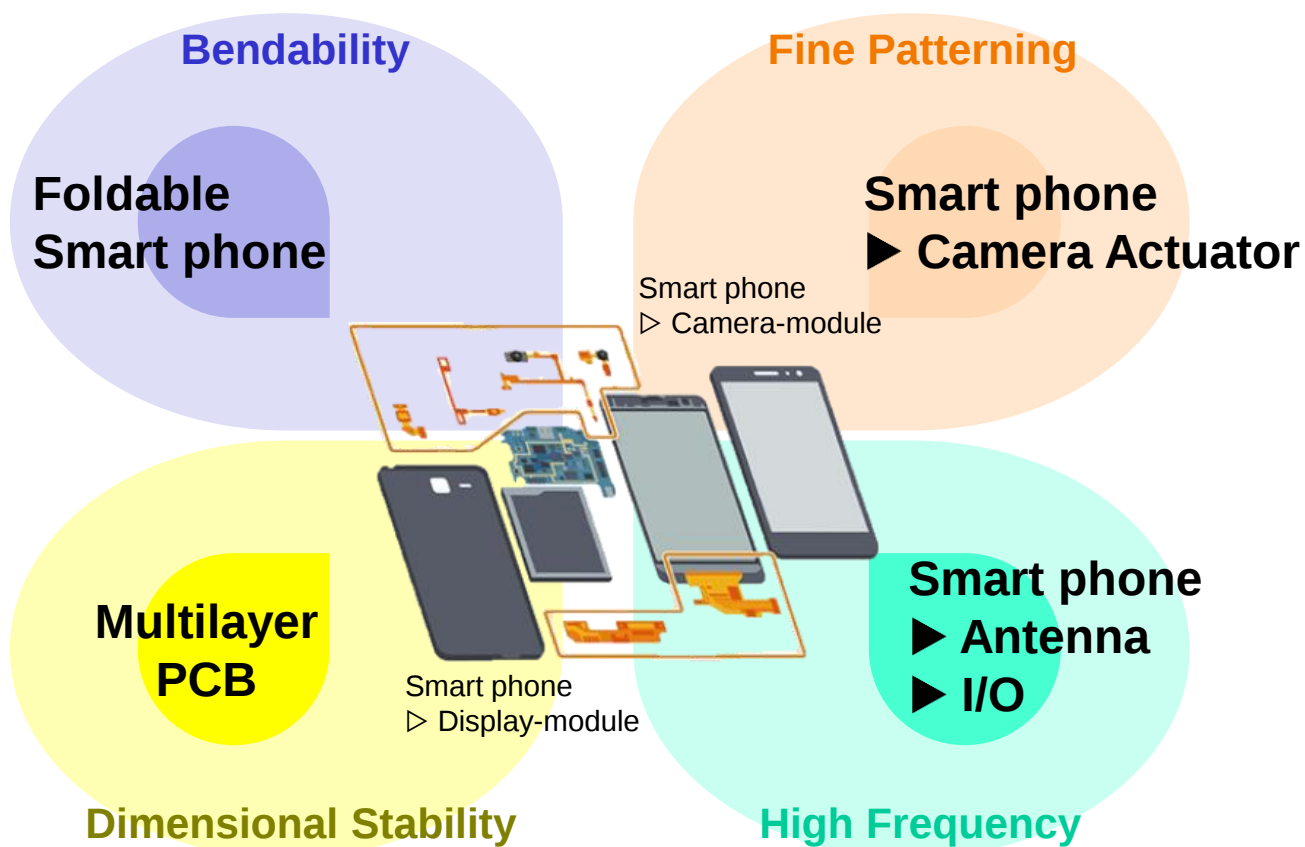
#### MPI type "ESPANEX® F Series" for High Frequency Applications

- ✓ Low Dielectric Factor ( $DK=3.3[xy]$  /  $2.9[z]$ ,  $D_f=0.003@10GHz$ )
- ✓ Low Moisture Absorption
- ✓ Various Polyimide Thicknesses ( $9\mu m \sim 50\mu m$ )

#### New MPI Series Under development for Low $D_k/D_f$ Applications

- ✓ Low Dielectric Factor ( $D_k=3.0[xy]$ ,  $D_f=0.015@10GHz$ )
- ✓ Low Moisture Absorption
- ✓ In Preparation for Thick Polyimide Grade ( $\sim 75\mu m$ )

## New Application

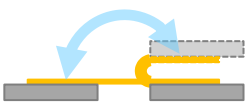
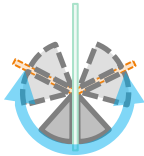


## Road Map

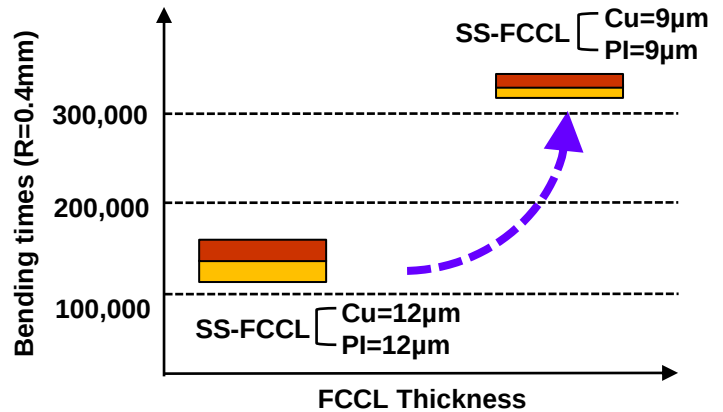
|                            | 2025                                                    | 2026 | 2027 | 2028                                          | 2029                     | ~2030FY |
|----------------------------|---------------------------------------------------------|------|------|-----------------------------------------------|--------------------------|---------|
| Bendability<br>(Thin FCCL) | M Series & F Series Thin FCCL Grade                     |      |      | R&D : Ultra Thin PI Grade (PI: ≤6μm)          |                          |         |
| Fine Patterning            | M Series New RA Copper FCCL Grade                       |      |      | R&D : Ultra Thin Copper Grade (Cu: 1.5μm~7μm) |                          |         |
| Dimensional<br>Stability   | R&D : High DS Grade                                     |      |      |                                               |                          |         |
| High Frequency             | F Series MPI Grade (Dk: 3.3[XY] / 2.8[Z] , Df: 0.003)   |      |      |                                               | R&D : F Series Next gen. |         |
|                            | R&D : Low dielectric PI Grade (Dk: 2.5[XY] , Df: 0.001) |      |      |                                               |                          |         |
| Carbon Neutral             | R&D : PI made from biomass monomer                      |      |      |                                               |                          |         |

## Bendability -High Bending (Thin) FCCL-

### Bending Mode

| Bending Mode  | Image                                                                             |
|---------------|-----------------------------------------------------------------------------------|
| Foldable Test |  |
| MIT           |  |

### Effects of Thin FCCL



### Thin FCCL Lineup

|                          |                          |    | Polyimide Thickness (μm) |          |       |          |
|--------------------------|--------------------------|----|--------------------------|----------|-------|----------|
| Copper Thickness<br>(μm) |                          |    | 5                        | 7        | 9     | 12       |
|                          | 1.5~5<br>(+Carrier foil) | ED | Δ(SS)                    | -        | Δ(SS) | -        |
|                          |                          | 9  | ED                       | -        | -     | -        |
|                          | RA                       |    | -                        | -        | Δ(SS) | Δ(SS)    |
|                          | 12                       | ED | Δ(SS)                    | Δ(SS/DS) | -     | O(SS&DS) |
|                          |                          | RA | Δ(SS)                    | -        | O(SS) | O(SS&DS) |

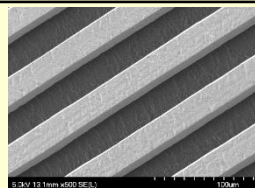
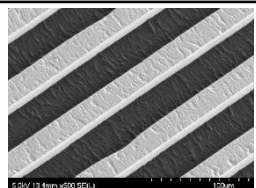
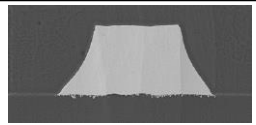
※ O: Mass product, Δ: Proto product, -: Please contact us  
 SS: Single-sided Copper, DS: Double-sided Copper

## Fine Patterning -High E.F. FCCL-

### FCCL Properties

| Double-sided RA FCCL (Cu=12μm, PI=25μm) |      | High E.F. Grade | General Grade |
|-----------------------------------------|------|-----------------|---------------|
| Peel strength                           | kN/m | 1.2             | 1.1           |
| Young's modulus of PI                   | GPa  | 6.8             | 6.8           |
| Moisture Absorption                     | %    | 0.6             | 0.6           |
| Solder Heatproof                        | °C   | >320            | >320          |

### Wiring Shape

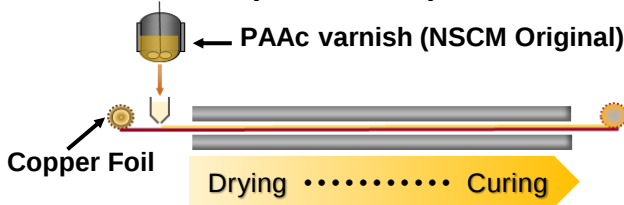
| New Grade                                                                            | Current Grade                                                                         |
|--------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|  |  |
|  |  |
| E.F. 4.5                                                                             | E.F. 2.0                                                                              |

- Target L/S : 25/25μm
- Etchant : Ferric Chloride type

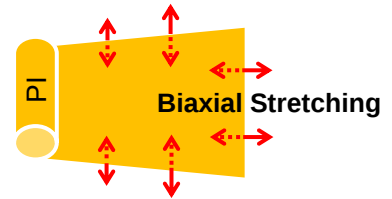
Notice : NSCM makes no warranty, guarantee or representation, either express or implied, of non-infringement on any Intellectual property rights of any third parties with respect to use, processing or application of any NSCM's products. Further, NSCM shall not be liable for any losses, damages, costs, claims or demands including those for consequential or indirect damages, arising out of or in connection with infringement of any third parties' intellectual property rights with respect to any use, processing or application of any NSCM's products."

## Multilayer -High Dimensional Stability FCCL-

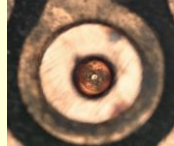
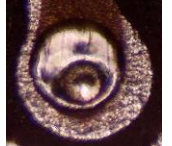
### Polyimide Film made by Coating (ESPANEX®)



### Polyimide Film made by Stretching



### Comparison of Polyimide Process for Dimensional Stability

| Double-sided RA FCCL (Cu=12μm, PI=25μm)                                   |               |    |   | ESPANEX® M Series                                                                          | Stretching PI FCCL                                                                              |
|---------------------------------------------------------------------------|---------------|----|---|--------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| Dimensional Stability<br>(Average ± σ)                                    | After Etching | MD | % | 0.05 ± 0.004                                                                               | -0.04 ± 0.007                                                                                   |
|                                                                           |               | TD |   | -0.01 ± 0.006                                                                              | 0.02 ± 0.008                                                                                    |
|                                                                           | After Heating | MD |   | -0.05 ± 0.007                                                                              | -0.02 ± 0.010                                                                                   |
|                                                                           |               | TD |   | -0.05 ± 0.006                                                                              | -0.02 ± 0.012                                                                                   |
| Via Breakout on Multilayer PCB<br>(Benefit of high Dimensional stability) |               |    |   | Good<br> | No Good<br> |

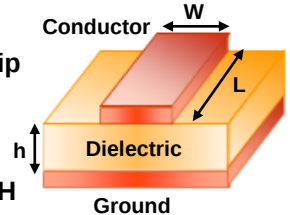
## High Frequency -Low Loss FCCL-

### FCCL Properties

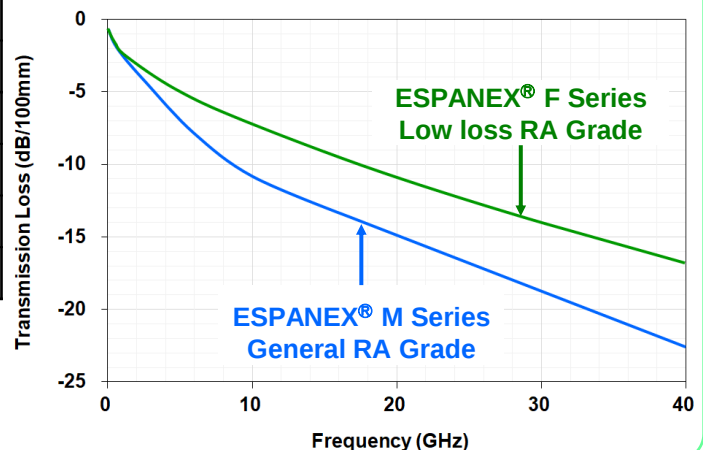
| Double-sided RA FCCL<br>(Cu=12μm, PI=12μm) |      | Low Loss Grade | General Grade |
|--------------------------------------------|------|----------------|---------------|
| Dielectric Constant                        |      |                |               |
| SPDR                                       | -    | 3.3            | 3.3           |
| BCDR                                       | -    | 2.9            | 2.9           |
| Dissipation Factor                         | -    | 0.003          | 0.006         |
| Peel strength                              | kN/m | 0.9            | 1.2           |
| Young's modulus of PI                      | GPa  | 7.5            | 6.8           |
| Moisture Absorption                        | %    | 0.6            | 0.6           |
| Solder Heatproof                           | °C   | >320           | >320          |

### Conditions

- Transmission Line : Microstrip
- Line Length : 100mm
  - Dielectric height : 12μm
  - Impedance : 50Ω
  - Environment : 23°C/50%RH



### Comparison of Transmission Loss



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