

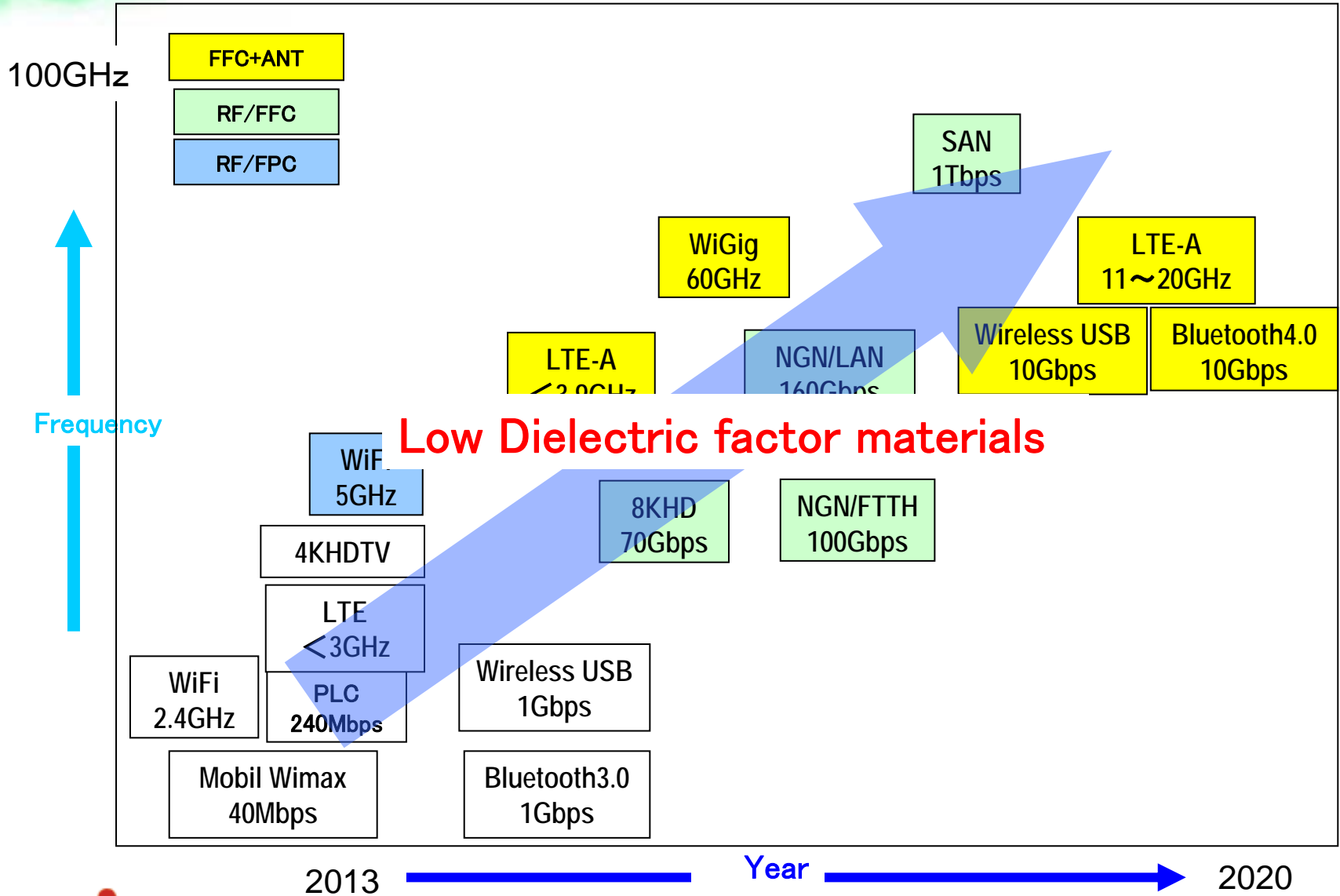
# New Functional Insulating Film for High-speed Transmission Circuit

Shin Teraki  
NAMICS CORPORATION  
ADFLEMA Division

# Outline

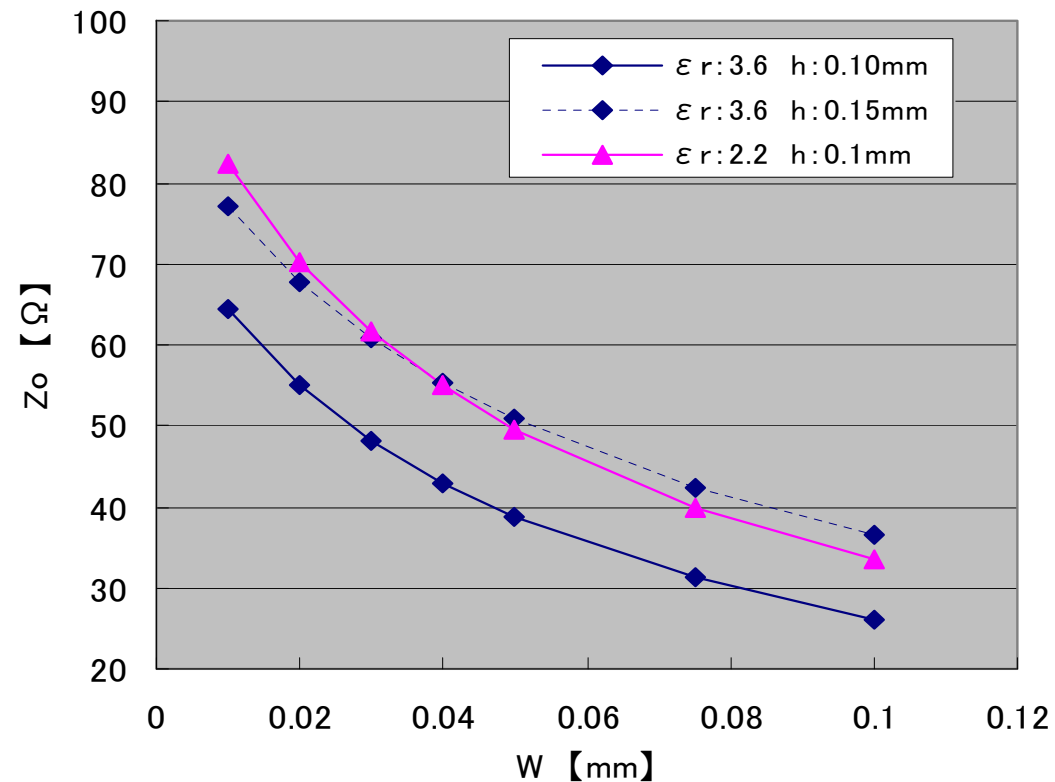
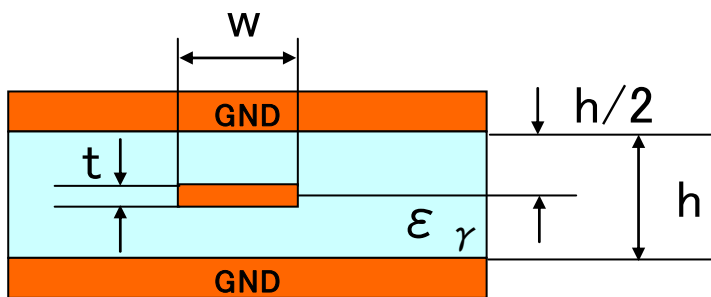
- ◆ Background
- ◆ Approach to an organic insulation material for high frequency
- ◆ Film Properties
- ◆ Application to high frequency circuit
- ◆ Summary

# Background

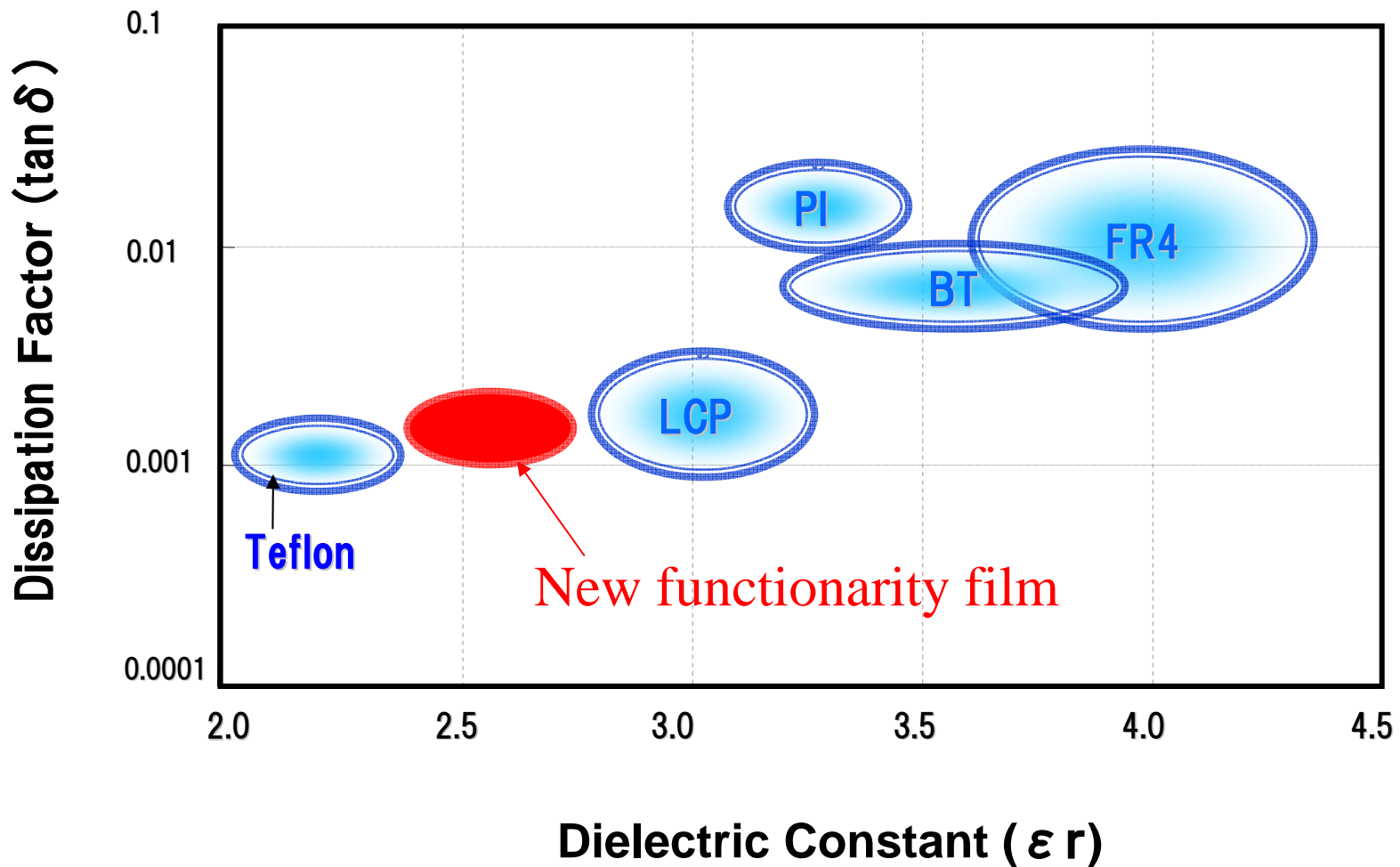


# The merit of a low dielectric constant material

$$Z_0 = \frac{60}{\sqrt{\epsilon_r}} \ln \left( \frac{4h}{0.67 \pi (0.8w + t)} \right)$$



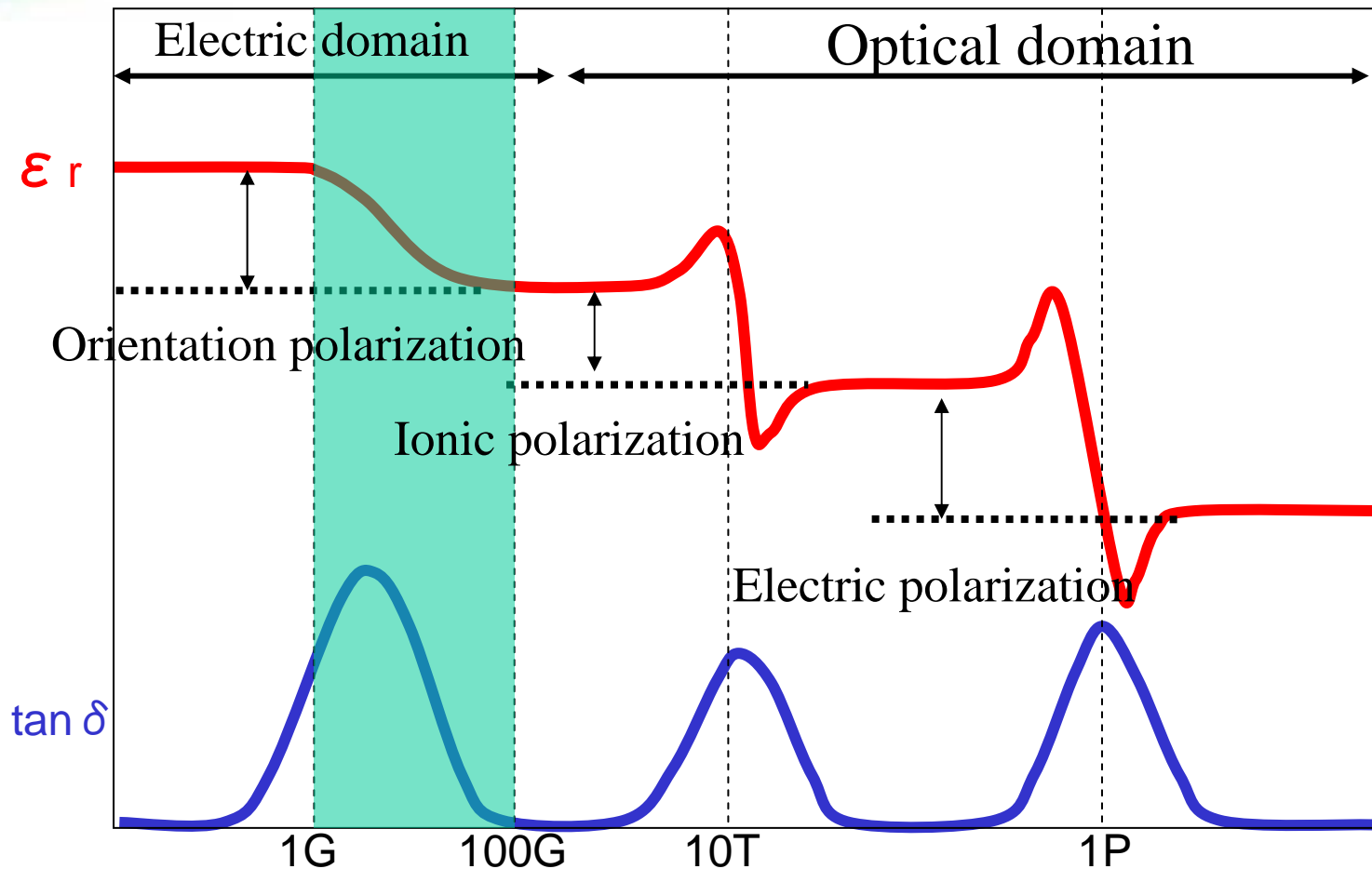
# Dielectric property of various materials



# Outline

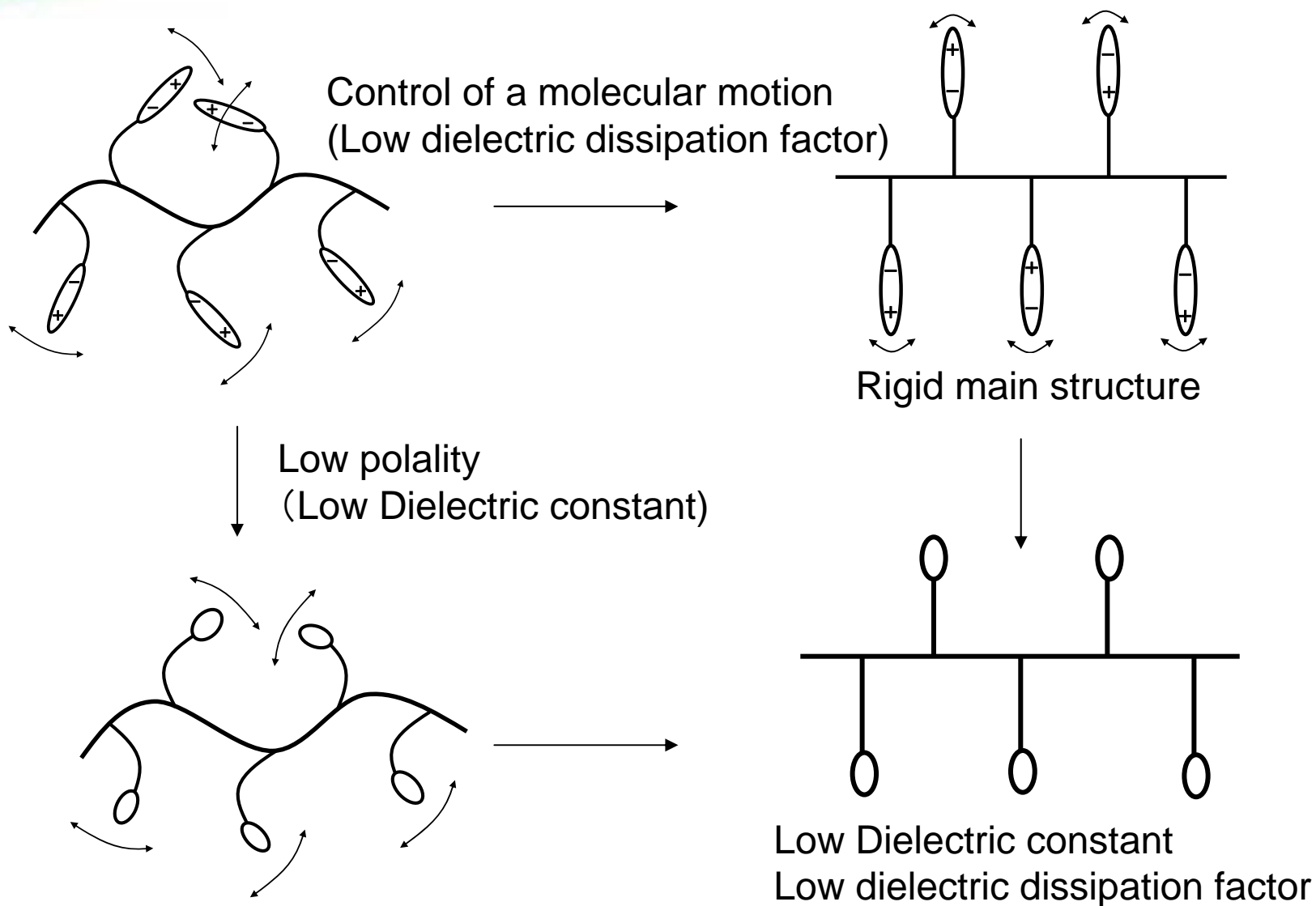
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# Approach to an organic system



In a high frequency band in a GHz range,  
an influence of orientational polarization needs to be minimized.

# Approach to an organic system






# Approach to an organic system

Clausius-Mosotti

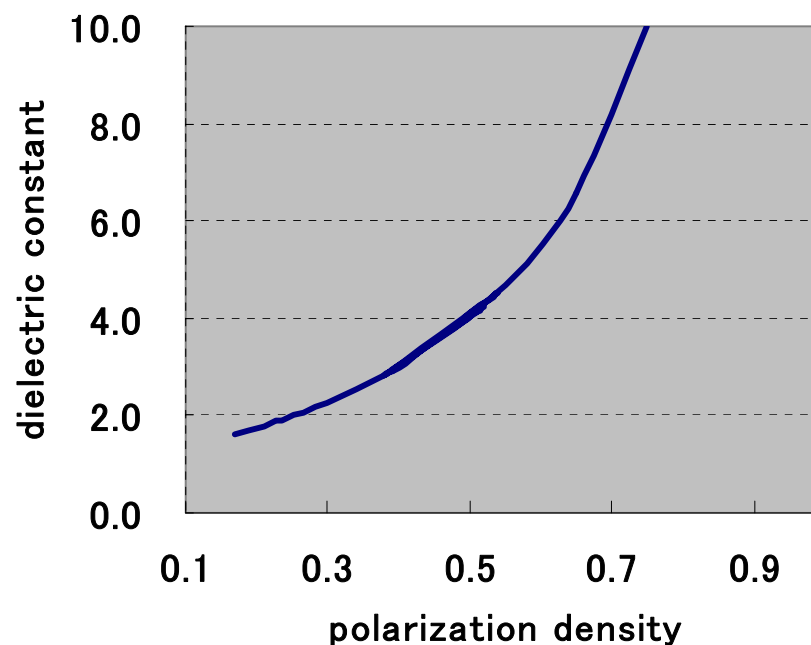
$$\epsilon_r = (1 + 2a) / (1 - a)$$

a : Polarization density  $\Sigma P_m / \Sigma V_m$

$P_m$  : Molar Polarization,  $V_m$  : Molar volume,

| Atom group  | $P_m$ | $V_m$ | a     | $\epsilon_r$ |
|---|-------|-------|-------|--------------|
| —CH <sub>2</sub> —  | 4.7   | 23.9  | 0.24  | 1.95         |
| —CH<  | 3.6   | 9.5   | 0.38  | 2.84         |
| >CH<  | 2.6   | 4.8   | 0.54  | 4.52         |
|  | 25    | 65.5  | 0.38  | 2.84         |
| —O—   | 5.2   | 10    | 0.52  | 4.25         |
| —COO—   | 15    | 23    | 0.65  | 6.57         |
| —CO—  | 10    | 13.4  | 0.75  | 10.00        |
| —F  | 1.8   | 10.9  | 0.17  | 1.61         |
| —CH <sub>3</sub>  | 5.6   | 23.9  | 0.24  | 1.95         |
| —Br   | 11.7  | 30    | 0.39  | 2.92         |
| —Cl   | 9.5   | 19.9  | 0.477 | 3.74         |
| —CN   | 11    | 19.5  | 0.56  | 4.88         |
| —OH   | 6     | 9.7   | 0.62  | 5.87         |

Relation between  $\epsilon_r$ ,  
and polarization density



# Outline

- ◆ Background
- ◆ Approach to an organic insulation material for high frequency
- ◆ **Film Properties**
- ◆ Application to high frequency circuit
- ◆ Summary

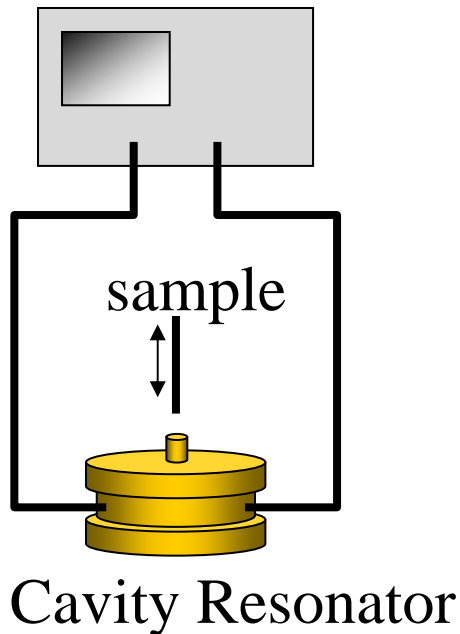
## Properties of thermosetting film

| Item                               | Unit                              | Low Dk, Df     | Method                  |
|------------------------------------|-----------------------------------|----------------|-------------------------|
| <b>Dielectric constant</b>         | <b>2 GHz</b>                      | <b>2.4</b>     | <b>Cavity Resonator</b> |
| <b>Dissipation factor</b>          | <b>2GHz</b>                       | <b>0.0025</b>  |                         |
| <b>Copper peel strength</b>        | <b>N/cm</b>                       | <b>10</b>      | <b>JIS C6471</b>        |
| <b>Tensile strength</b>            | <b>MPa</b>                        | <b>42</b>      | <b>ASTM D 882</b>       |
| <b>Elongation</b>                  | <b>%</b>                          | <b>250</b>     | <b>ASTM D 882</b>       |
| <b>Tensile modulus</b>             | <b>MPa</b>                        | <b>800</b>     | <b>ASTM D 882</b>       |
| <b>Glass transition temp.</b>      | <b>°C</b>                         | <b>190</b>     | <b>DMA</b>              |
| <b>CTE (<math>\alpha 1</math>)</b> | <b>ppm/°C</b>                     | <b>110</b>     | <b>TMA</b>              |
| <b>Volume resistance</b>           | <b>E15 <math>\Omega</math> cm</b> | <b>1</b>       | <b>JIS C2170</b>        |
| <b>Thermal Decomposition temp.</b> | <b>°C</b>                         | <b>370</b>     | <b>TG-DTA</b>           |
| <b>Water absorption</b>            | <b>%</b>                          | <b>&lt;0.1</b> | <b>25°C, 24hr</b>       |

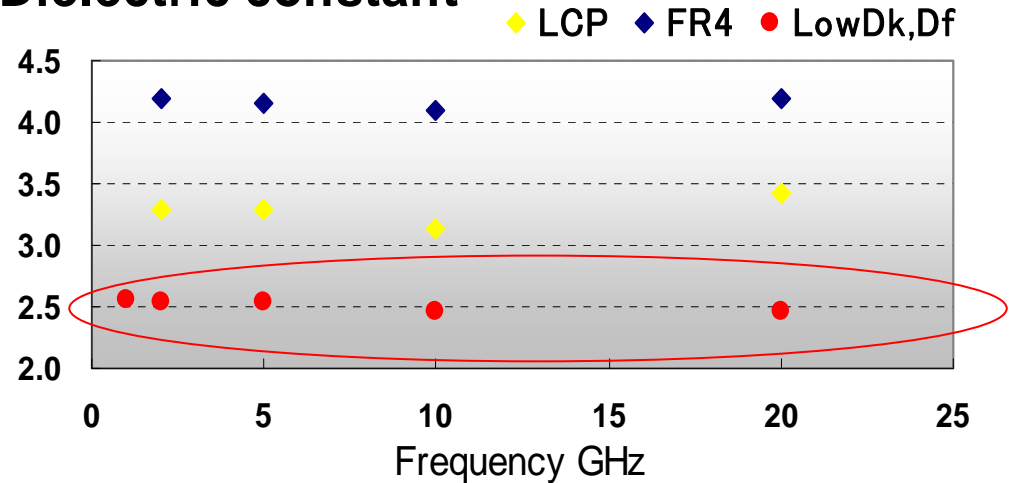
# High frequency properties of the film

## Frequency dependence

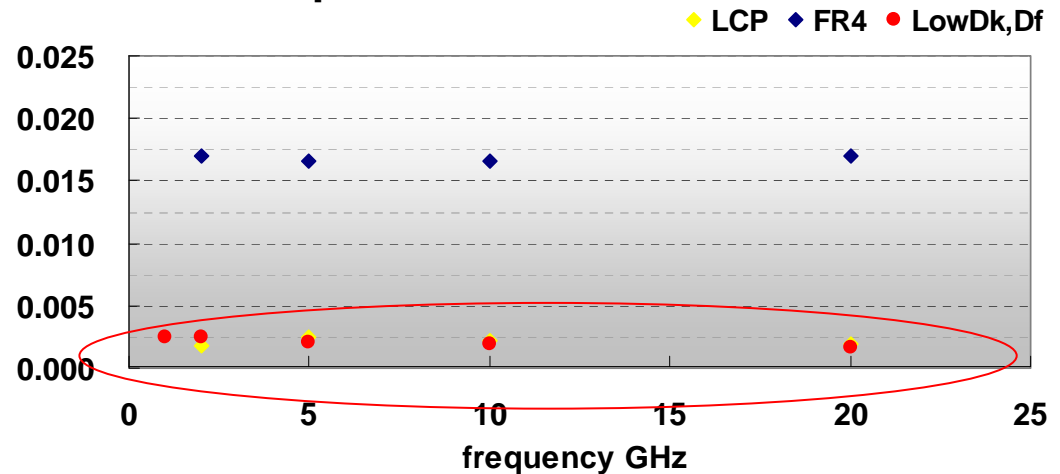
Method  
Cavity Resonator  
Frequency  
1G—20GHz



### Dielectric constant



### Dielectric dissipation factor



# High frequency properties of the film

## Temperature dependence

Method

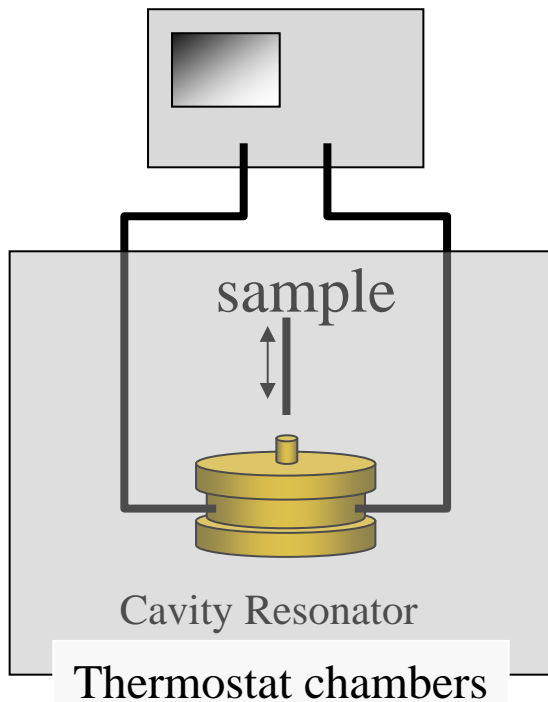
Cavity Resonator

Frequency

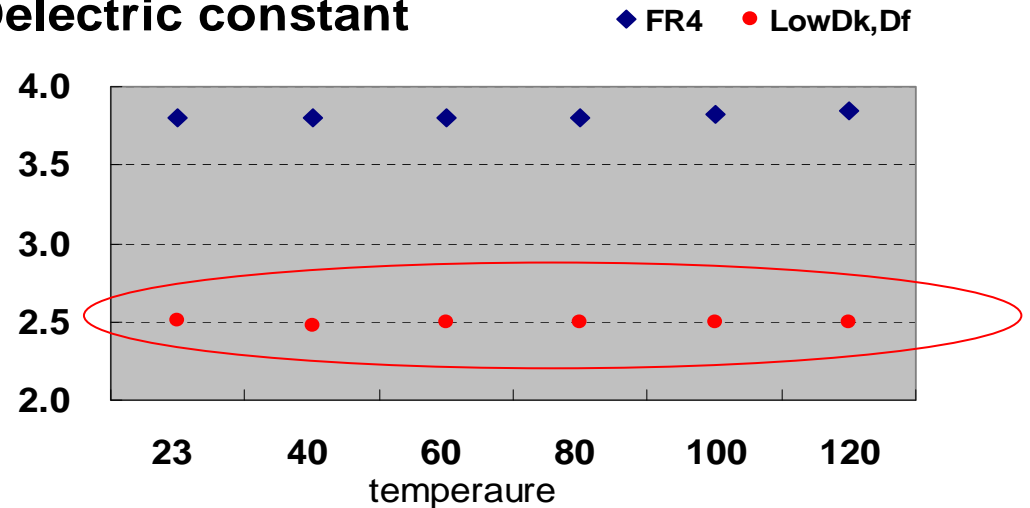
10GHz

Condition

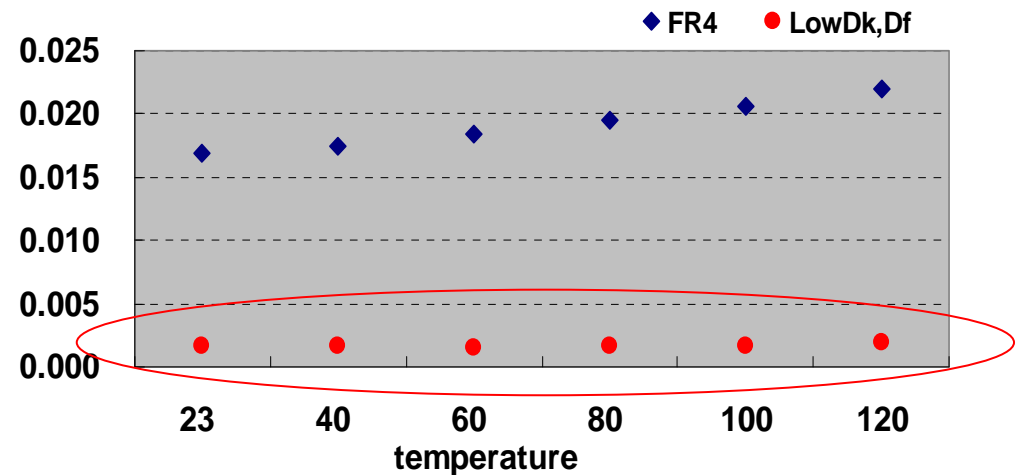
temp.23, 40, 60, 80, 100, 120°C



### Dielectric constant



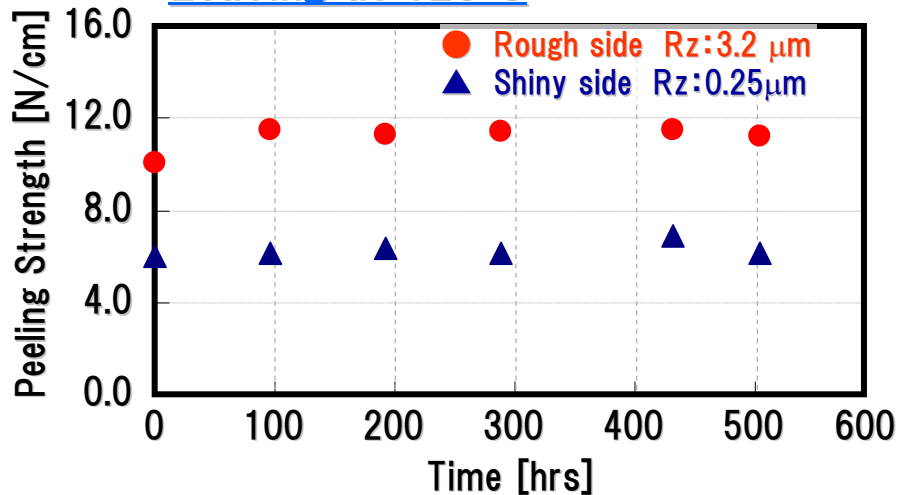
### Dielectric dissipation factor



# Properties

## Adhesive Reliability

### Leaving at 125°C



### 【Cu Peeling Strength】

○Cu Foil

Electrolytic 3EC-VLP 12μm

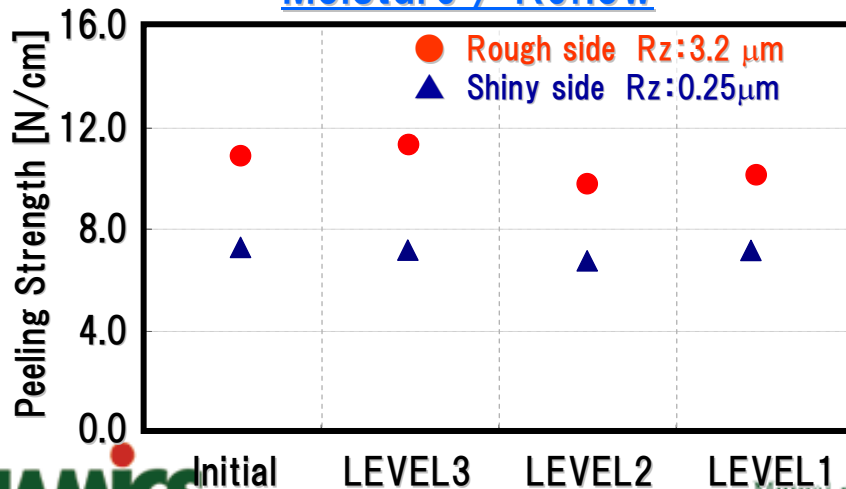
○Lamination Condition

200°C×60min、1MPa、Vacuum<10KPa

○180° Peeling Test(@RT)

Peeling Speed 50mm/min

### Moisture / Reflow



### JEDEC LEVEL1·2·3

Level1: 168hrs 85°C/85%RH & 260°C×3times

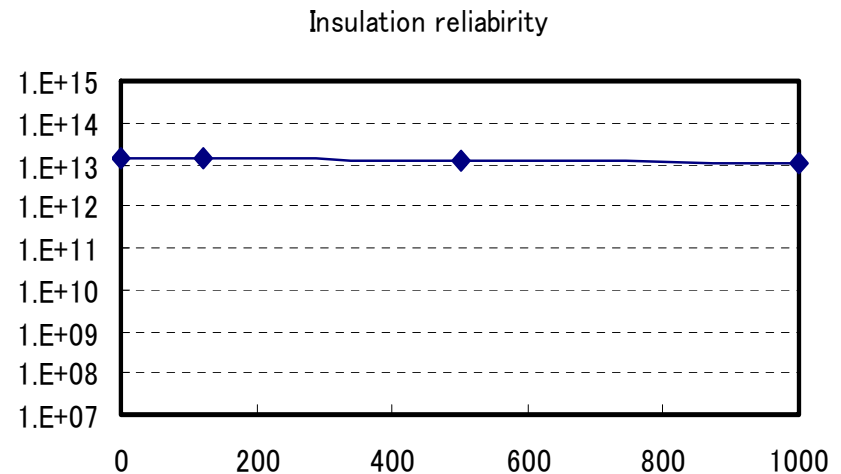
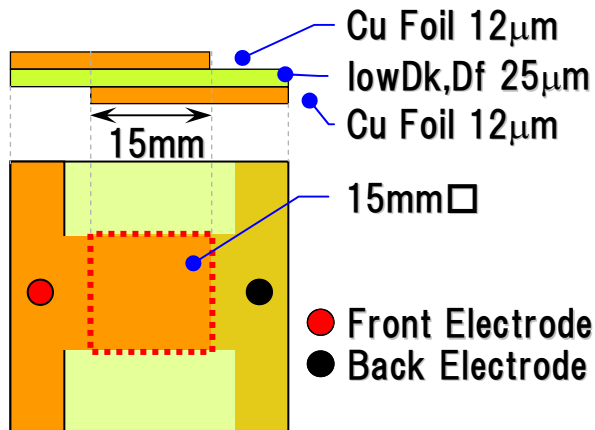
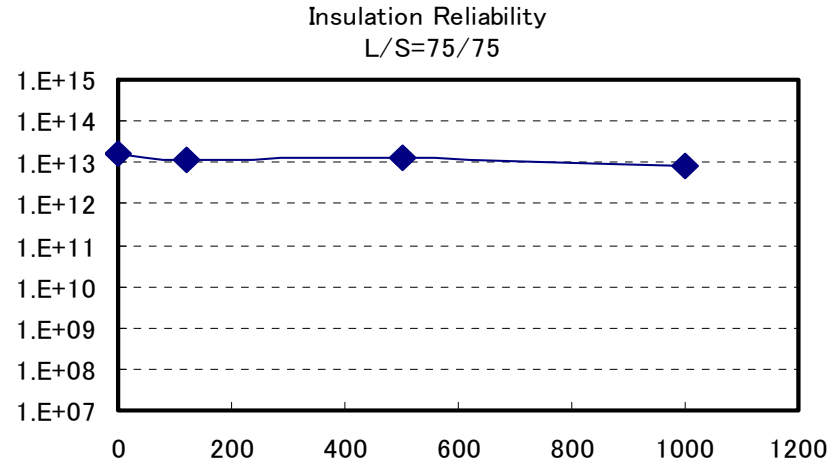
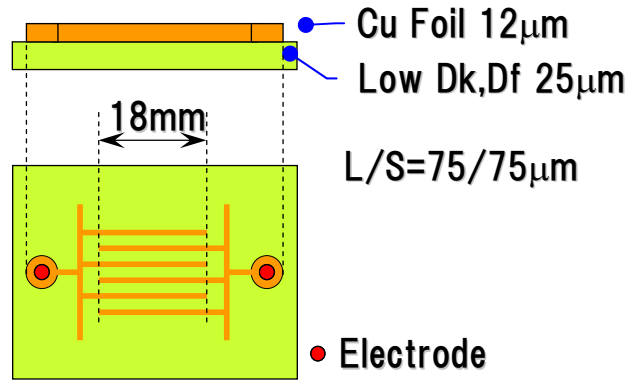
Level2: 168hrs 85°C/60%RH & 260°C×3times

Level3: 192hrs 30°C/60%RH & 260°C×3times

## Condition

Pretreatment : JEDEC Level 3 30°C60%RH192hr→Reflow peek temp.260°C × 3

Test condition85°C/85%RH/DC30V,1000h



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# Application

FPC for high-speed transmission circuit  
High-speed & High reliability Multilayer Board

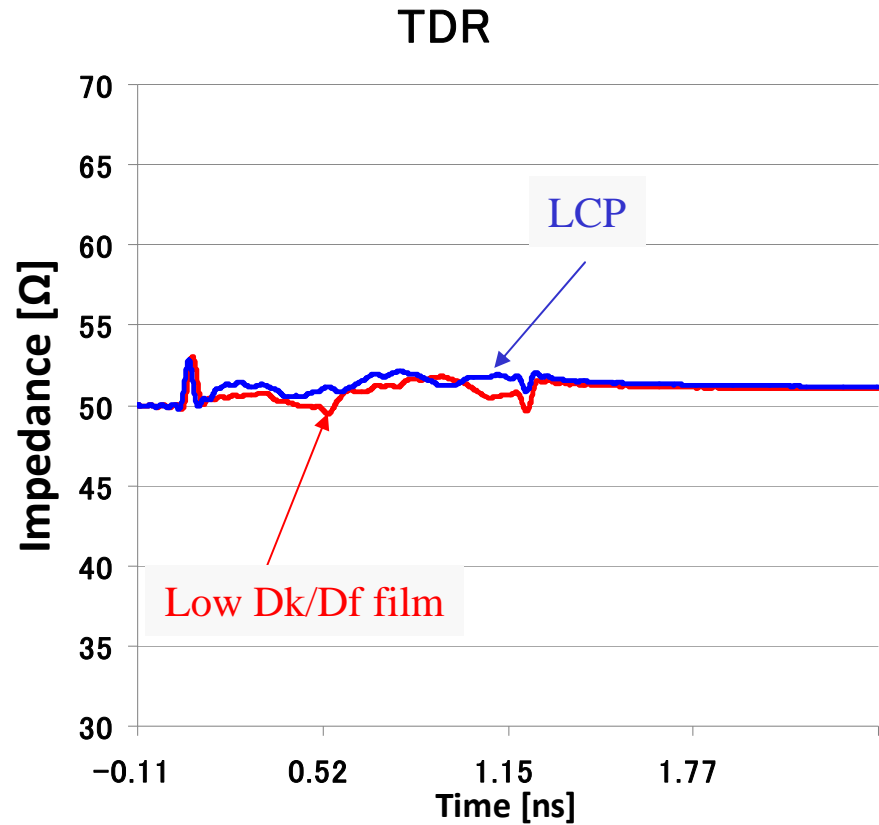
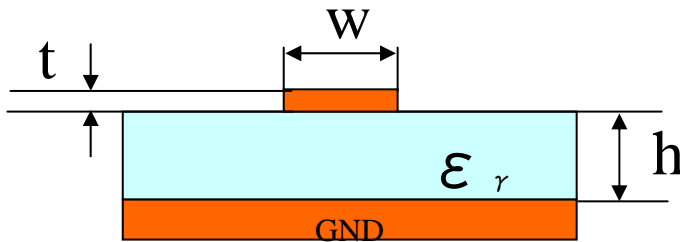
- Ex. ◆ High speed transmission cable  
◆ Antenna substrate  
◆ PWB with embedded devices

FPC ⇒ Bonding-sheet、Cover-lay

Multilayer Board ⇒ Build-Up layer

## Microstrip line

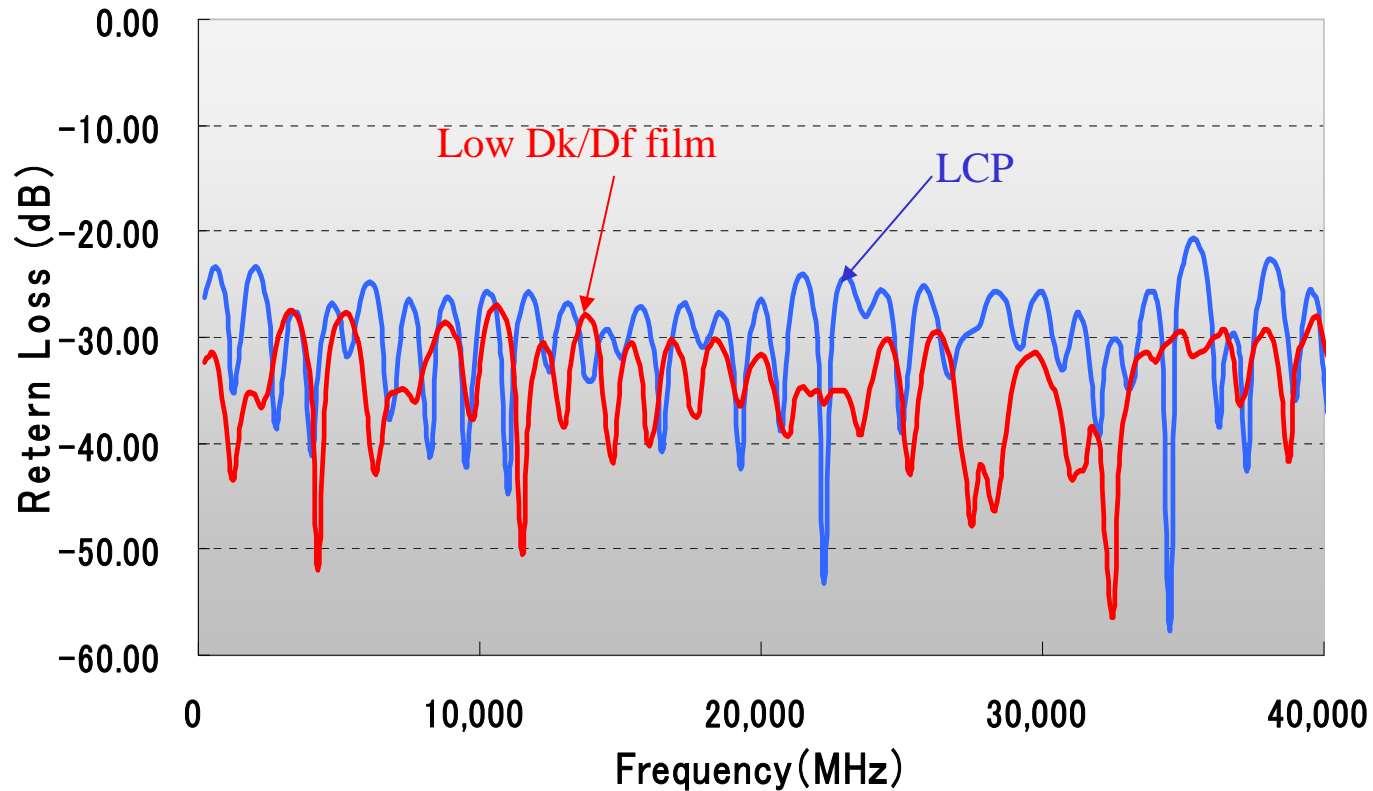
$$Z_o = \frac{87}{\sqrt{\epsilon_r + 1.41}} \ln \left( \frac{5.98h}{(0.8w + t)} \right)$$



|           | $\epsilon_r$ | Thickness<br>[ $\mu m$ ] | Line width<br>[ $\mu m$ ] | Impedance<br>[ $\Omega$ ] |
|-----------|--------------|--------------------------|---------------------------|---------------------------|
| LCP       | 3.0          | 50                       | 112                       | 50                        |
| Low Dk.Df | 2.4          | 50                       | 130                       | 50                        |

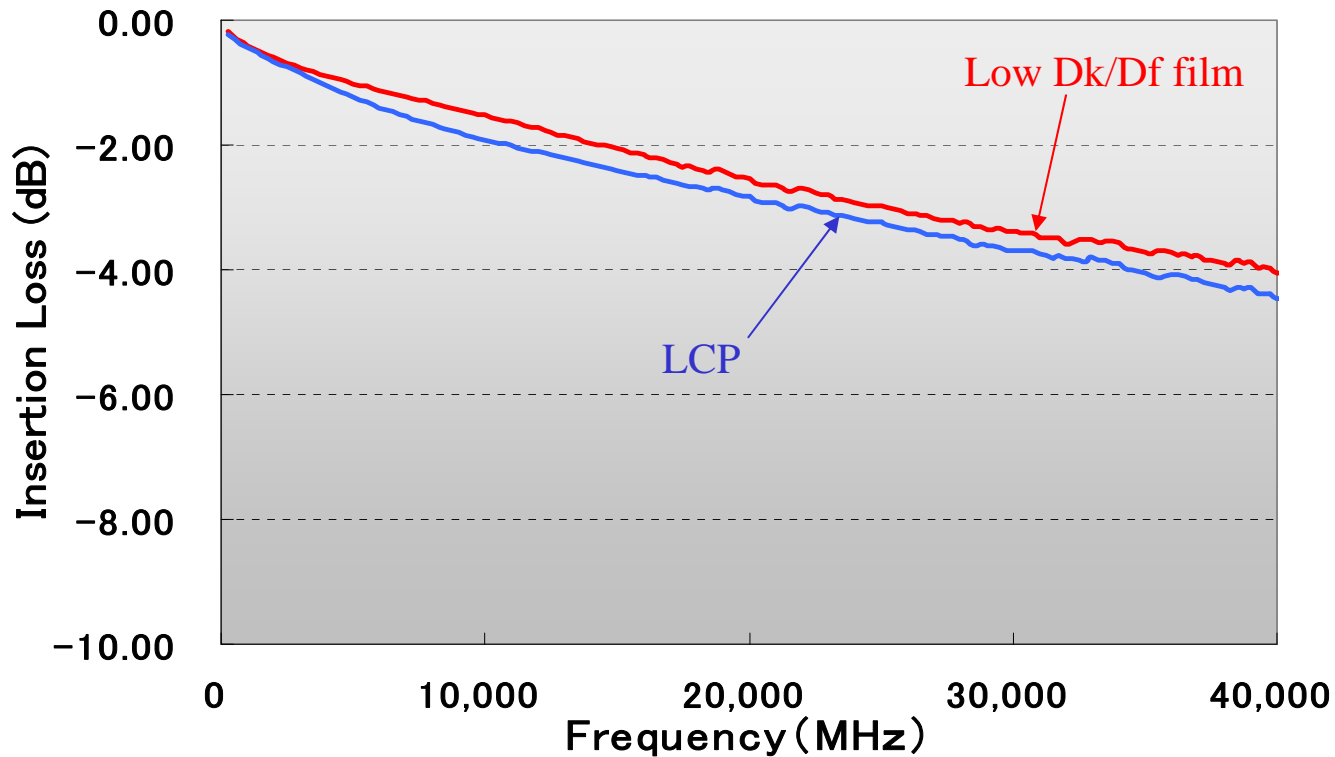
# Return Loss (S11)

Machine : E8363B (Agilent Technologies)  
Frequency : 10M–40GHz  
Insulating Layer :  $50\ \mu\text{m}$   
Wiring Length : 70mm  
Wiring Thickness :  $18\ \mu\text{m}$



# Insertion Loss (S21)

Machine : E8363B (Agilent Technologies)  
Frequency : 10M–40GHz  
Insulating Layer :  $50\ \mu\text{m}$   
Wiring Length : 70mm  
Wiring Thickness :  $18\ \mu\text{m}$



# Summary

**Our new functional film is excellent in high frequency characteristics, heat resistance, and moisture resistance.**

**It is a promising film to apply to various electronic devices which require high-speed large-volume data processing.**

**For future study, we will put more effort into reducing a further dielectric constant and a low dielectric dissipation factor.**