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Novel Viscoelastic Measurement Techniques for Multilayer Coatings Utilizing Nano-Indenter

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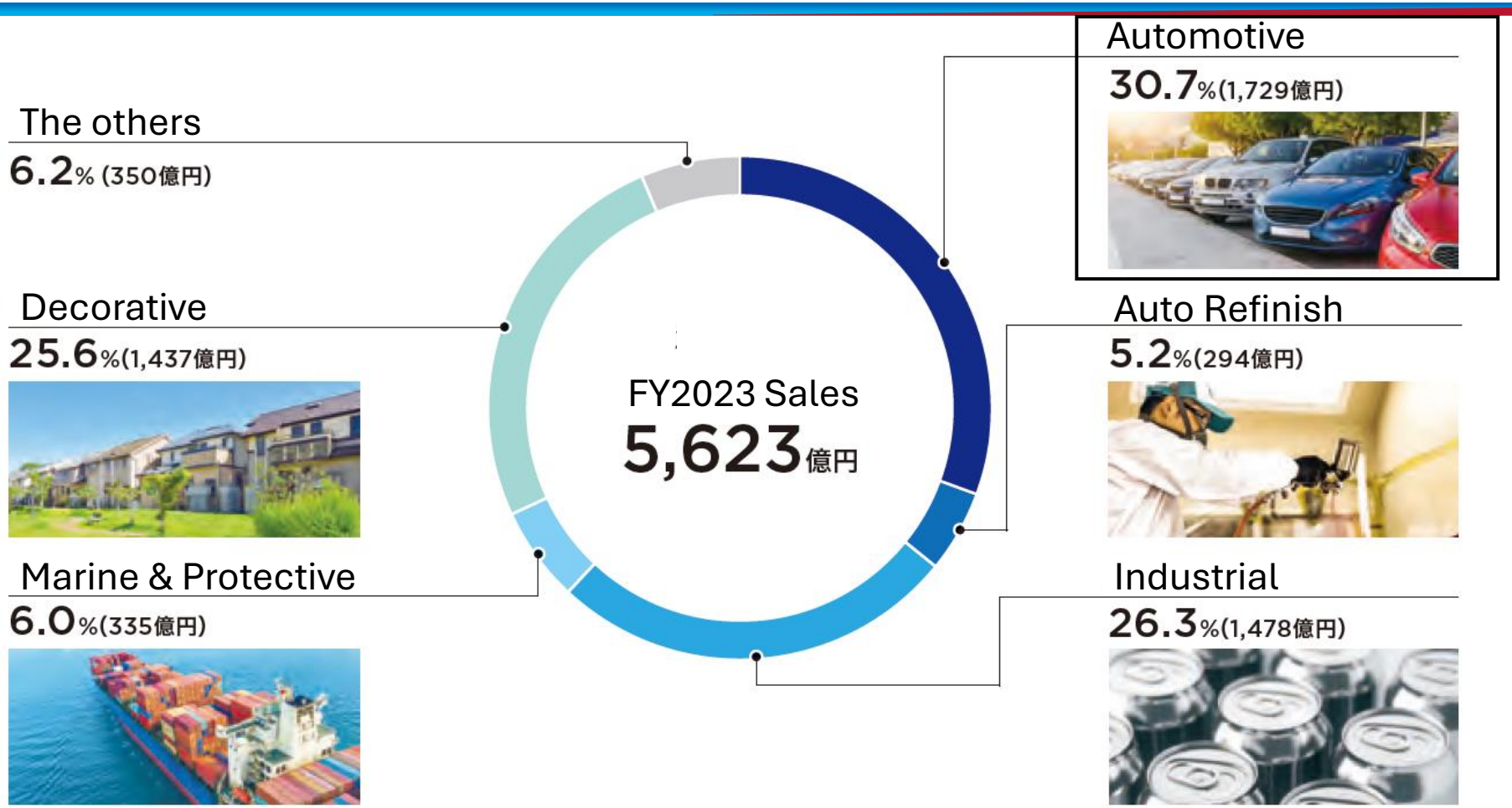
Kansai Paint Market Share by Sector



We offer various categories of coatings worldwide.
Automotive coatings are one of our most important sector.

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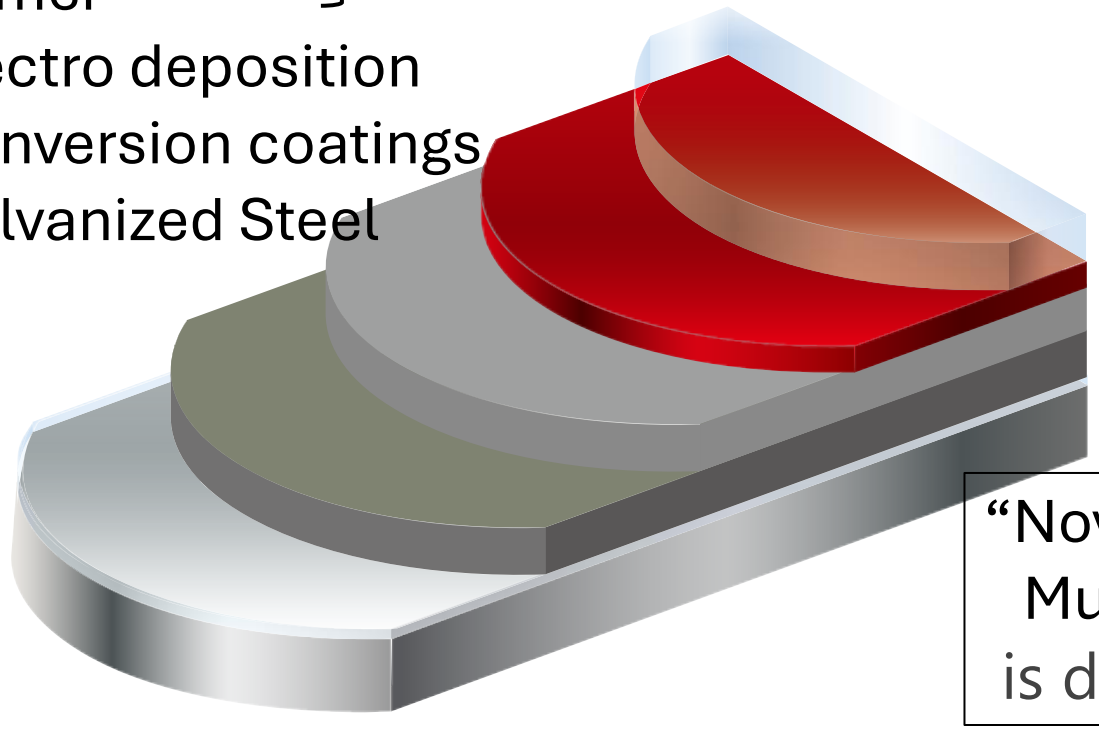
Sustainable technology for automotive coatings

Automotive Coatings

- Clear coat
- Base coat
- Primer

} Streamlined process
3Coat 1Bake

- Electro deposition
- Conversion coatings
- Galvanized Steel



Eco-friendly Innovations

-Low VOC

Water borne, High solid

-High Efficiency Coatings

Low Temperature Cured, Thin layer

-Streamlined Process

"Novel Viscoelastic Measurement Techniques for Multilayer Coatings Utilizing Nano-Indenter" is developed to evaluate these coating films.

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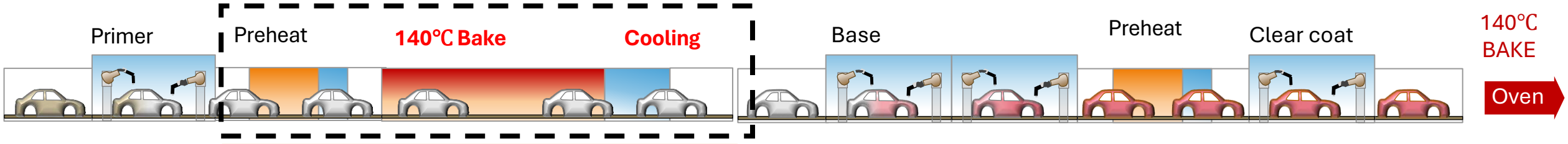
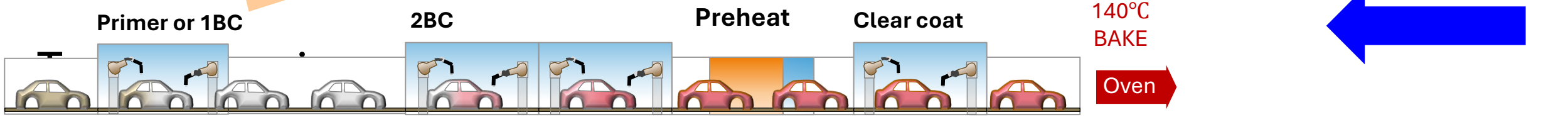
Streamlined Process for Automotive Coatings

Conventional Process
3Coat2Bake (150-200m)



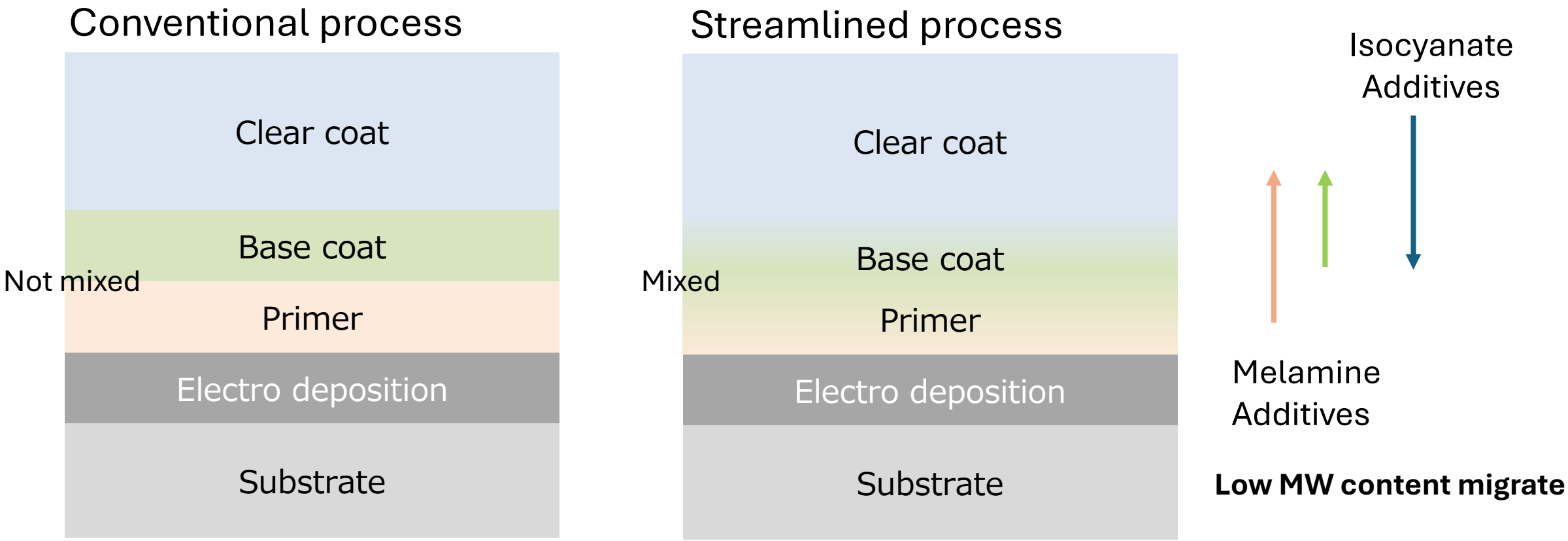
Streamlined Process
3Coat1Bake (120-150m)

Shorten line length
Low energy consumption



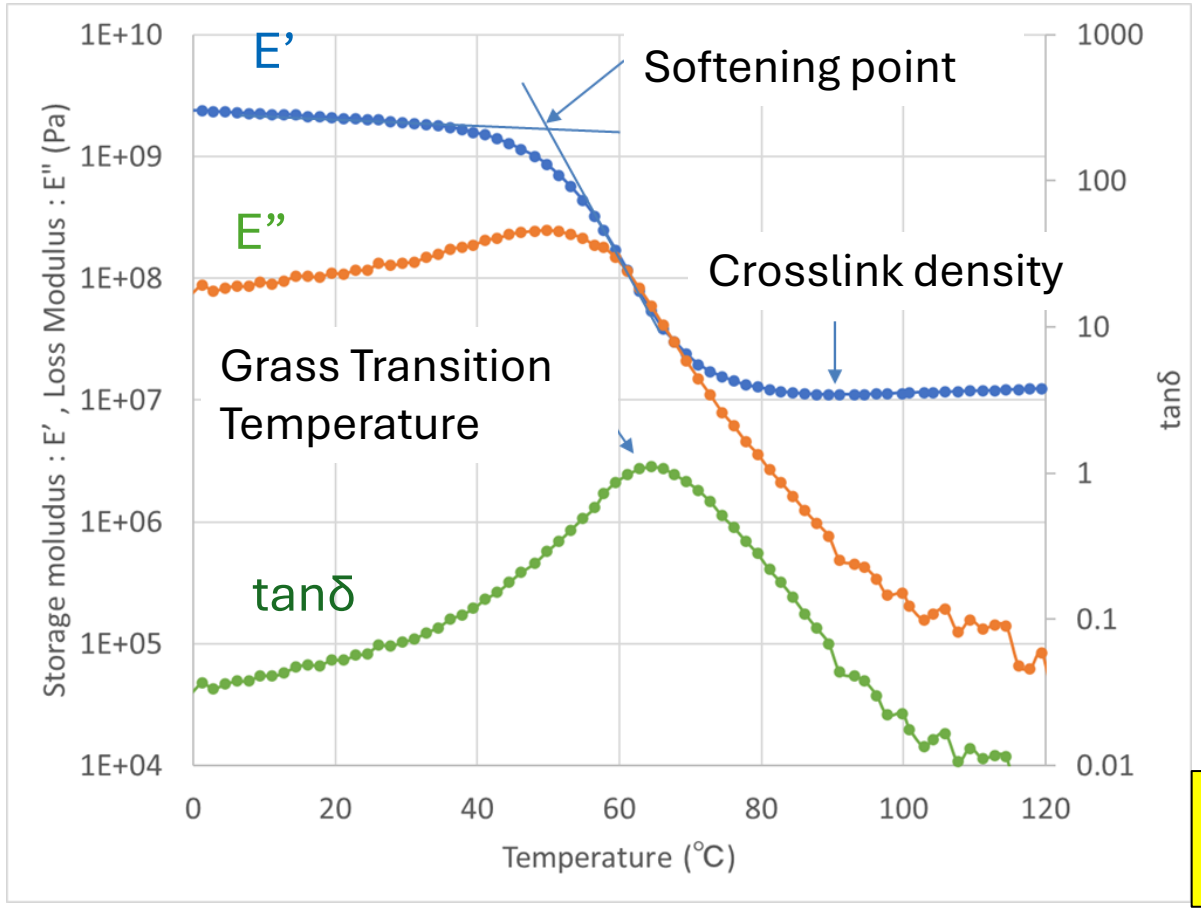
We faced challenges in evaluating physical properties during development.

Layered Films by Streamlined Process

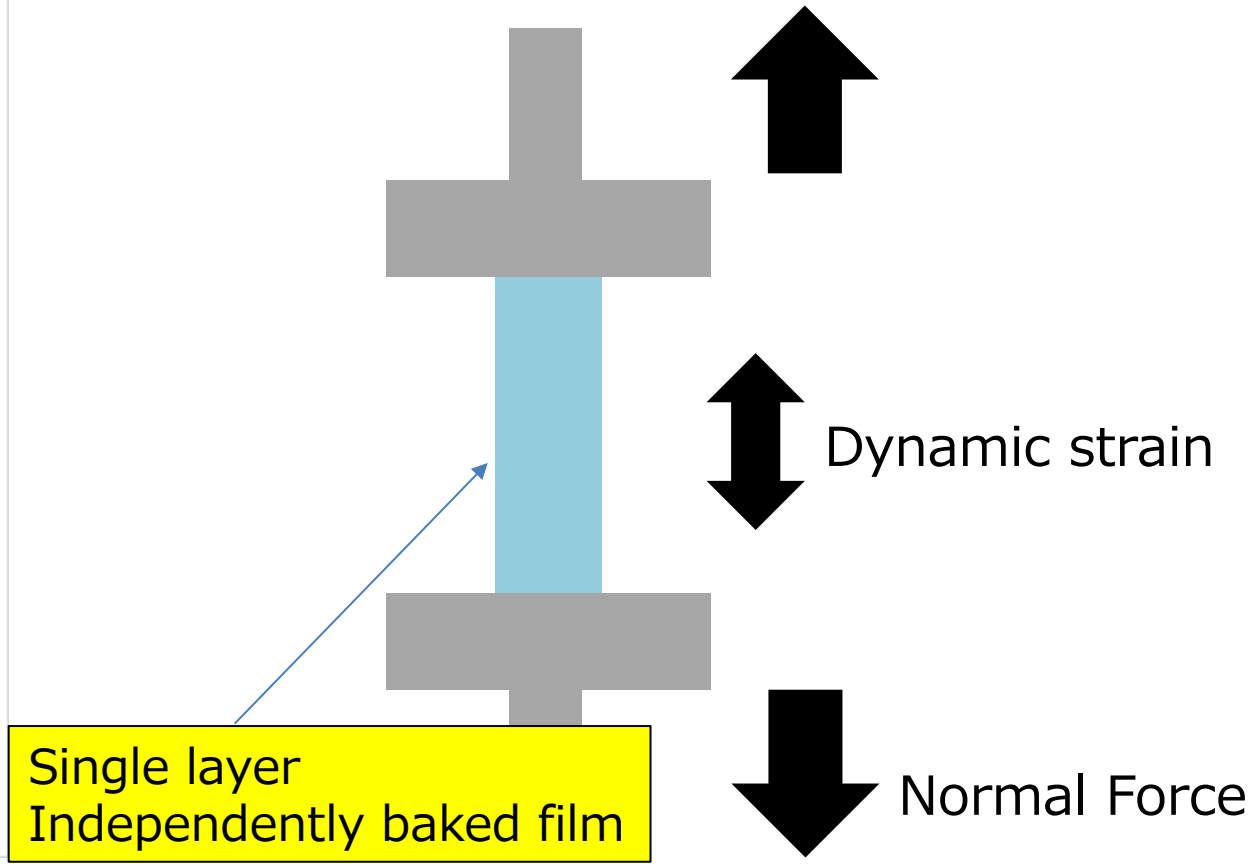


The layered films obtained by the streamlined process are quite different from independently baked films. Our new product are designed to utilize this migration.

Viscoelastic Property of Coating Film



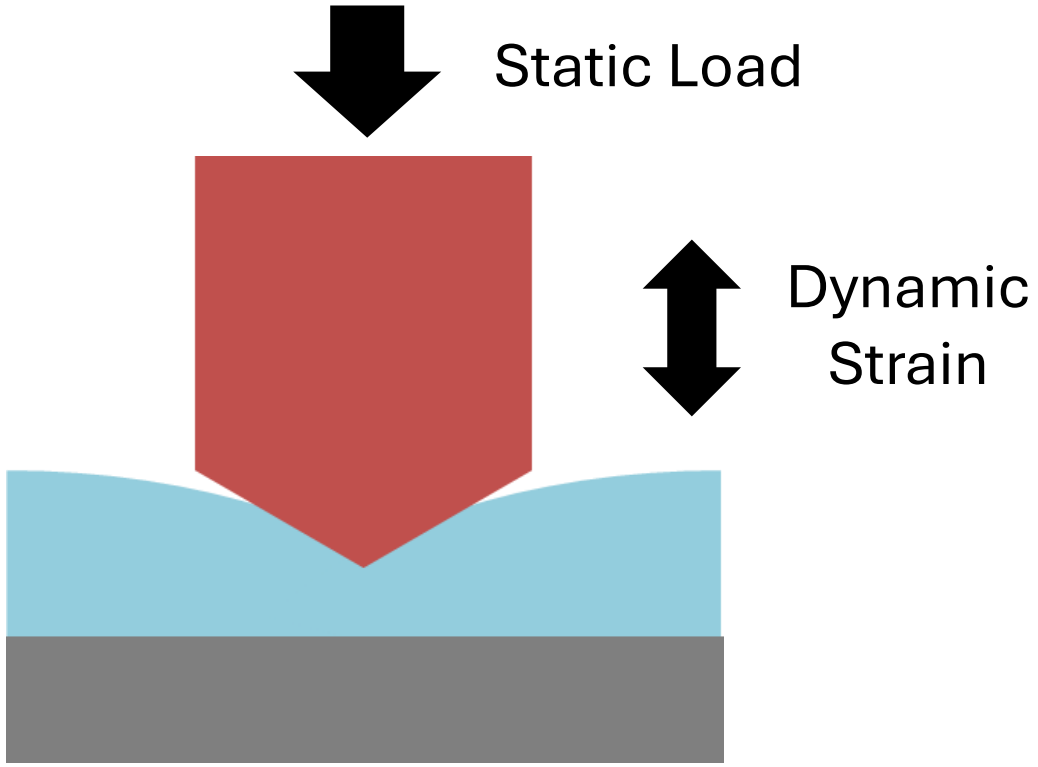
DMA measurement of coating films



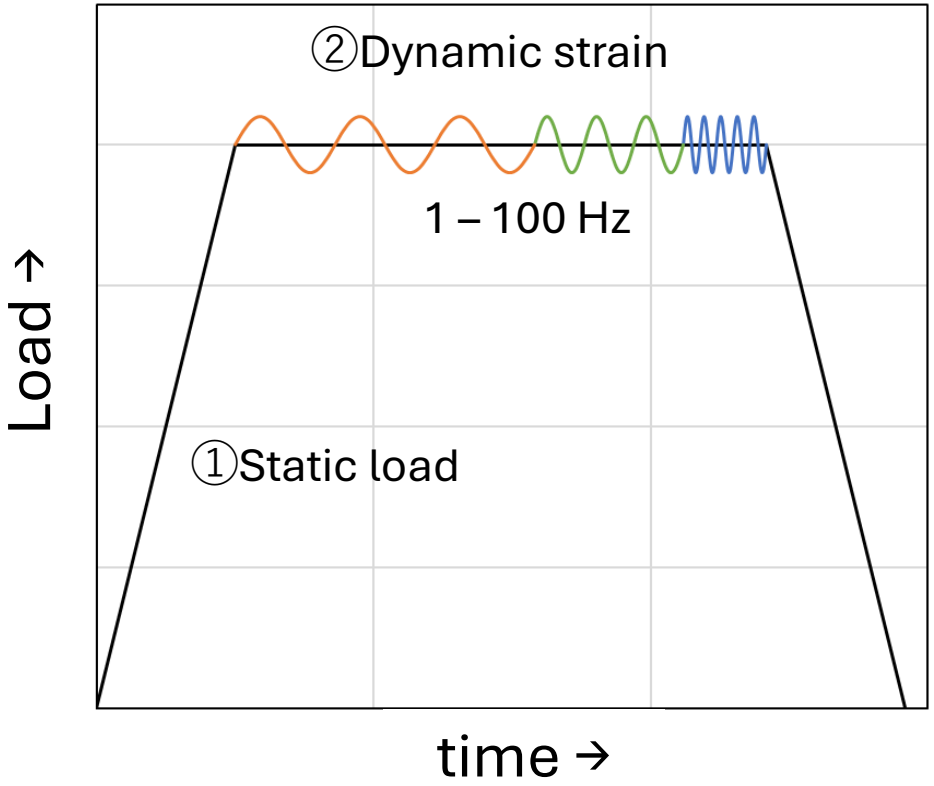
For our streamlined process, this method is becoming less meaningful.

DMA Measurement by Nano-indenter

Schematic of Nanoindentation



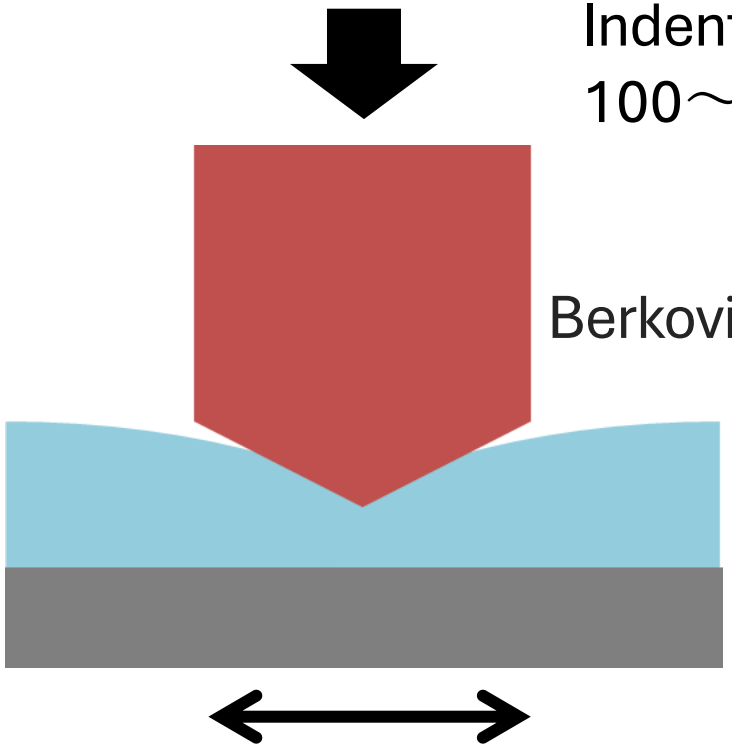
Load function



We can measure the viscoelastic properties of the coating panel without peeling off the substrate.

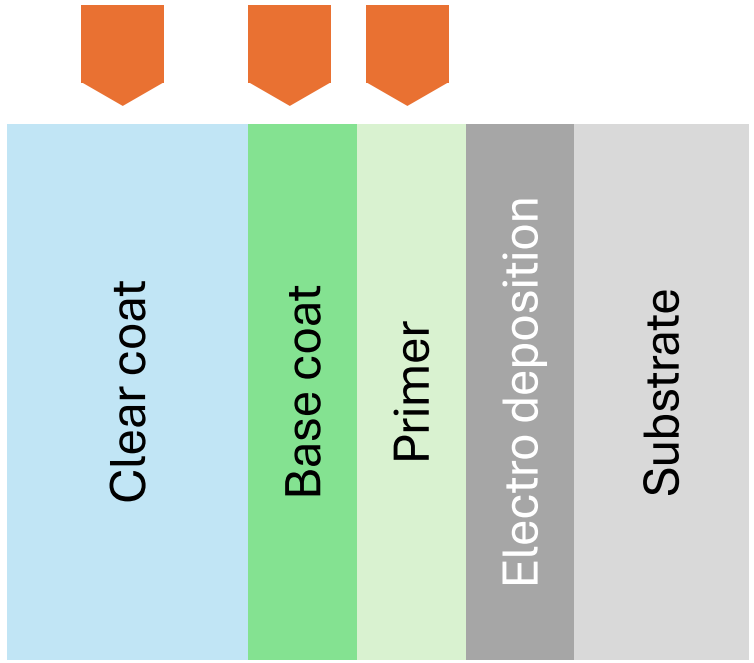
Measurement of Underlayer from Cross-section

Schematic of Nanoindentation Method



Sufficiently small

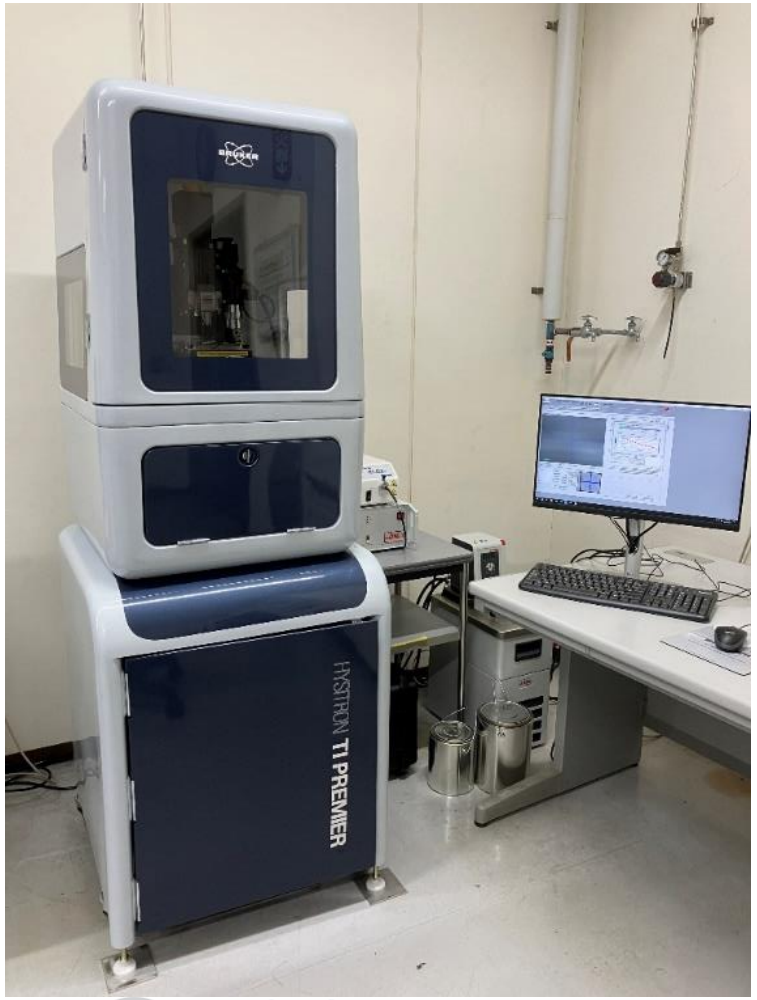
Measurement from cross-section

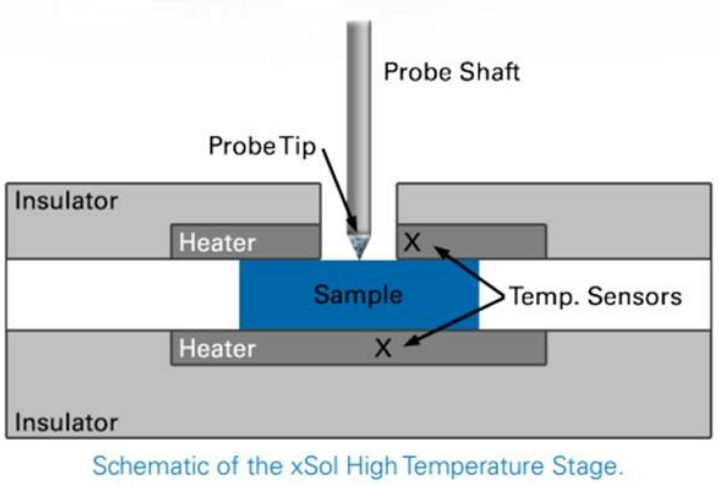


10～40μm for each layers

Experiment

Equipment





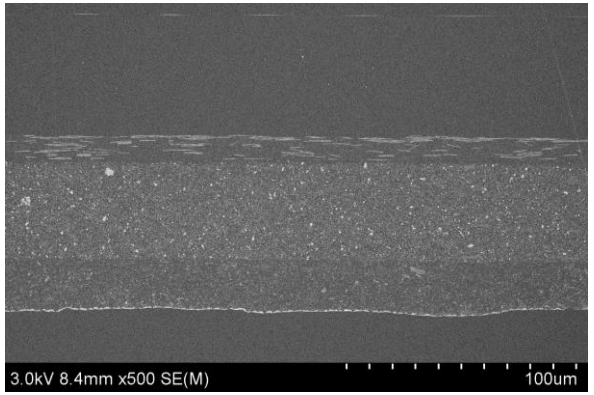
Schematic of the xSol High Temperature Stage.

Buruker TI-premier
with X-sol stage

Sample

Multi-layer coating films
for automotive

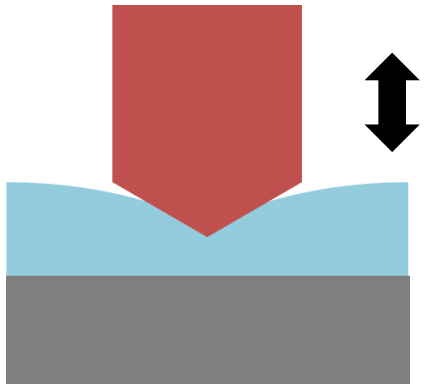
Preparing of cross-section
- Machine polishing
- Cross-section polisher



(SEM-image)

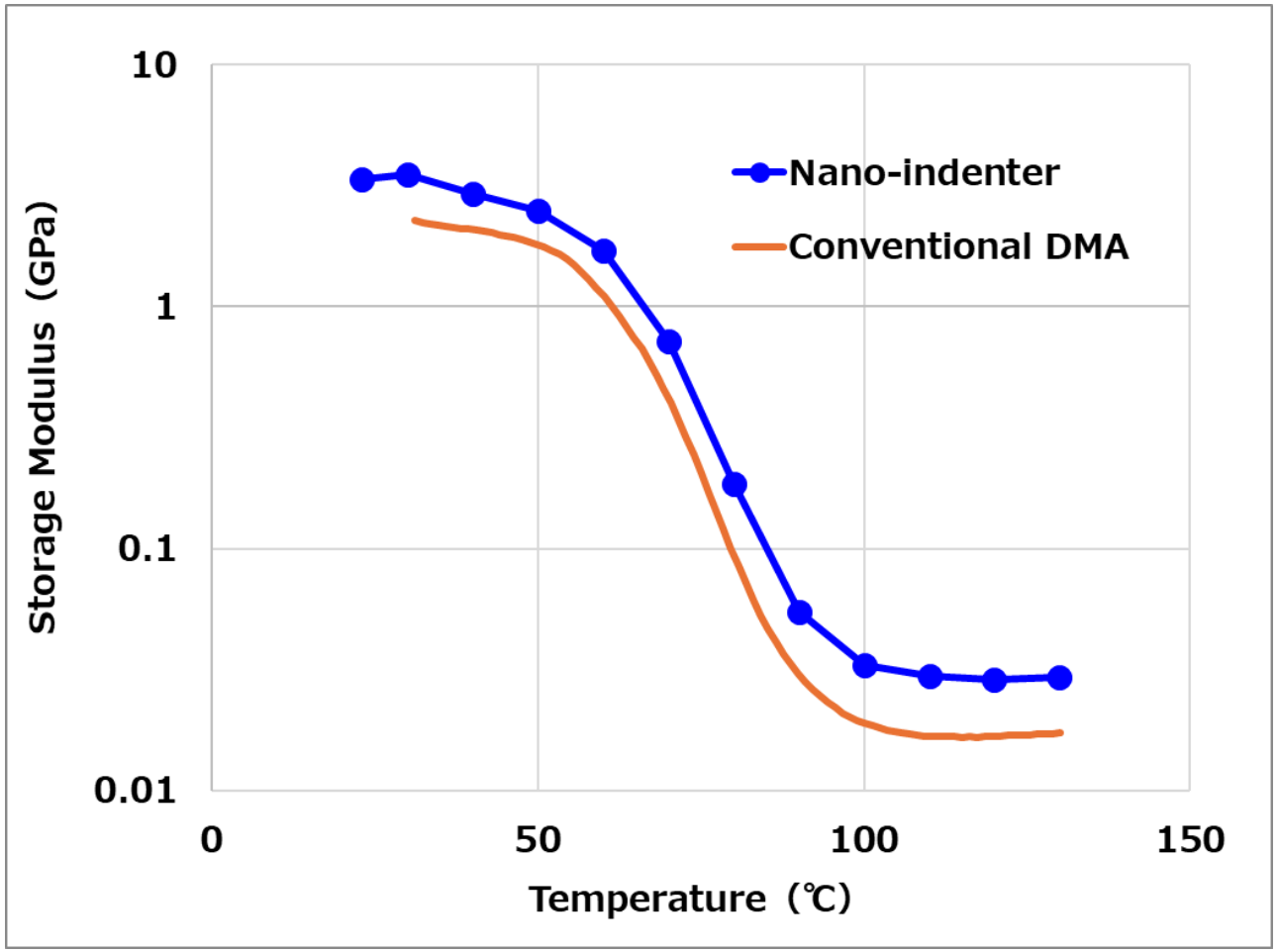
The Comparison Between Nano-Indenter and Conventional DMA, E’

Nano-indenter

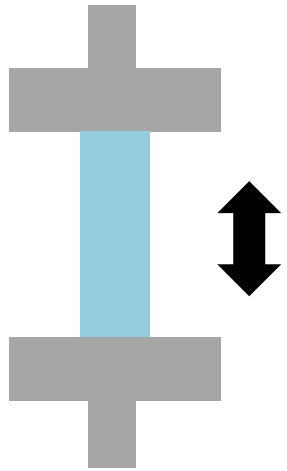


2-3hours

Frequency : 10Hz
Temperature:
23℃-130℃



Conventional DMA



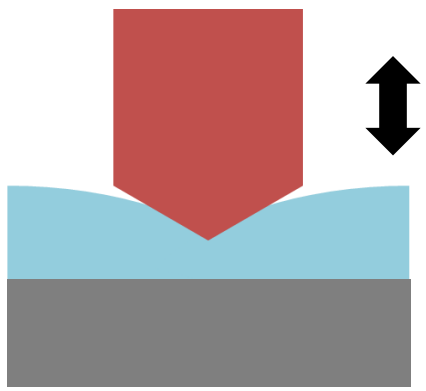
30-40minutes

Frequency : 10Hz
Temperature:
40℃-130℃

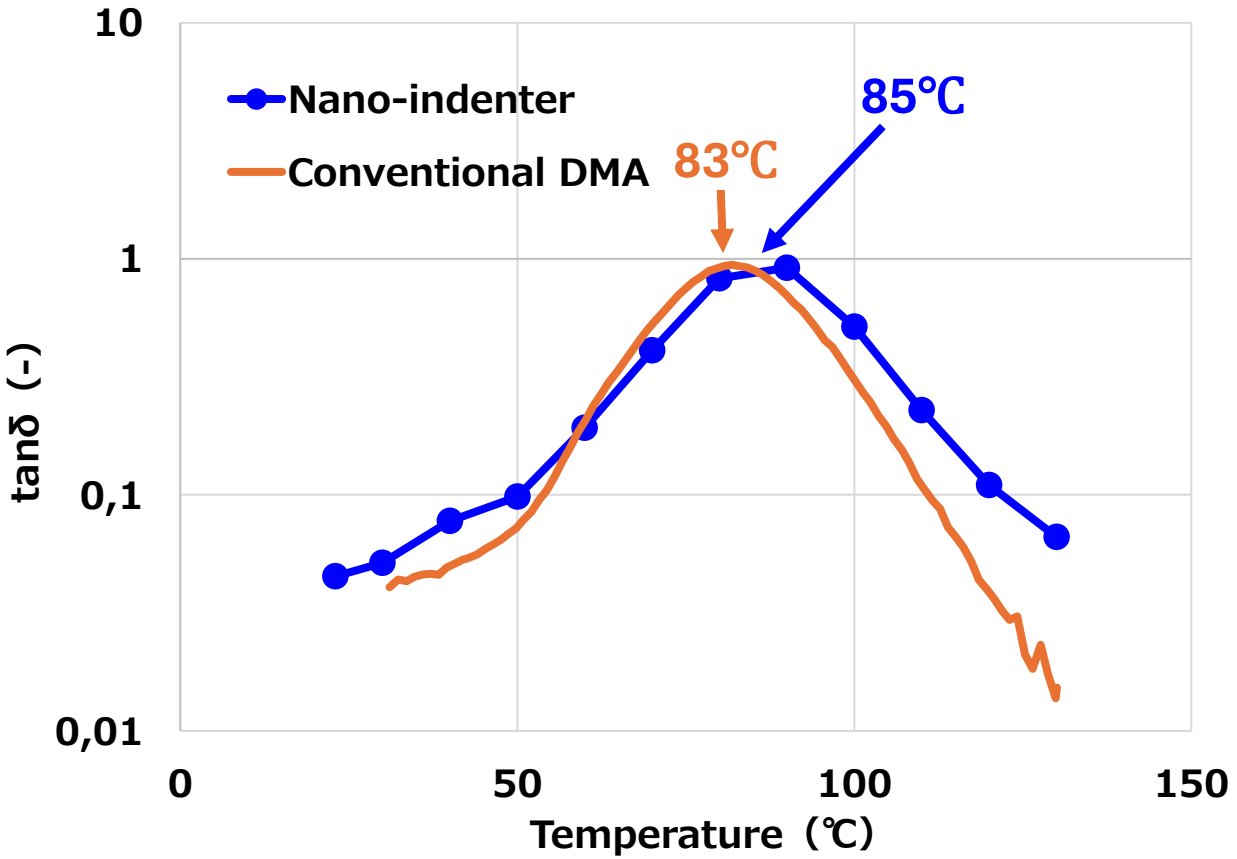
The Comparison Between Nano-Indenter and Conventional DMA, tanδ

Tanδ of Clear Coat Film

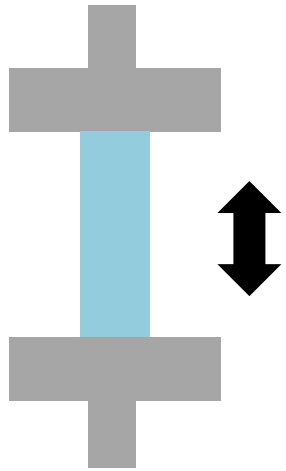
Nano-indenter



Frequency : 10Hz
Temperature:
23℃-130℃



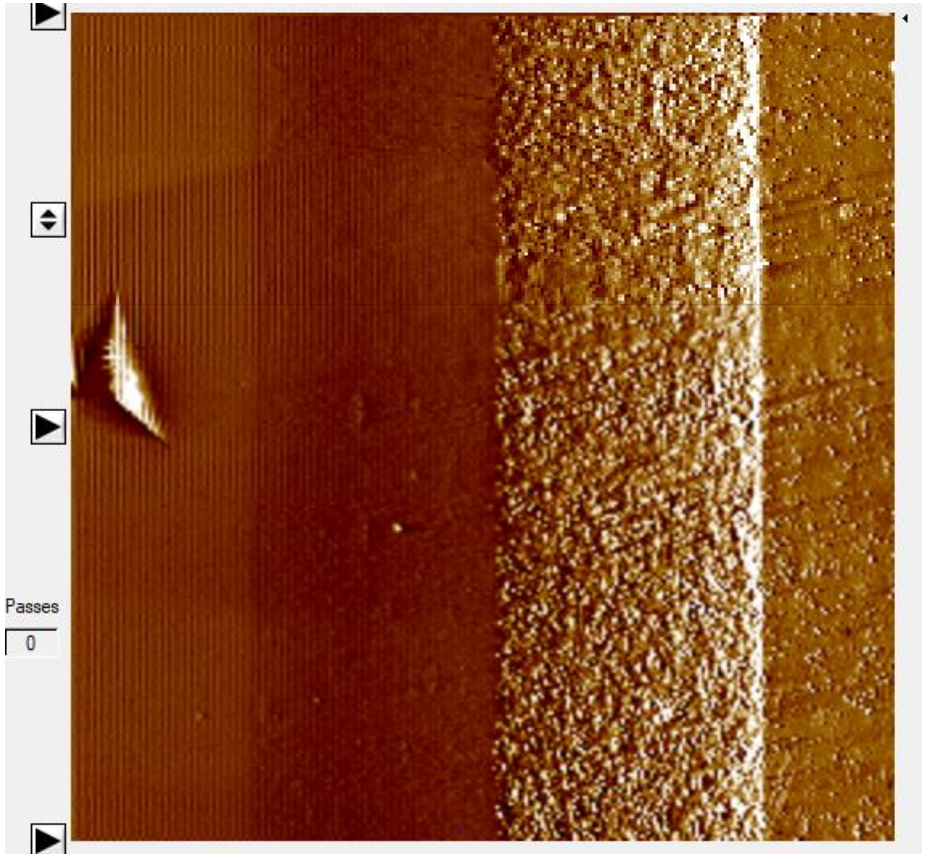
Conventional DMA



Frequency : 10Hz
Temperature:
23℃-130℃

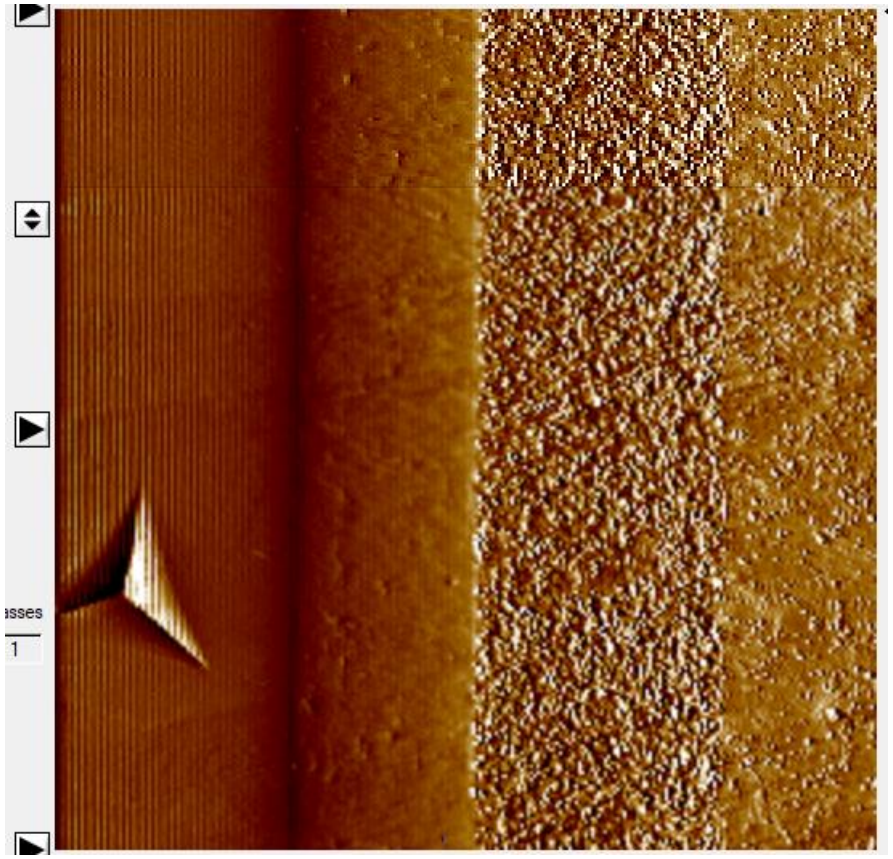
DMA of Multi-Layer Film : SPM Images of Cross Section

Streamlined Process (3Coat1Bake)



CC BC Pr ED

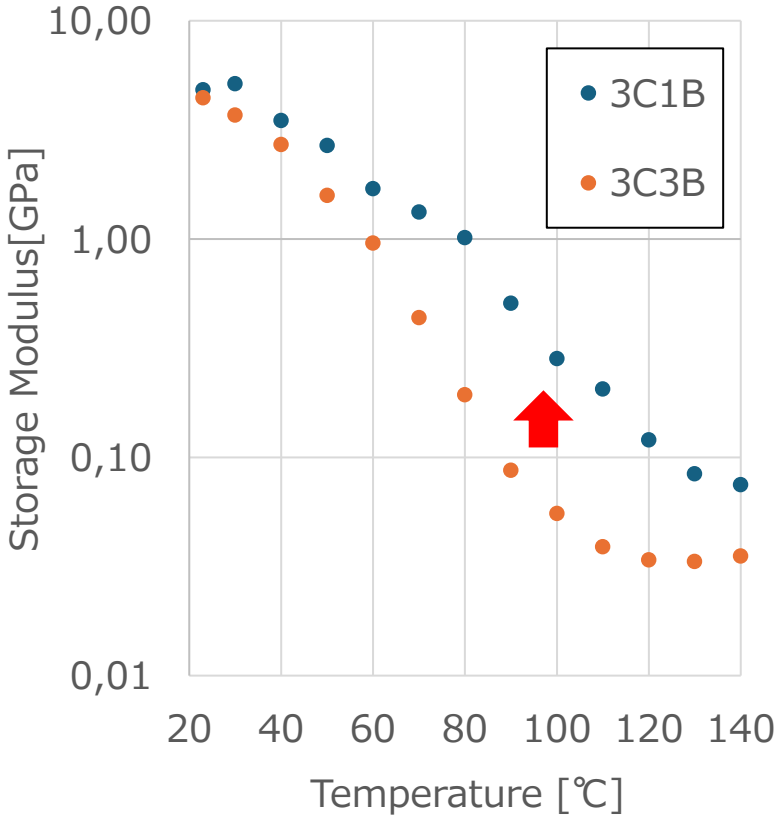
Conventional Process (3Coat3Bake)



CC BC Pr ED

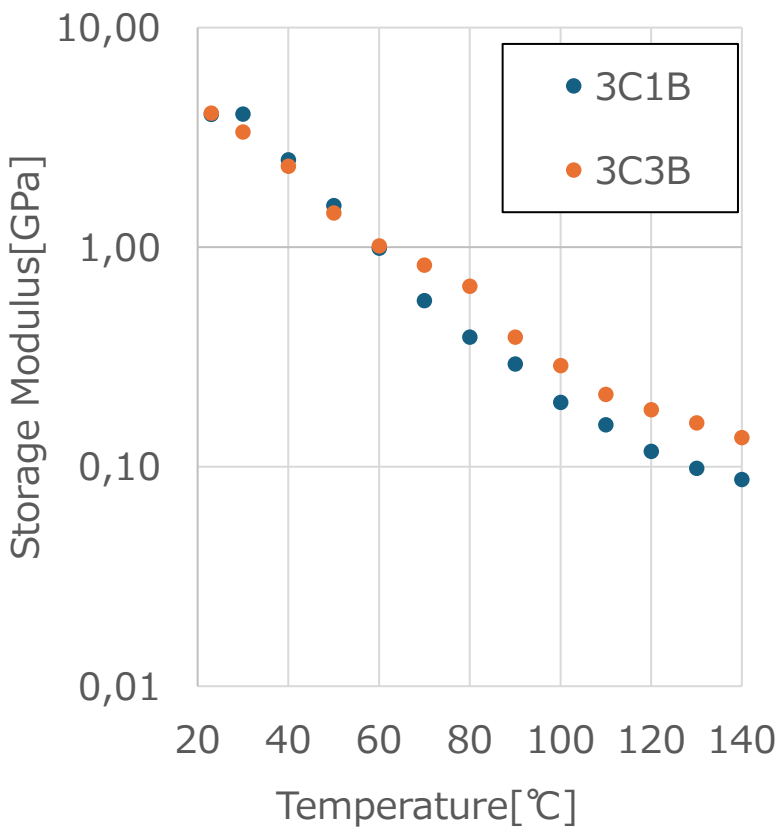
DMA of Multi-Layer Film : Storage Modulus

Clear Coat (1K)

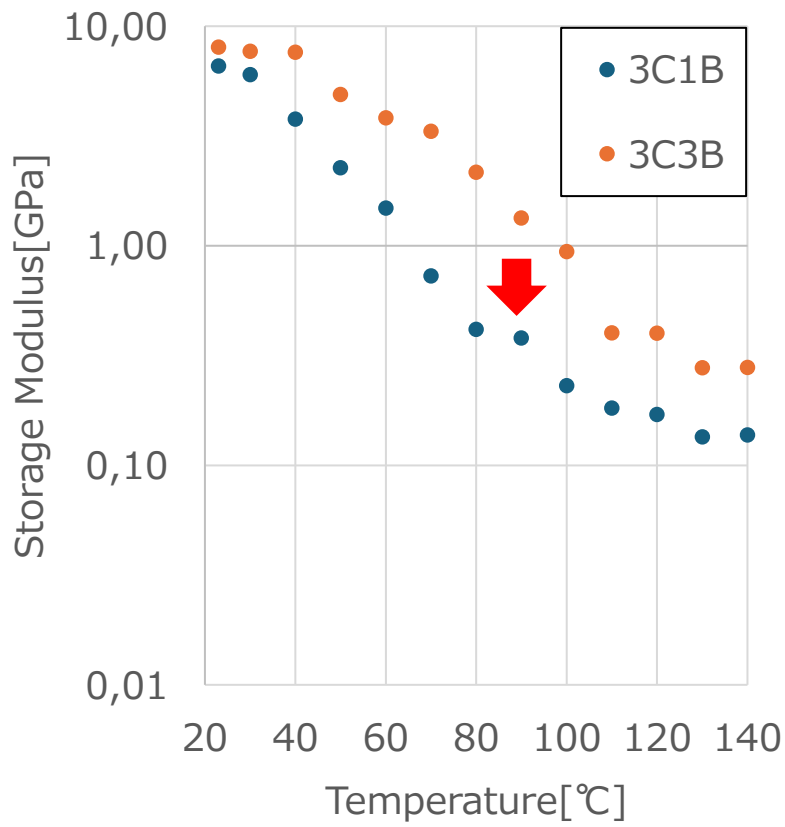


Harder than 3C3B Process

Base Coat



Primer



Softer than 3C3B Process

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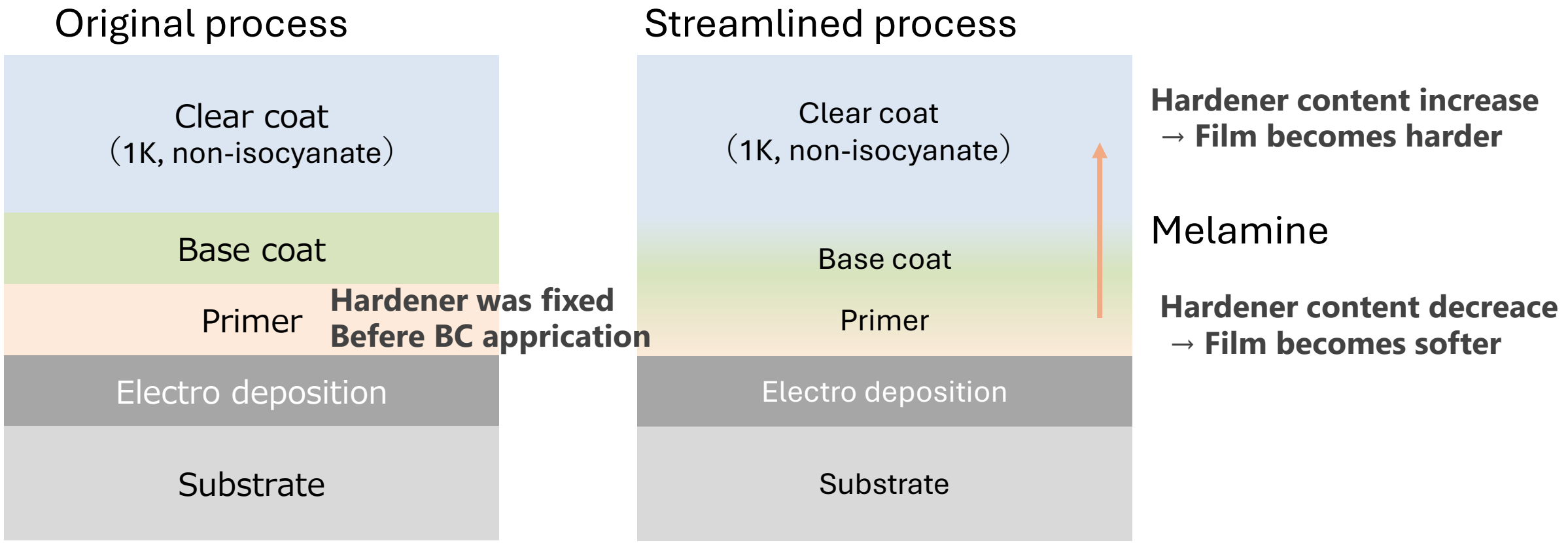
DMA of Multi-Layer Film : Migration of Melamine

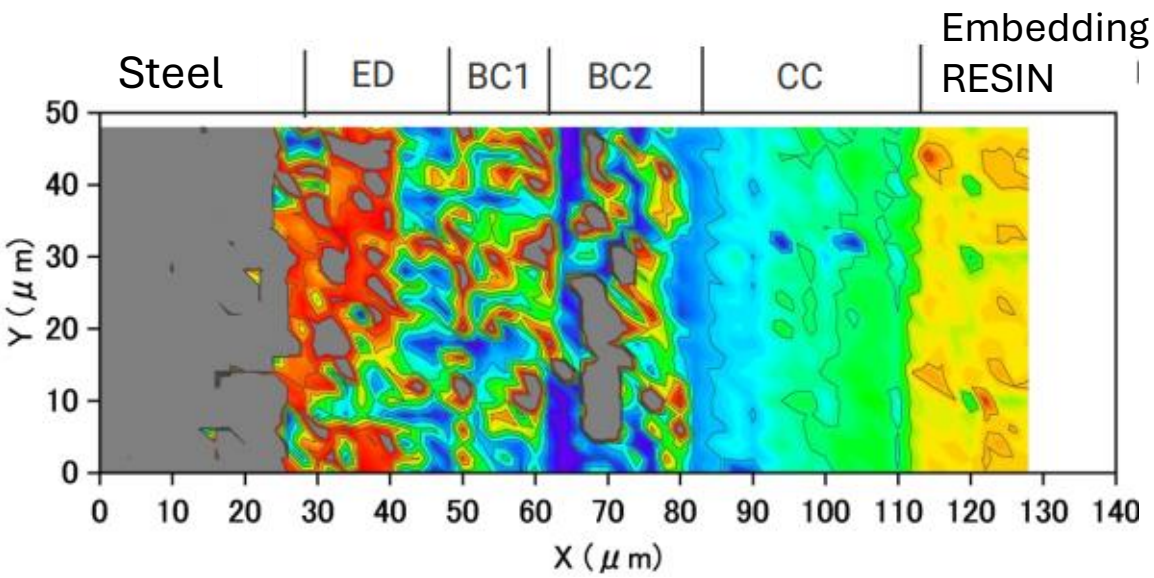


Streaming-lined process should be designed with consideration of these facts.

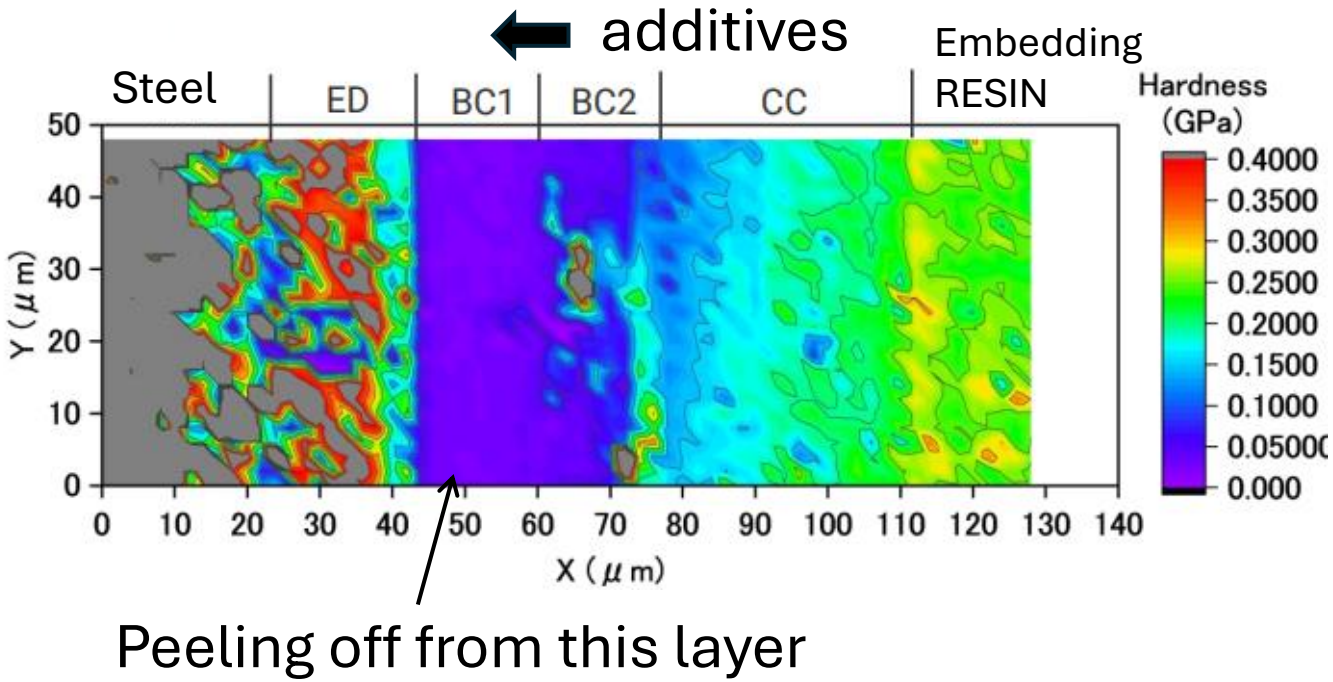
Analysis for Adhesion Mechanism

Hardness mapping with XPM

Good Adhesion Sample



Poor Adhesion Sample



Additives present in BC2 inhibited the curing reaction.

This analysis also could not have been achieved without this new method.

Summary

Novel viscoelastic measurement techniques using a nano-indenter

Advantage Over Conventional Method:

- DMA Measurement without removing from the substrate
- Analysis of under layers in multilayer coatings from the cross-section.

Applications :

- Streamlined Processes : migration of hardener was suggested
- Adhesion Analysis : Prevention of curing by additives was identified

This method provides a lot of valuable information for development of coatings and will be widely used in the paint industry in the future.