FPM-Trinity

Introduction of advanced all-in-one machine for AME + SMT

FUJI

J.A.M.E.S

Ryojiro Tominaga
Section manager
Development center
Fuji Corporation

FUJI innovative spirit

About Fuji Corporation

FPM-Trinity

Electronic component mounters

Solder printing machines

Robotic Solutions Division

FUJI robots lead the way

Machine tools

(CNC lathes, multi-task machine,

dedicated machines)

Machine Tools Division

New Business Development

Compact multijoint robots

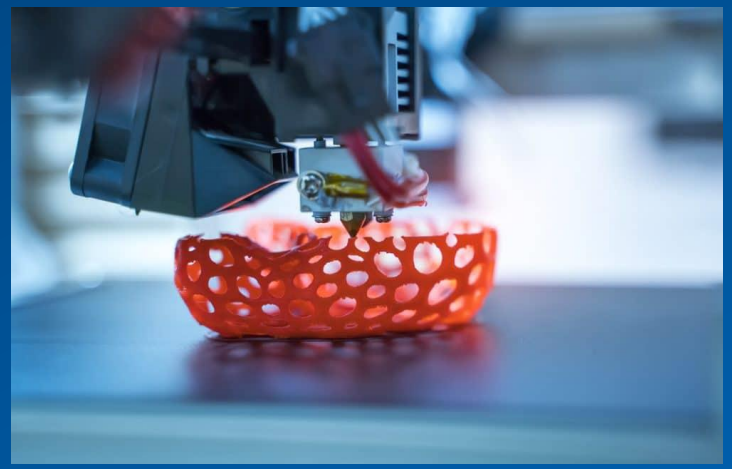
Atmospheric pressure plasma units

Mobility support robots

Public stocker system

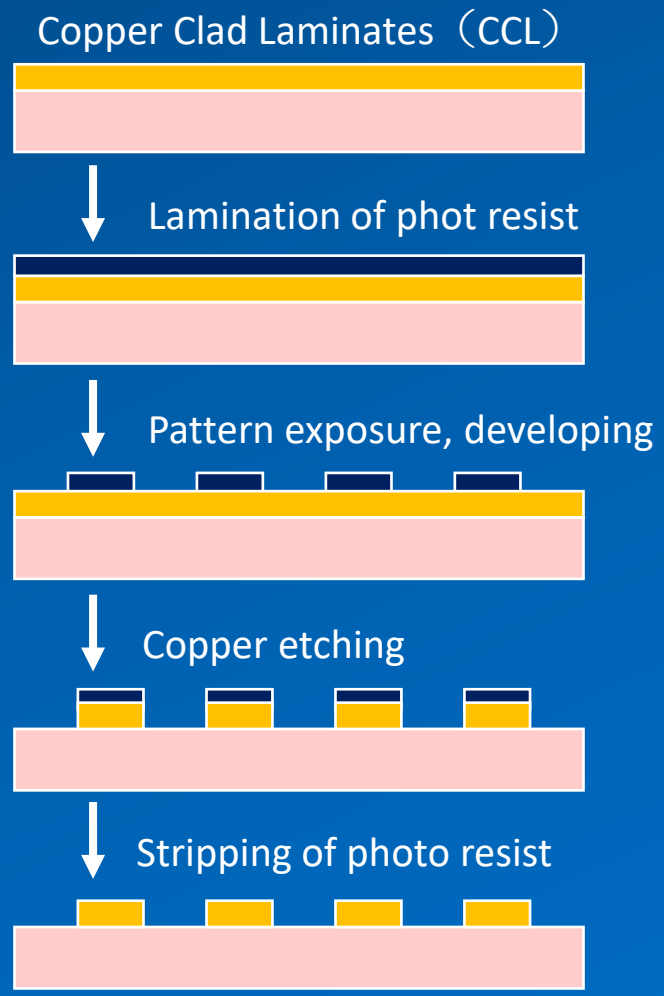
What’s the AME?

Additively Manufactured Electronics (AME)

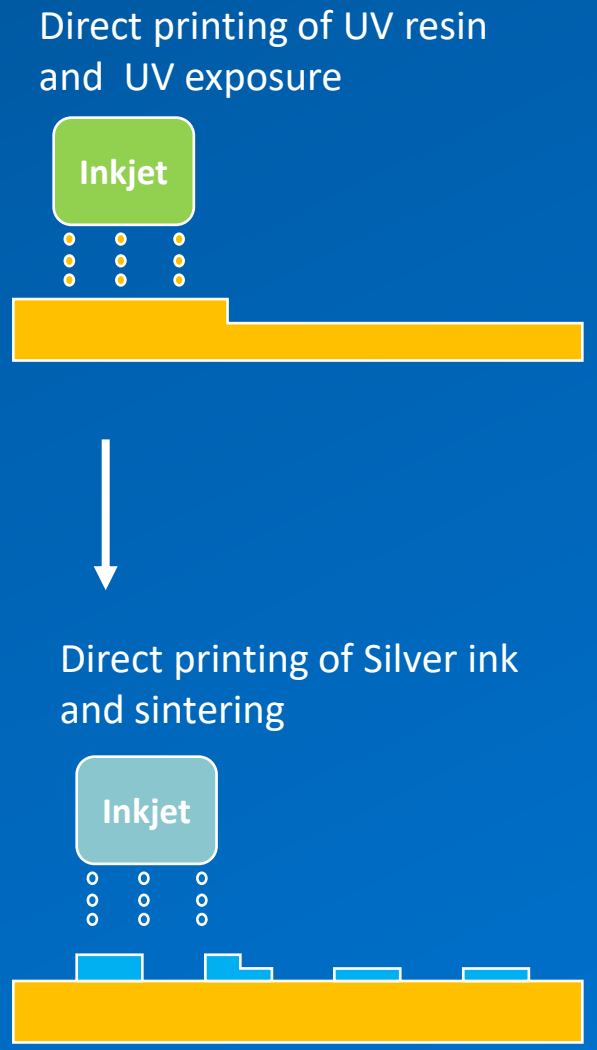


Additive manufacturing is selective direct deposition

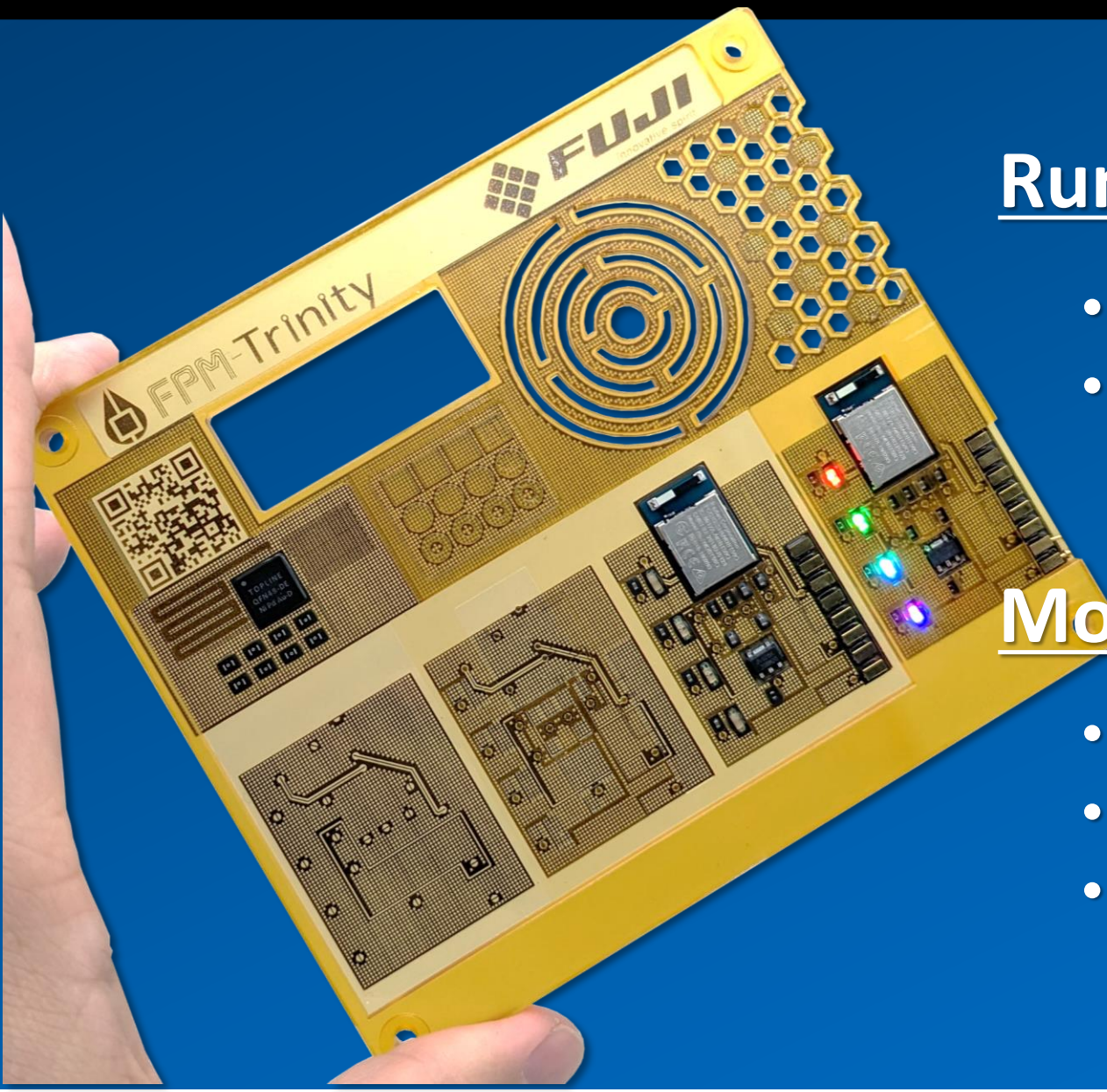
PCB（Subtract）



Additive Electronics



What's the benefit AME can offer?



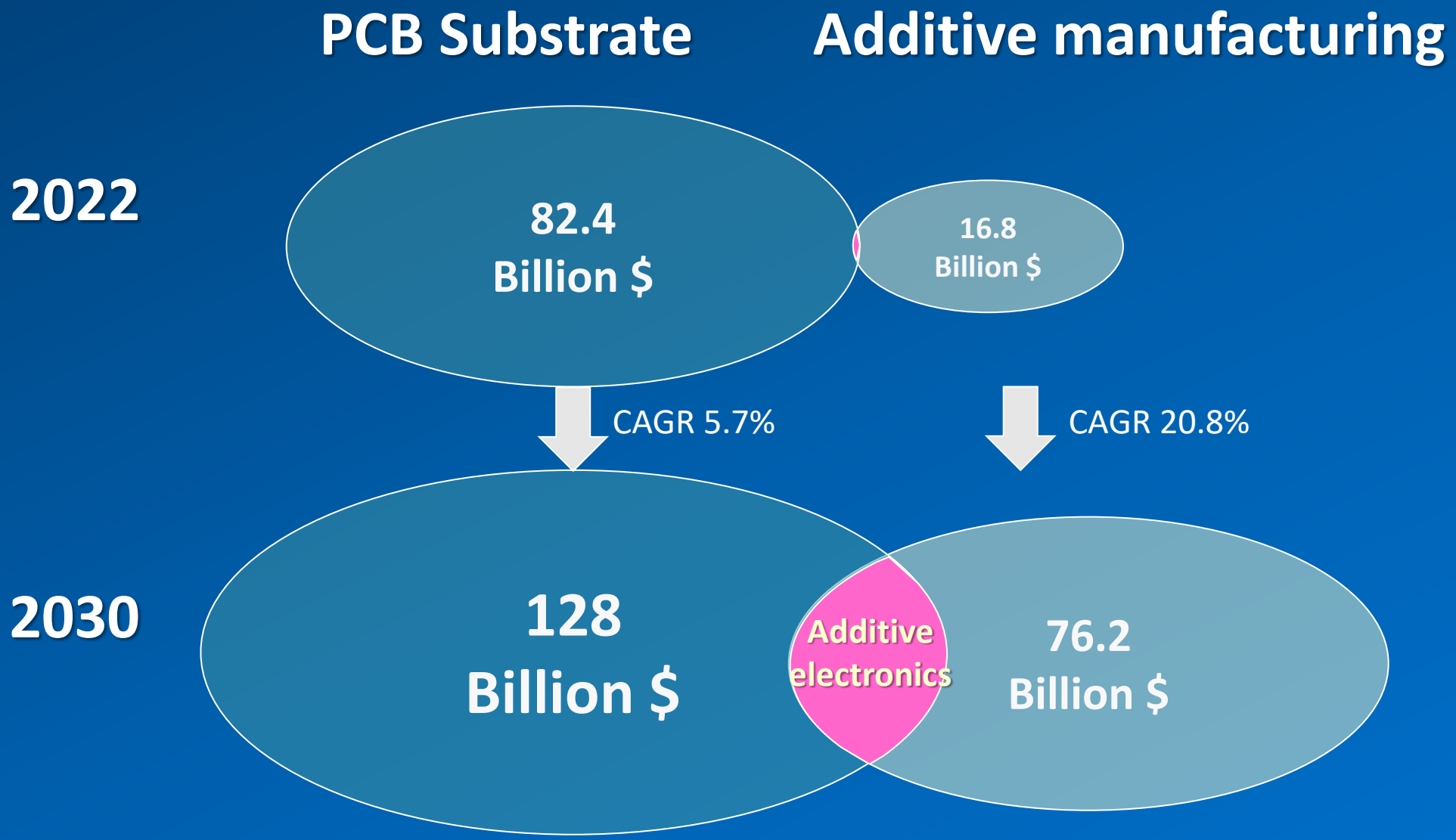
Run fast!

- No initial tool cost required
- Within 1 day manufacturing

More efficient!

- Minimum waste of material and liquid
- Small factory
- 3D free shape electronics

Forecasting the global market size

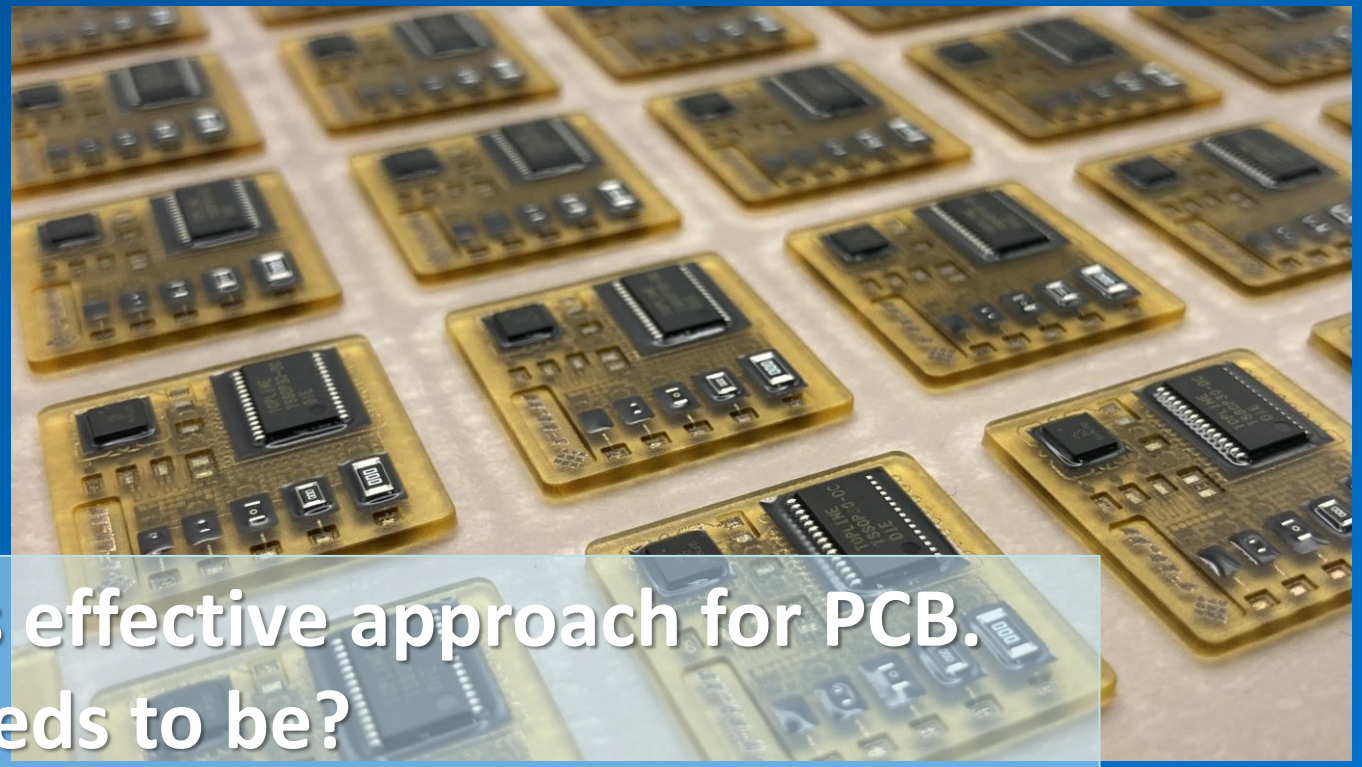


How the SMT needs to be?

Today’s scope

FPM-Trinity

AME + SMT



We’re believing AME is effective approach for PCB.
Then, how the SMT needs to be?

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Inconsistency of SMT against AME

FPM-Trinity

Drastic changes required

- Temperature and material → Low temperature process
- Screen printing → Direct deposition process
- Line production → Cell production

	Common SMT	Common PCB	Cons. for AME
Interconnect	Solder material	• Surface finish ex. ENIG / OSP, • IMC formation	• Conductive is Ag • ENIG and OSP not available
	Solder printing	• Screen mask printing	• Printing capability on 3D surface
Thermal condition	220-260 deg.C of reflow	• Low CTE prepreg material with glass • Low dynamic warpage during thermal process	• Much higher CTE • Swelling and warpage
Production line	Operation ratio and capacity	• Compatibility of material and conditions	• Material mixing with common PCB products • Line contamination

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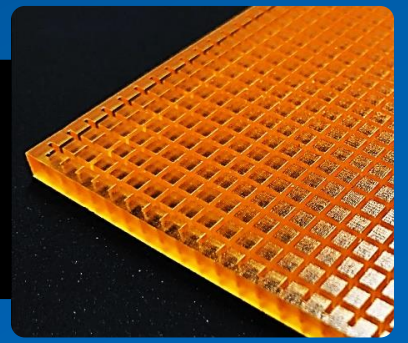
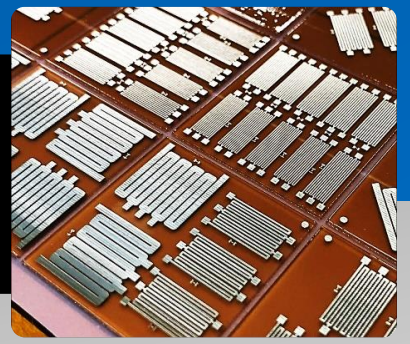
Our machine and the vision

About FPM-Trinity

Resin 3D printing



Circuit formation



Low temp. SMT

Data import

- Gerber and STL

JOB Edit

- Panel layout
- Optimized process parameter

Machine configuration

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AME + SMT

Parts placement
- Parts mounting head
- Vision system

Parts supply
- Alternative unit for feeder and tray

Inkjet heads and maintenance
- UV resin ink
- Ag nano ink

Post printing process
- IR Heater
- UV exposure

Air dispensers and calibration
- Ag paste for parts mount
- Epoxy paste as Underfill

Post parts placement process
- Press heater

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Hybrid machine and process of AME + SMT

Traditional PCB vs FPM-Trinity

FPM-Trinity has significant advantages for “Delivery”, “Sustainability” and “Design”.

		Traditional PCB factory	FPM-Trinity	Comparison
Productivity	Capacity	> 30,000 m^2/Month	**0.3 m^2/Month**	--
Quality	Line / Space	< 100/100um	**140/200um**	-
	SMT	0.4mm pitch Full array	**0.5mm pitch Peripheral**	-
	Temp. cycle test	>1000 cycles (IPC TC3)	**~100 cycles (IPC TC3)**	-
Delivery	LT (PCB +SMT)	>>1 week	**1 day**	++
	Initial tooling	Required	**Not required**	++
Sustainability	Waste / m^2	100	**5**	++
	Factory size	> 20,000 m^2	**20 m^2**	++
Design	Shape	2D	**3D and 2D**	++
	Light weight	1.5~2.0 g/cm^3	**1.2 g/cm^3**	+

Specifications (Design Rule as of today)

FPM-Trinity

	Parameter	Design rule	
Circuit formation	Conductive material	Silver ink	
	Standard thickness	4 or 7	um
	Min. L/S	140 / 200	um
Resin formation	Max resin build size	120 x 120	mm
	Max resin build thickness	4	mm
	Size of print bed	120 x 120	mm
Layer to layer connection	Max layer count	5	layers
	L to L connection	Blind via hole	
Part mounting	Conductive material	Silver paste	
	Min. electrode pitch (Peripheral)	0.5	mm
	Min. part size	0.6 x 0.3	mm

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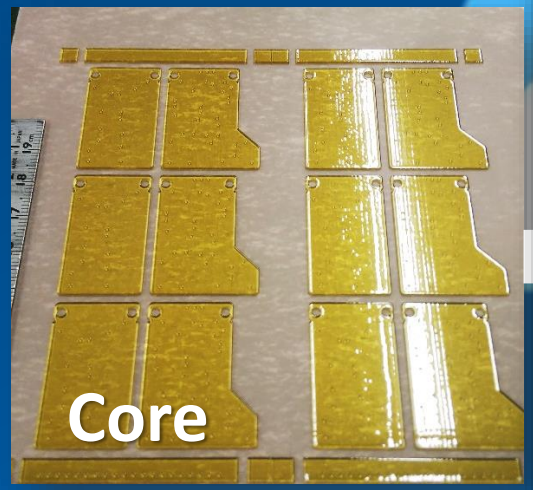
1 day manufacturing

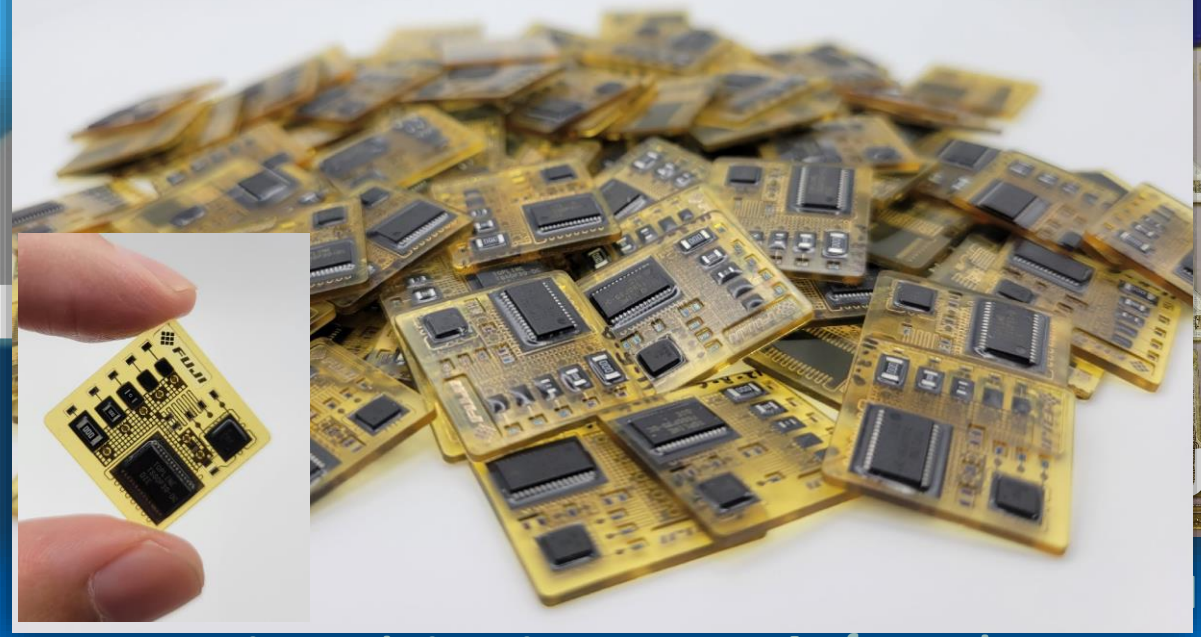
FPM-Trinity

Standard verification samples made “in one day”



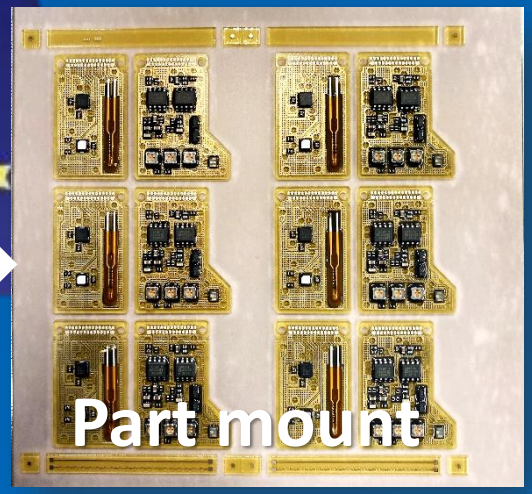
Core

- Resin ink printing
- UV exposure



- Drying and Sintering

Ag formation



Part mount

- Ag paste bump printing
- Part pick & placement
- Underfill epoxy printing
- Press curing

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Direct data import

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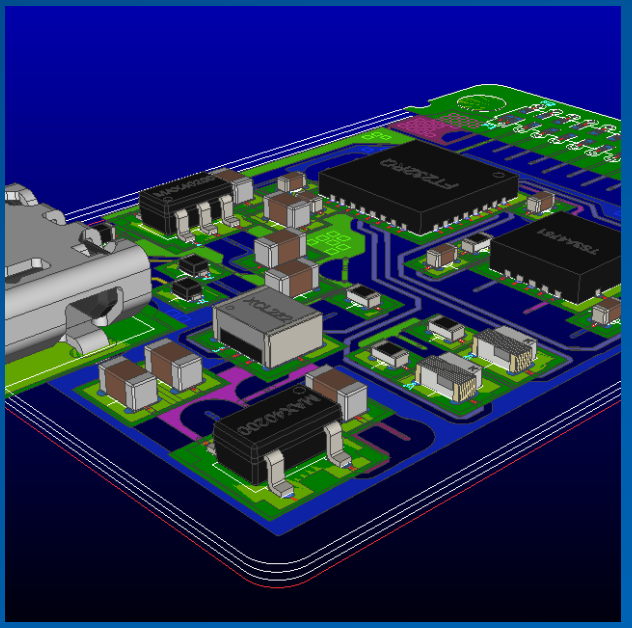
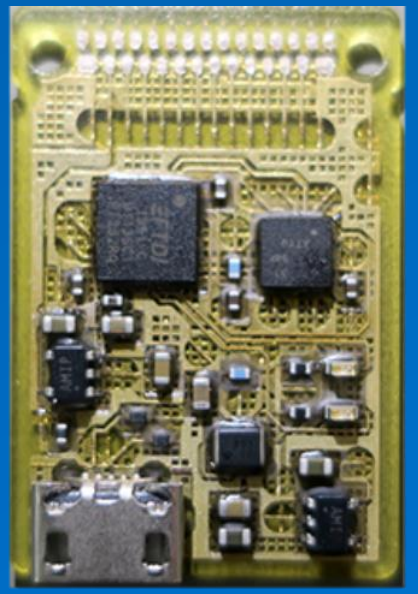
Direct data import from circuit CAD.
Automatic conversion to printing image data and printing program.



Design Data	Printing image and Program	Printing Material	Printing Method
STL Gerber	Resin formation	UV ink	Inkjet
STL Gerber	Circuit formation	Silver ink	Inkjet
Gerber BOM	Part mounting	Conductive Non-conductive paste	Air dispensers



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Minimize chemical waste

FPM-Trinity

Depositing materials directly means that no wet processing or etching are required, and waste is reduced by more than 95% compared to conventional PCB manufacturing.

SMT process

Inconsistency of SMT against AME

FPM-Trinity

Drastic changes required

- Temperature and material → Low temperature process
- Screen printing → Direct deposition process
- Line production → Cell production

	SMT of FPM-Trinity	Common PCB	Cons. for AME
Interconnect	Solder material Low temp. Ag paste	• Surface finish ex. ENIG / OSP, • IMC formation	• Conductive is Ag • ENIG and OSP not available
	Solder printing Direct dispensing	• Screen mask printing	• Printing capability on 3D surface
Thermal condition	220-260 deg.C of reflow 80 deg.C!	• Low CTE prepreg material with glass • Low dynamic warpage during thermal process	• Much higher CTE • Swelling and warpage
Production line	Operation ratio and capacity Cell production	• Compatibility of material and conditions	• Material mixing with common PCB products • Line contamination

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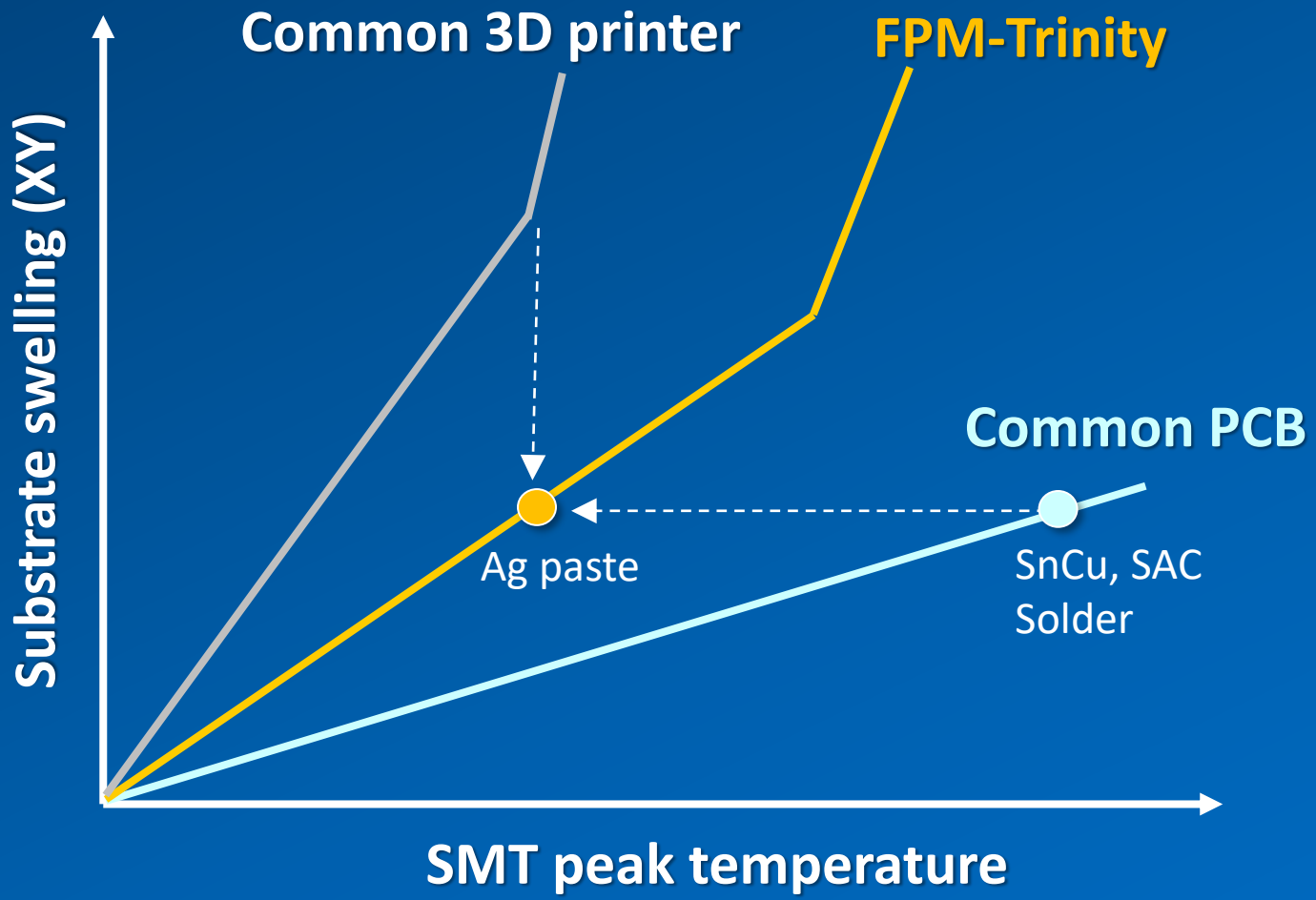
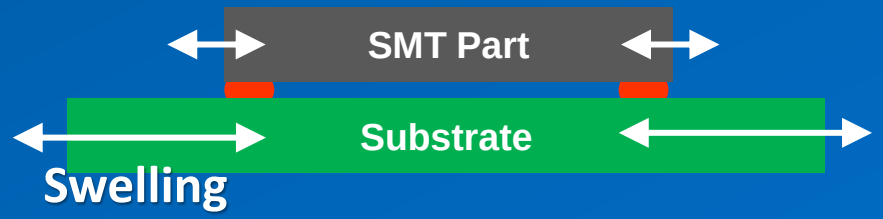
Why is low temperature SMT needed?





Ultra low temperature SMT process

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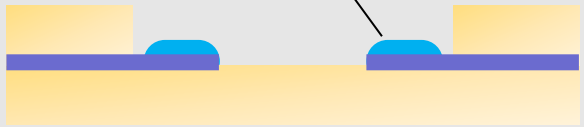
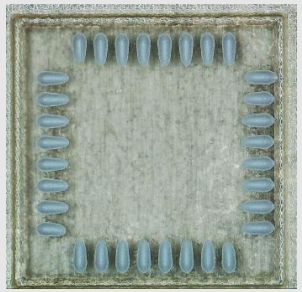
1. Ag paste dispense + Thermal curing

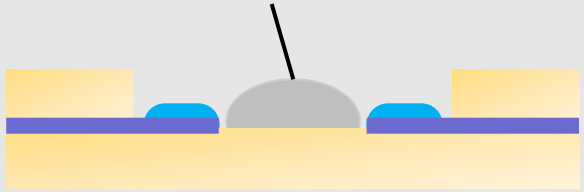
Low modulus
Low temp. curing

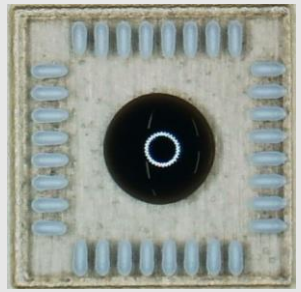




2. Under fill dispense

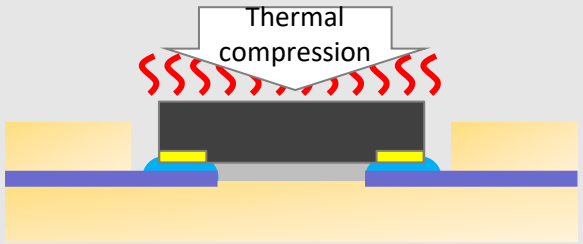
Optimized volume for each
SMT parts

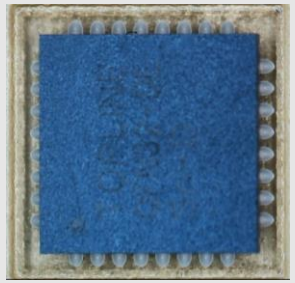




3. Parts mount and thermal compression

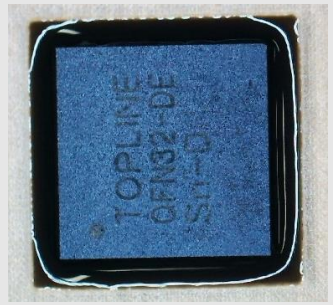
Low temp. curing
Enough compression





4. Side fill dispense and curing

Low temp. curing
Covering to avoid corrosion



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Contribution of Low modulus Ag paste

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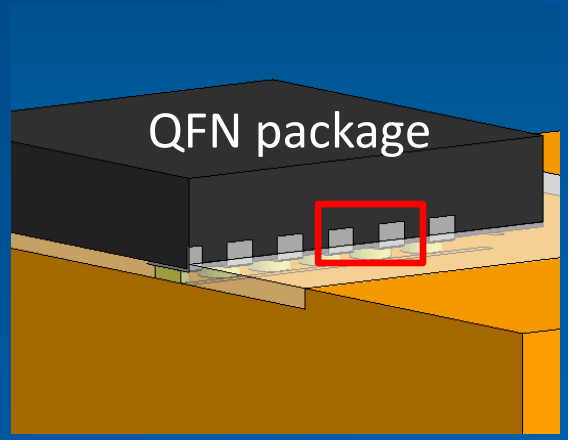
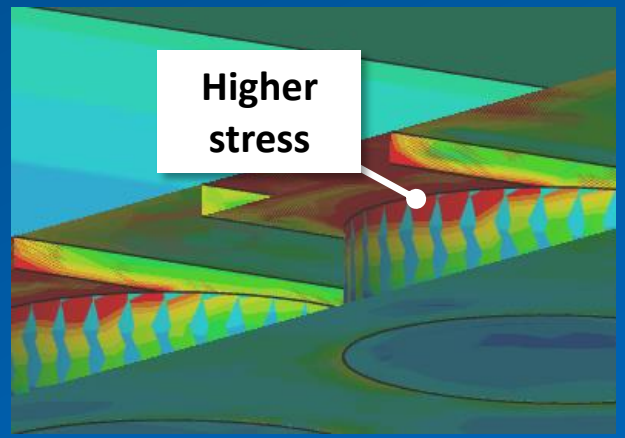
Low modulus Ag paste makes SMT stress lower !

CAE assumption

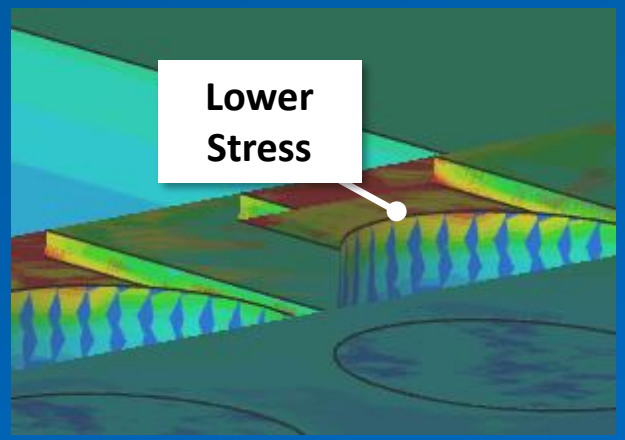
- 80deg.C → 25deg.C
- 7mmsq 44pins QFN
- w/ UF material

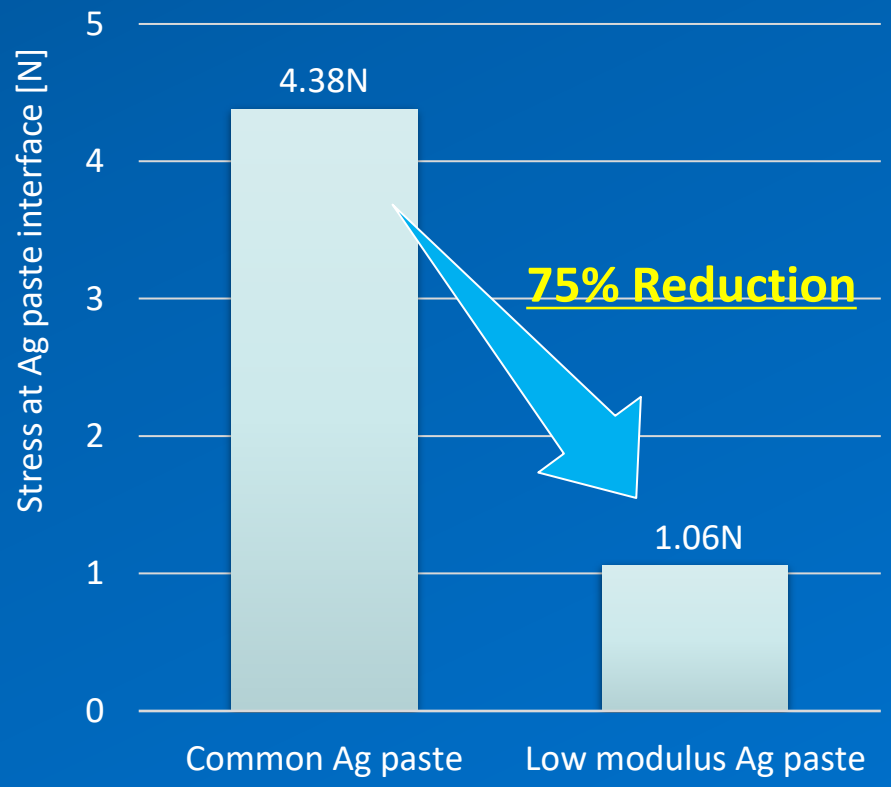


Common Ag paste



Low modulus Ag paste





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Effectiveness of compression bonding

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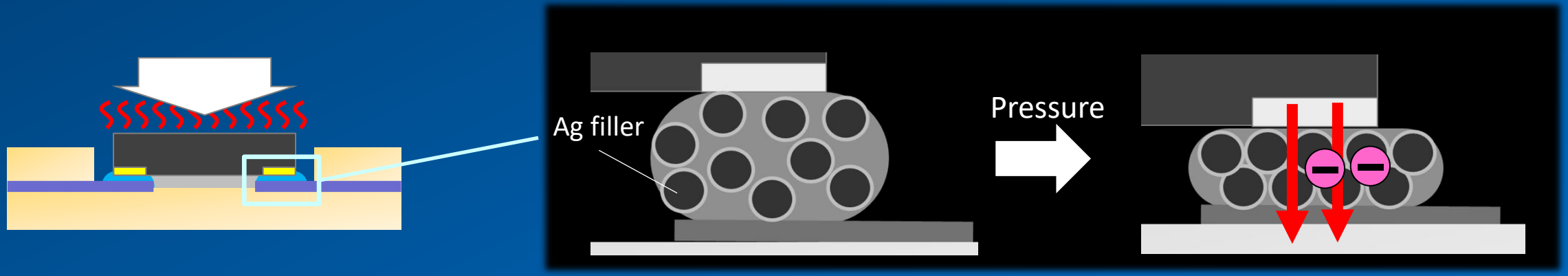
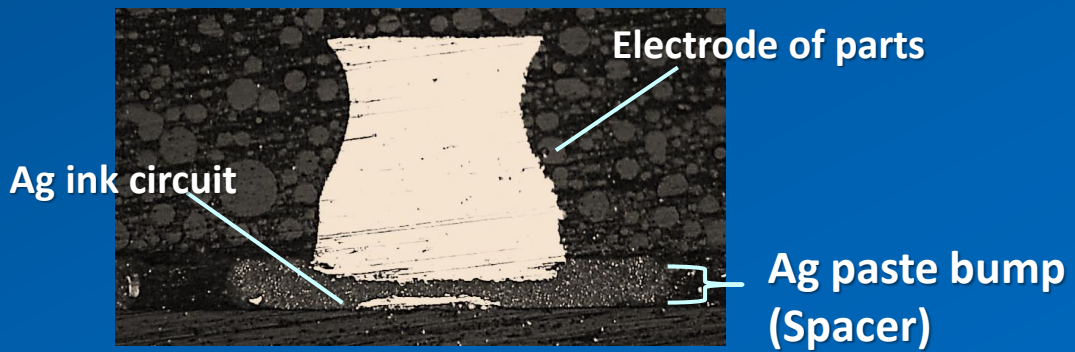
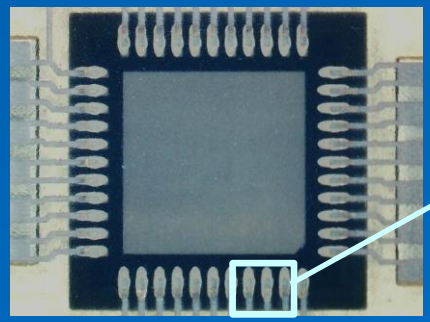
Thermal compression leads stable conductivity for Ag paste bump



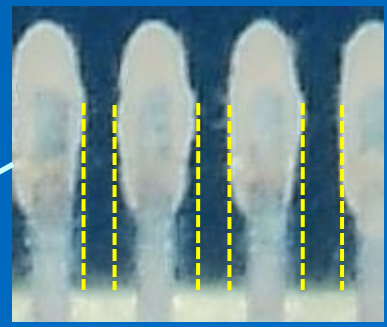
Post-cured Ag paste behaves as spacer



Post-cured Ag paste works for gap controlling



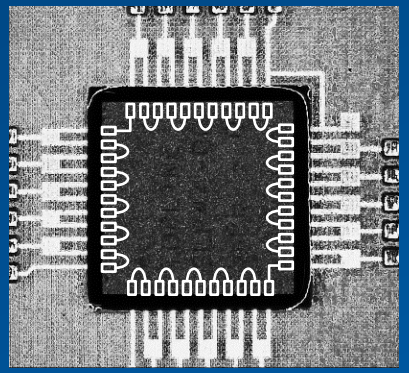
Back side view



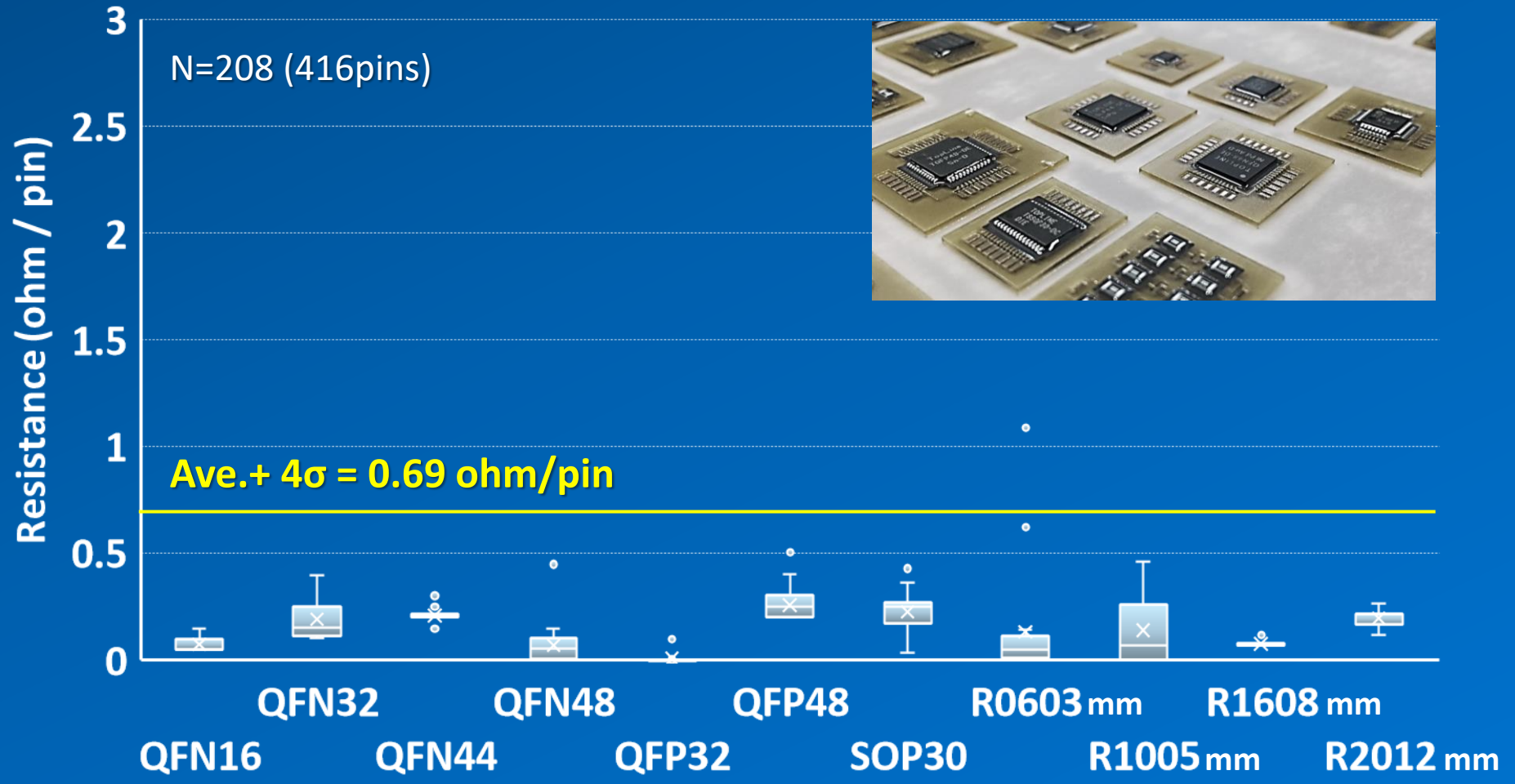
Gap between bumps

Capability of low temperature SMT process

Mixing test result with several type and size of SMT parts



Daisy chain dummy IC



AME process

Materials

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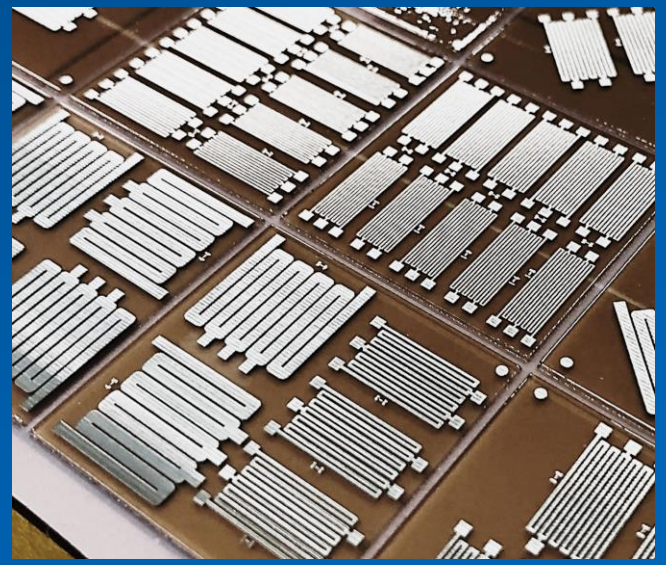
High performance UV ink for CTE and Tg.
Low temperature sintering property of Ag ink.

UV resin ink

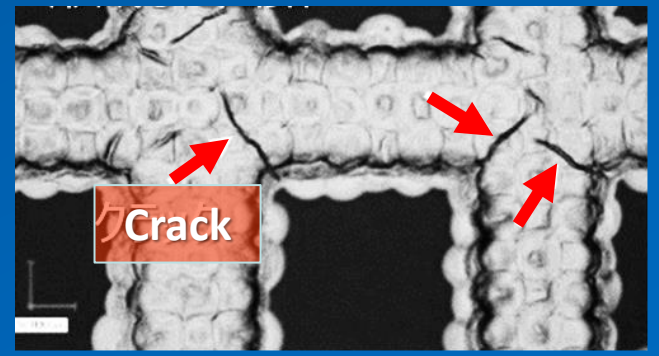
CTE α1 = 56ppm
Tg = 161 deg.C
Dielectric constant = 2.8
Tan δ = 0.017

Ag ink

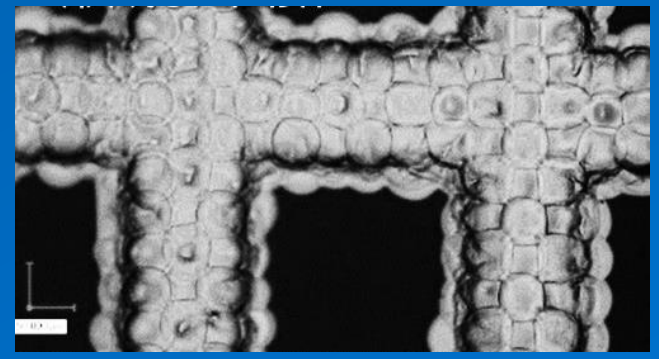


Electrical resistivity = 7μΩ cm
Sintering temp. = 120 deg.C

Ag trace on common 3D printer



Ag trace on FPM-Trinity UV resin



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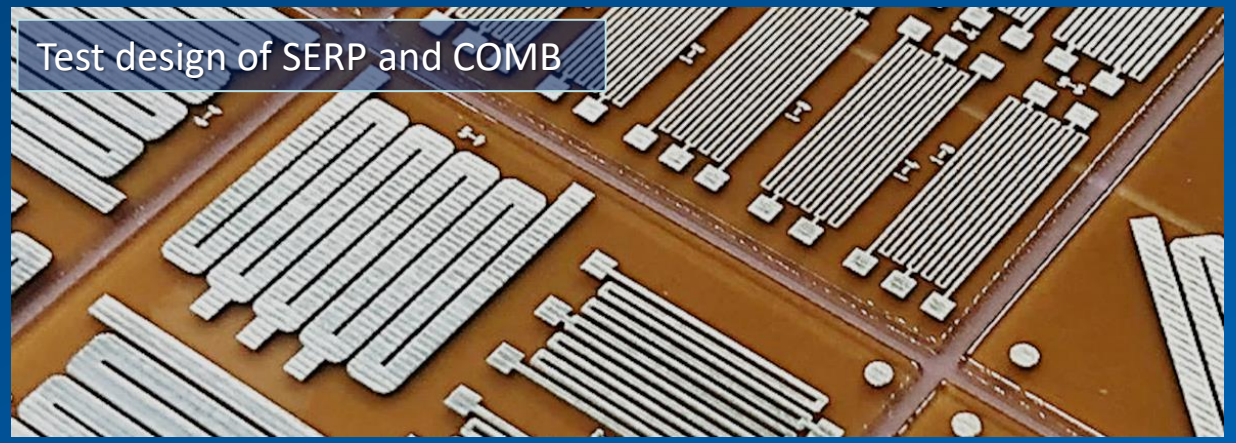
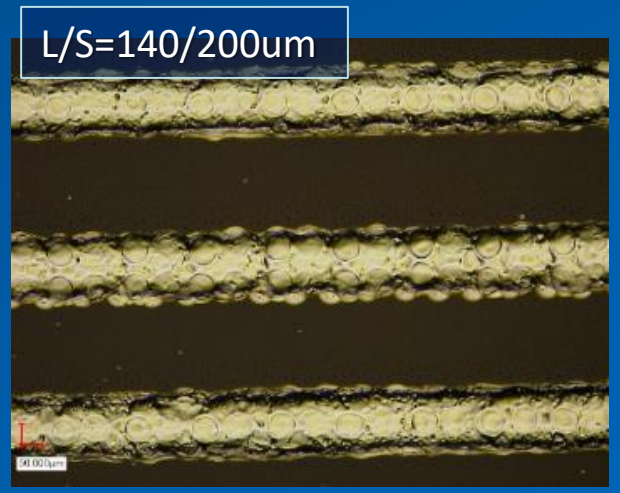
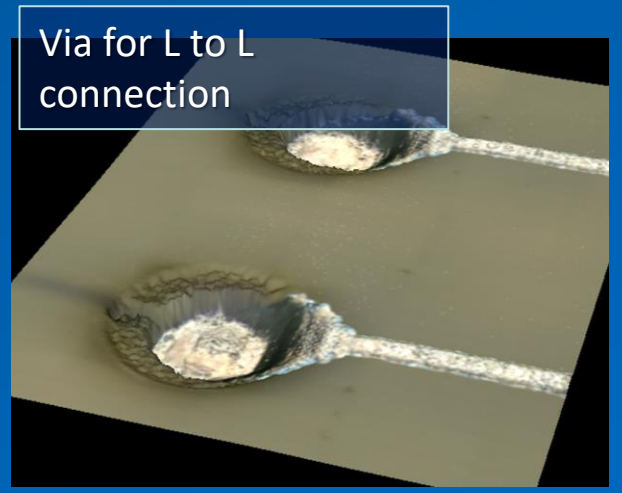
Conductive circuit formation capability

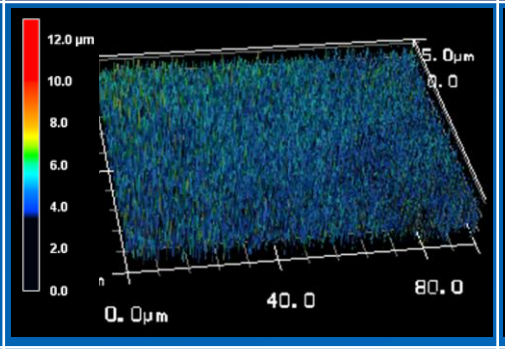
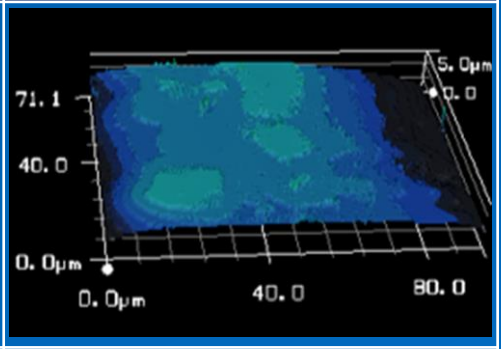
FPM-Trinity

L/S=140/200um is capable with low variation minimizing particle spreading.
Low surface roughness can contribute low loss of high frequency application.







	PCB Cu foil (Furukawa F2-WS)	AME circuit (FUJI FPM-Trinity)
Surface morphology		
Ra	1.01µm	0.26µm
Rq	1.42µm	0.29µm
Rz	8.2µm	1.6µm

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AME + SMT
Applications

Value of AME

FPM-Trinity

AME + SMT

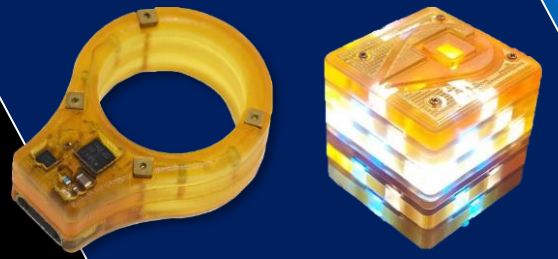
Build up substrate

Value of time

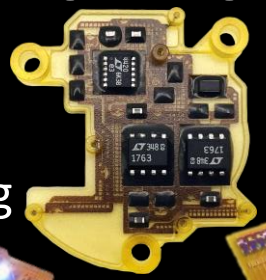
Rapid PoC

Value of design

3D device



Light weight



Easy assembling

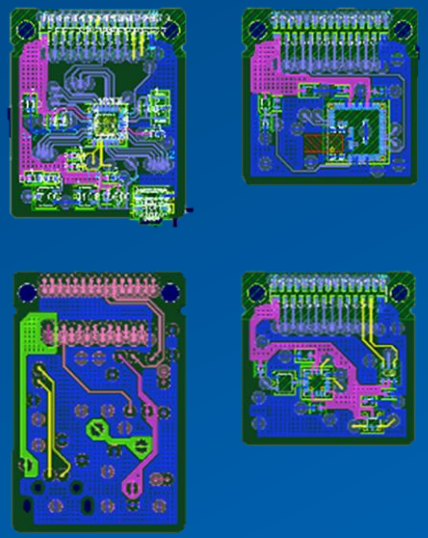
Bendable

Parts above Parts

Rapid PoC for IoT device

Designing

8 to 20hrs for each

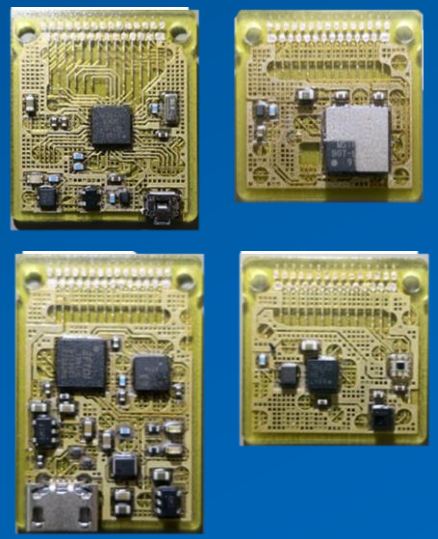


Design Force

STL import

Printing + SMT

42 hrs at R&D machine (Actual)
16 hrs at Developing machine (Target)



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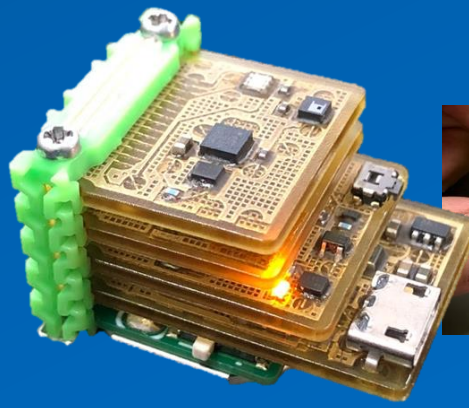
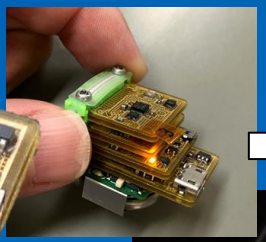
Assembling

Data writing and validation



- Micro computer
- Bluetooth
- Battery control
- Sensors (I2C)

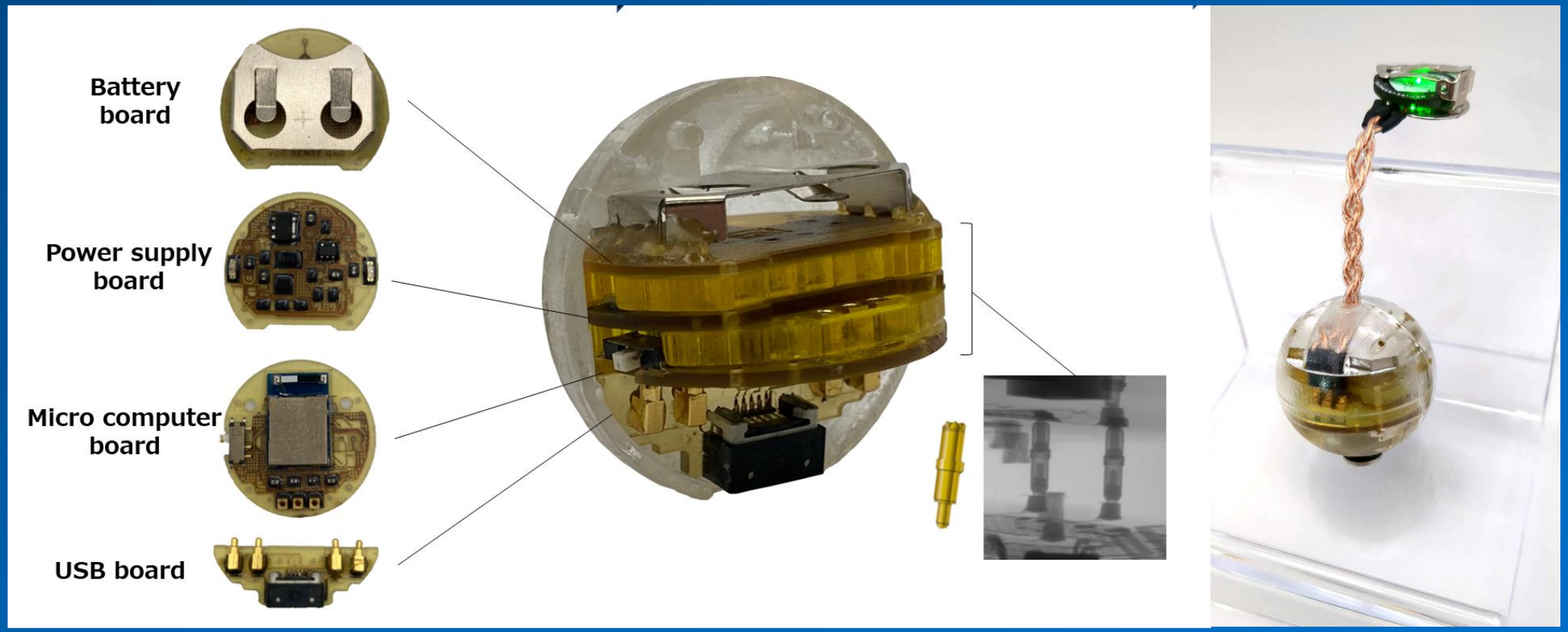


Connect to iOS

Enabling of 3D unique device

e-lamp.
Put on the light of heart.

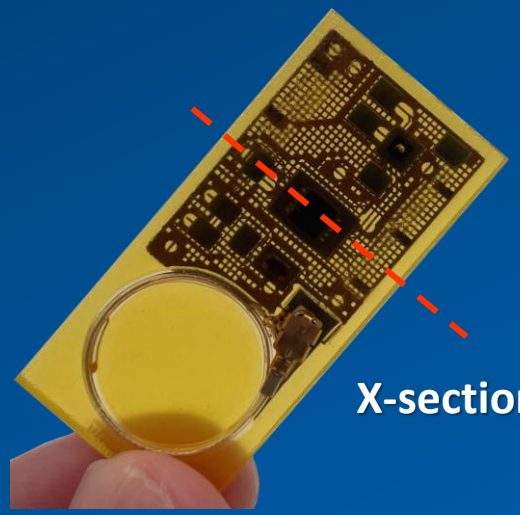
Heartbeat illuminator

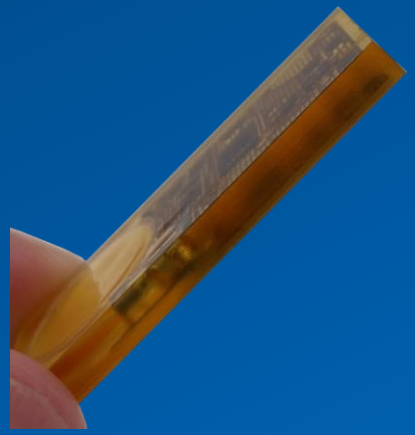


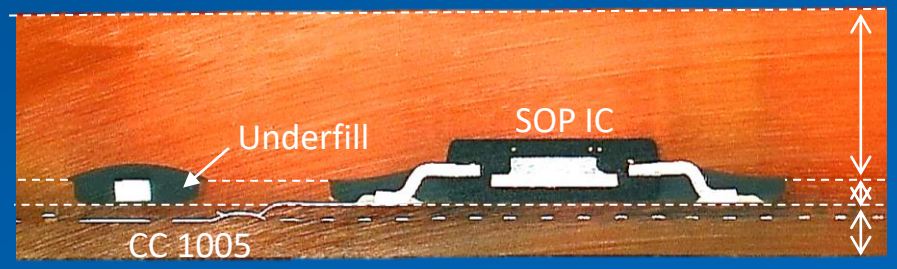
Low temperature SMT enables parts embedding

FPM-Trinity

Uniform encapsulation



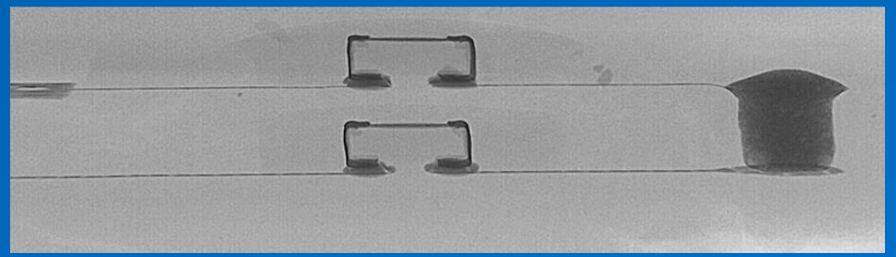




Embedded component (as feasibility study)

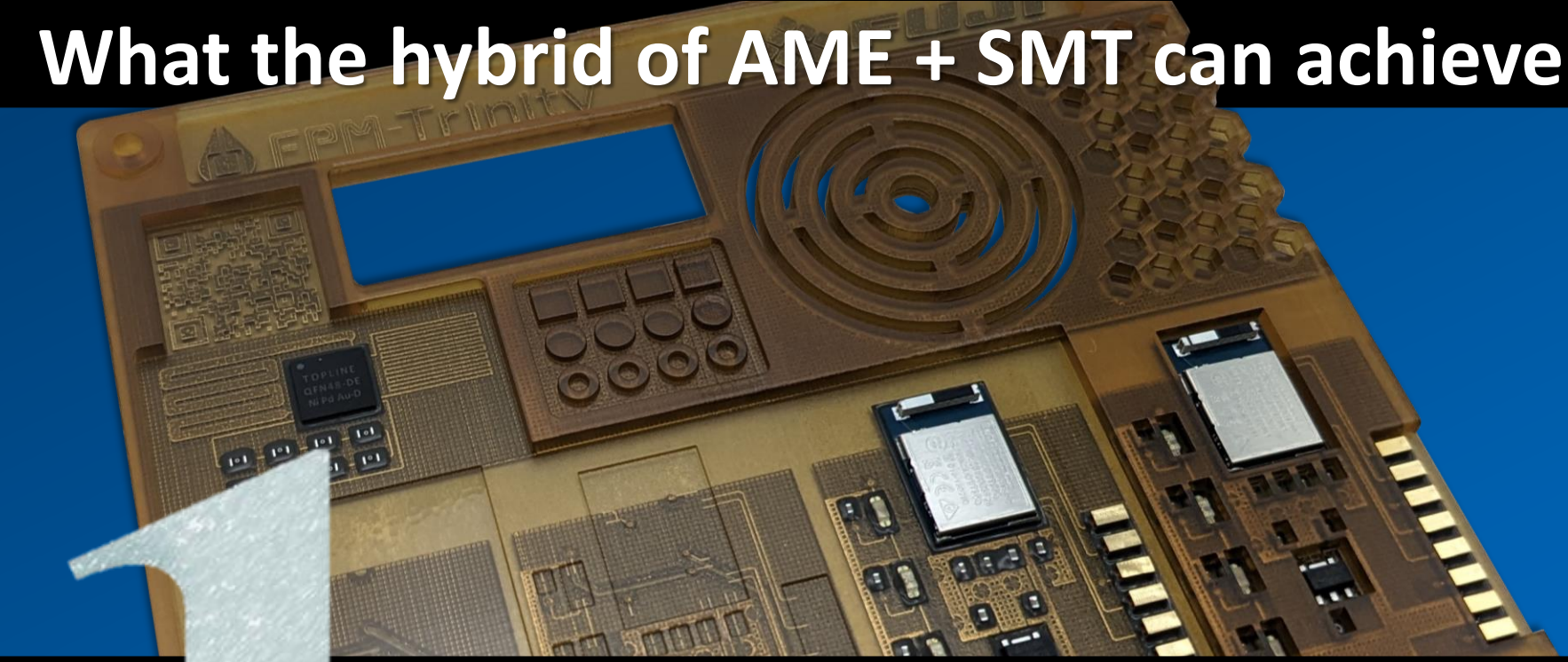
X-section

X-ray



FUJI innovative spirit

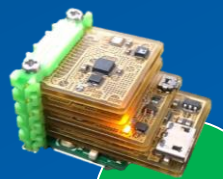
What the hybrid of AME + SMT can achieve



1

- All in ONE !
- ONE stop !
- Within ONE day !
- From ONE piece !
- From ONE person !

Current project phase



Today

R&D

Sample manufacturing service (in Japan)

Prototype machine

Beta testing with domestic EMS

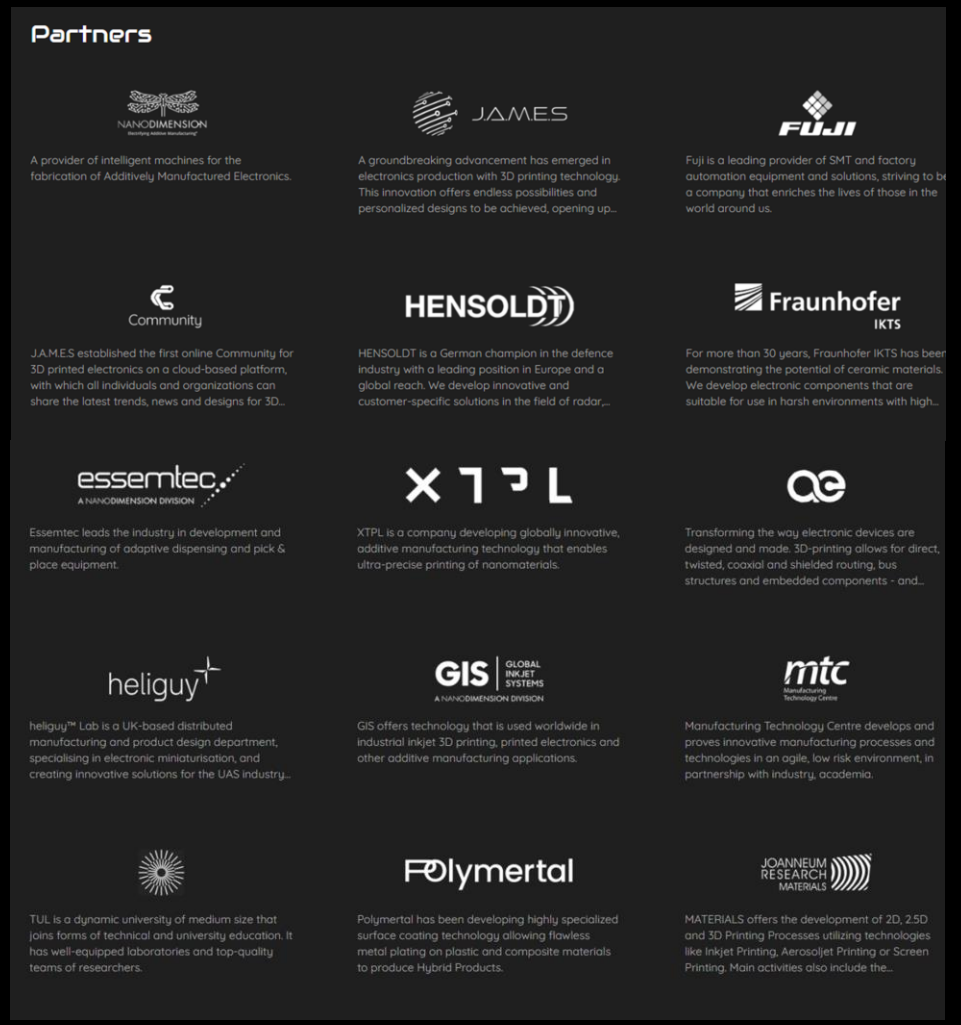
Product launch

FPM-Trinity

FUJI

J.A.M.E.S

We are partners to be involved into AME world!



FUJI innovative spirit