



Testing the Limits
FOR PRODUCT SUCCESS

Ultrasonic flip chip bonding on Organic substrate

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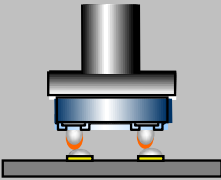
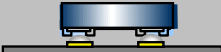
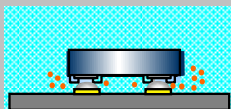
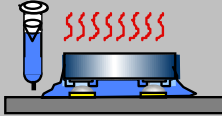


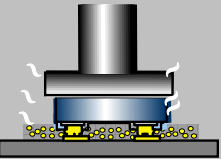


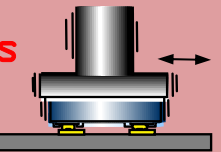
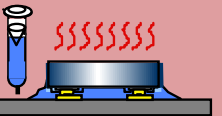


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- Comparison of Flip Chip Bonding Process
- Features and process issue of US-GGI
(Ultrasonic Gold-to-Gold Interconnection)
- Process condition and bond-ability of US-GGI
- Summary



Flip Chip Process Comparison

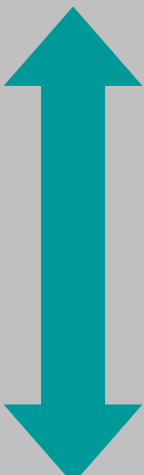
Process	pretreatment	Chip	Bonding & Process time	Re-flow	Cleaning	Under fill & cure
C4	 Transfer flux	 Solder bump	 mounting	 Re-flow	 Flux cleaning	 Under-fill & cure
ACF	 Applying ACF	 Gold bump	5s  Adding heat & pressure	Not necessary	Not necessary	Not necessary
US-GGI	 Plasma cleaning	 Gold bump	0.5s  Ultrasonic bonding	Not necessary	Not necessary	 Under-fill & cure Before/After bonding

US-GGI is simple with shorter process time.



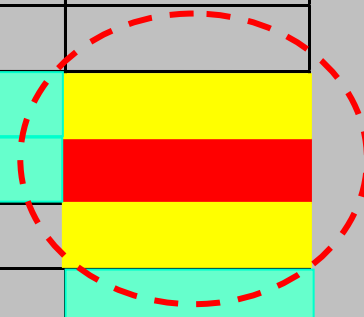
Current situation of applicable substrate

FLAT & HARD



ROUGH & SOFT

	Mass production	Test production	Development
Silicon wafer	Yellow		
Glass	Cyan		
Ceramic	Red		
Flex (TAB) single layer one side	Cyan		
BT single layer one side	Cyan		
Flex (TAB) single layer both sides		Cyan	Yellow
BT single layer both sides		Cyan	Red
Flex (TAB) multi layer both sides			Yellow
BT multi layer both sides			Cyan



There are challenges when US-GGI is applied to organic PCB.

The Issues of US-GGI to Organic Substrate

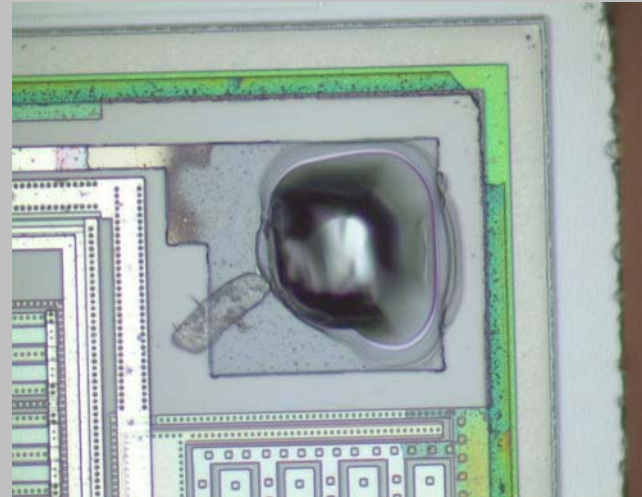
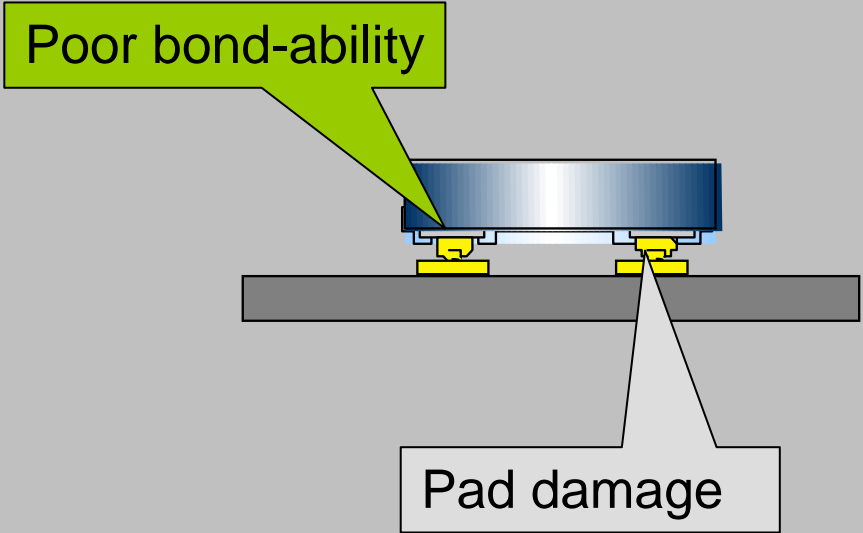
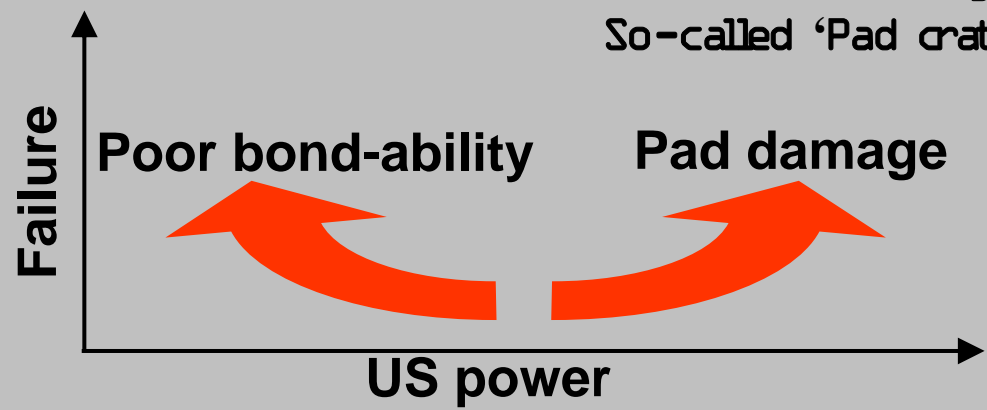
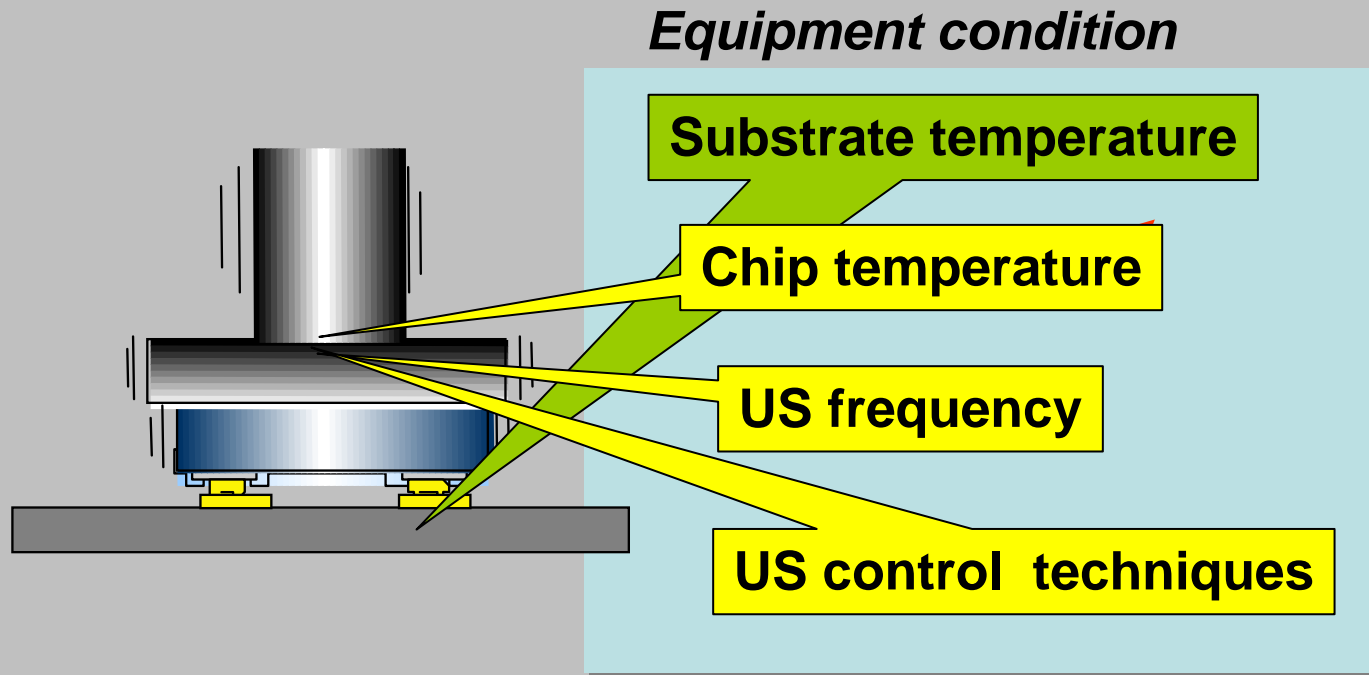


Photo of the damaged pad
So-called 'Pad crater' after the etching



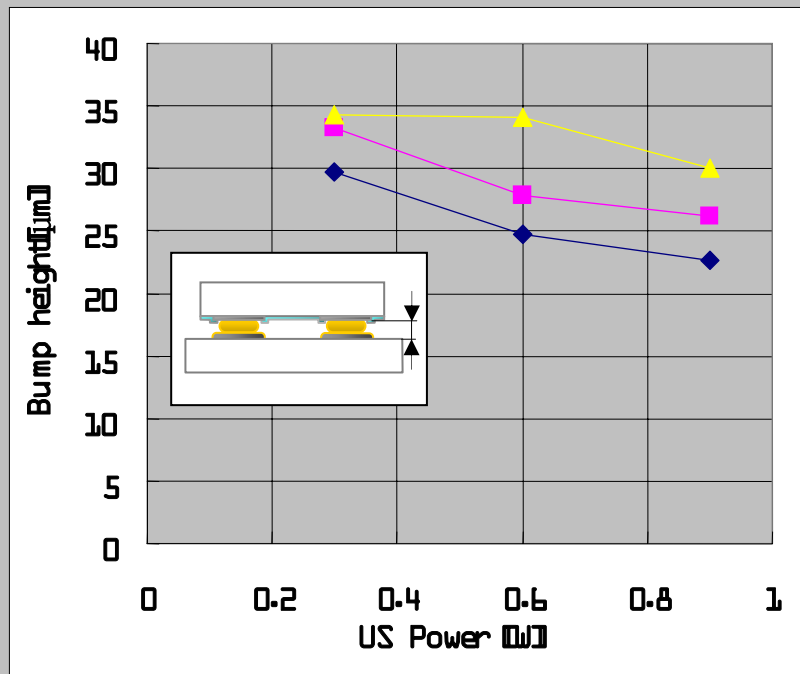
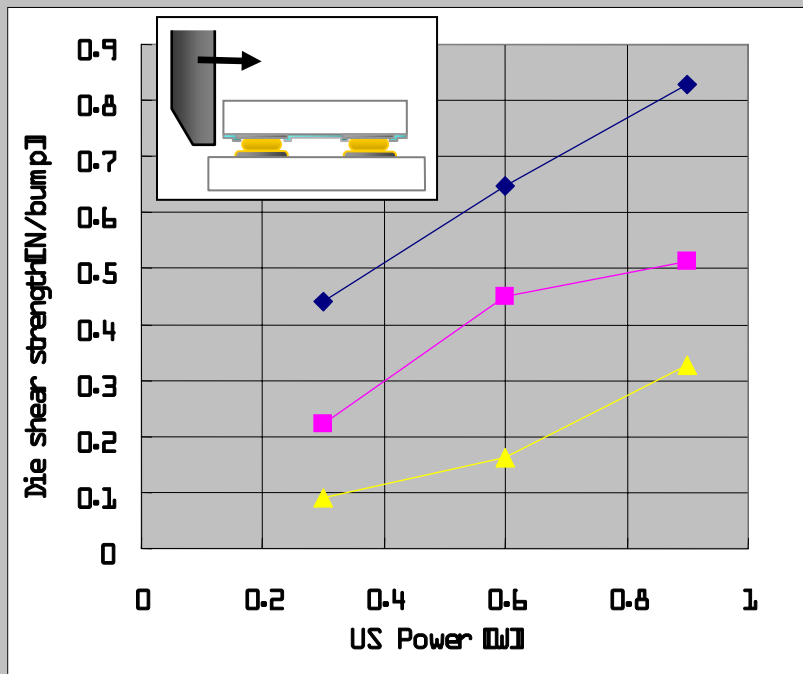
How can we optimize US process conditions ?

Process condition and bond-ability



*It is much important to optimize each process condition
for organic substrate.*

The substrate material and bonding strength



Force: 0.98N/bump US time: 0.3s tool temperature: RT stage temperature: RT

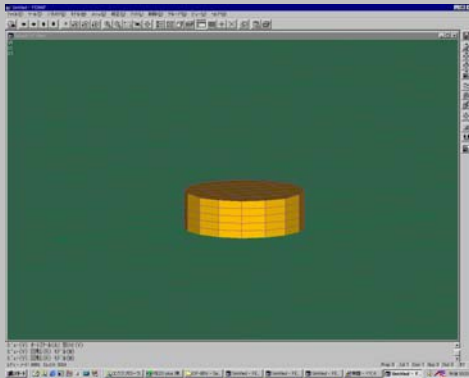
chip: 2mm Bump number: 12

= Bonding strength of ceramics is larger than that of organic; FR4, Flex.

= Bump deformation of organic is smaller than that of ceramics.

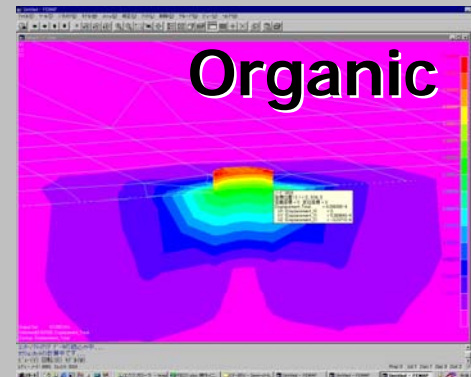
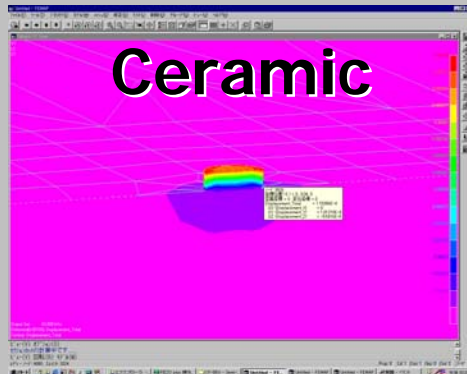
US bonding quality depends on the substrate material.

US Transfer depends on Material



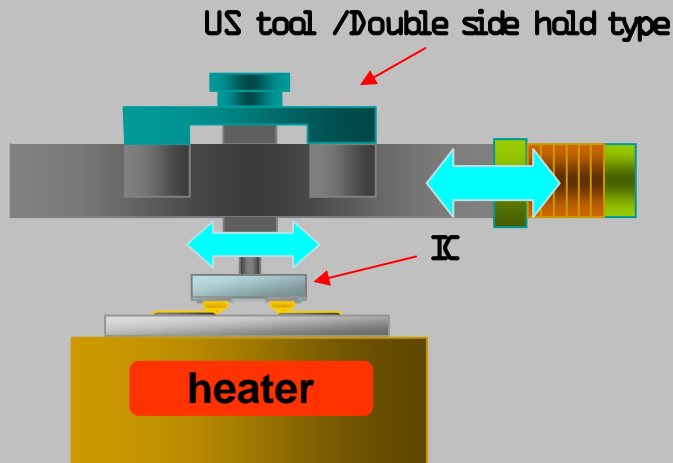
Applying ultrasonic force to bumps on ceramic and organic[FR4]

Bump diameter : 80 μ m
Bump height: 25 μ m



The organic substrate is vibrating in wide area.
The substrate deformation affected the US efficiency at the joint
in Organic Substrates

The effect of substrate Heating on US bond



Chip: 2mm

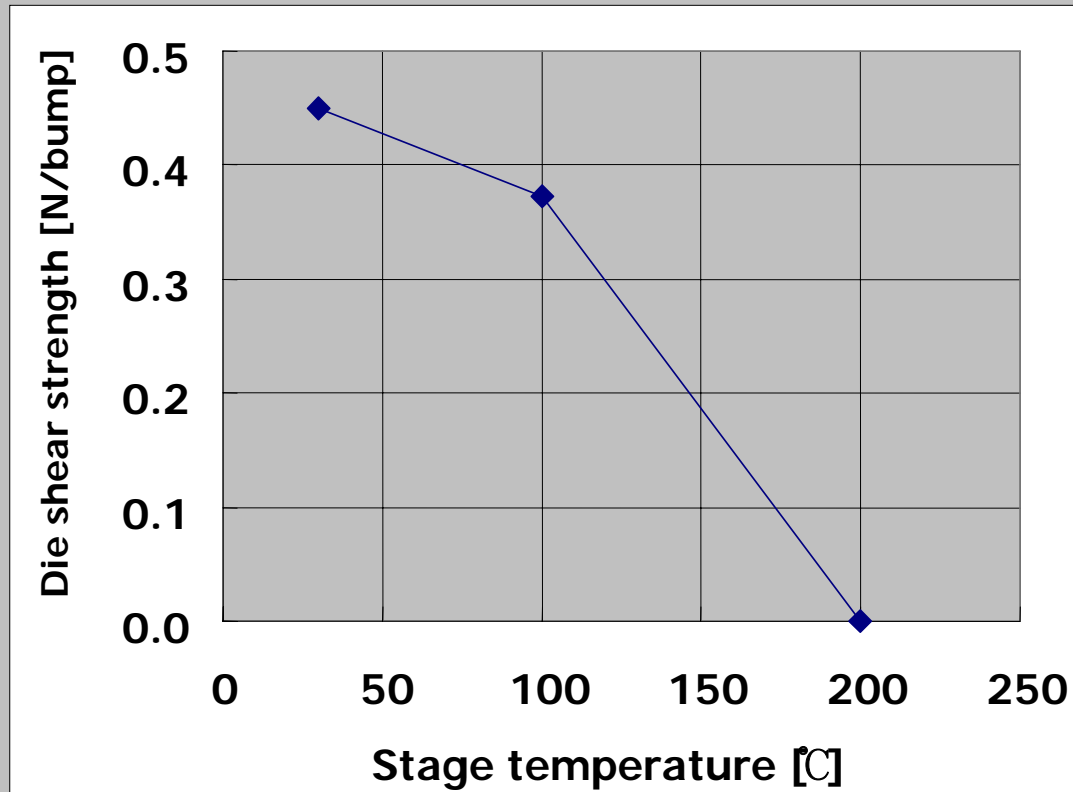
Bump number: 12

Force: 0.98N/bump

US power: 0.6W

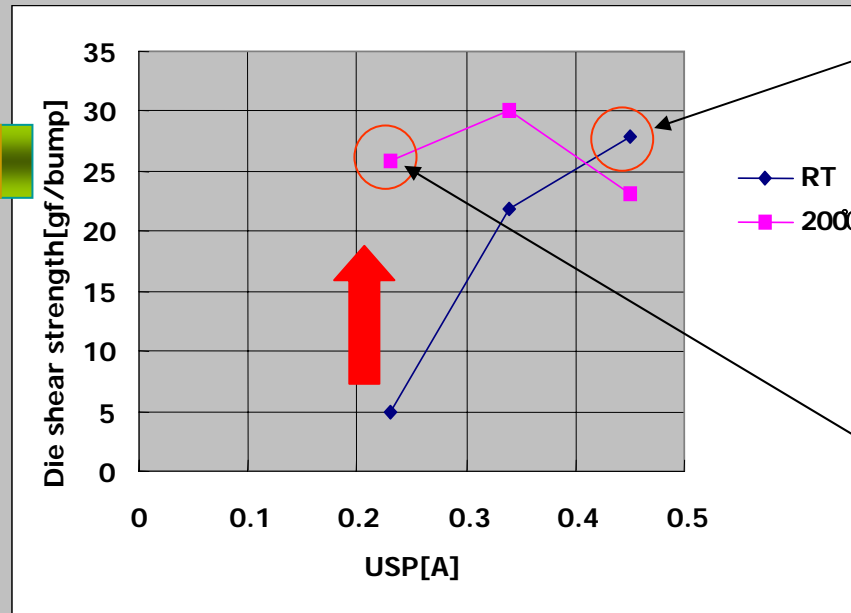
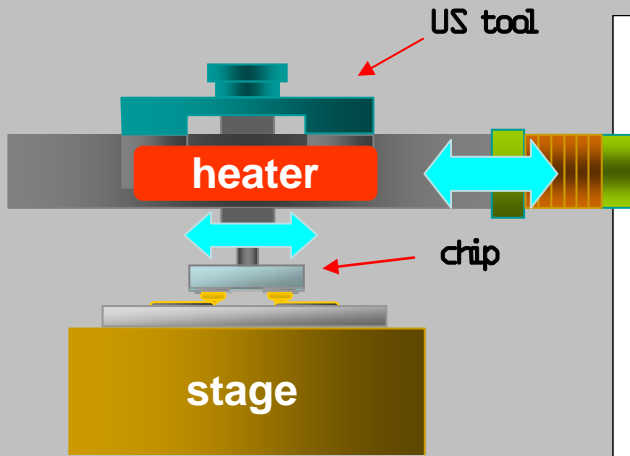
US time: 0.3s

Tool temperature: RT



***The substrate heating makes US bond weak,
Because of softening Organic Substrate.***

The effect of the chip heating



RT/0.45A



200°C/0.23A

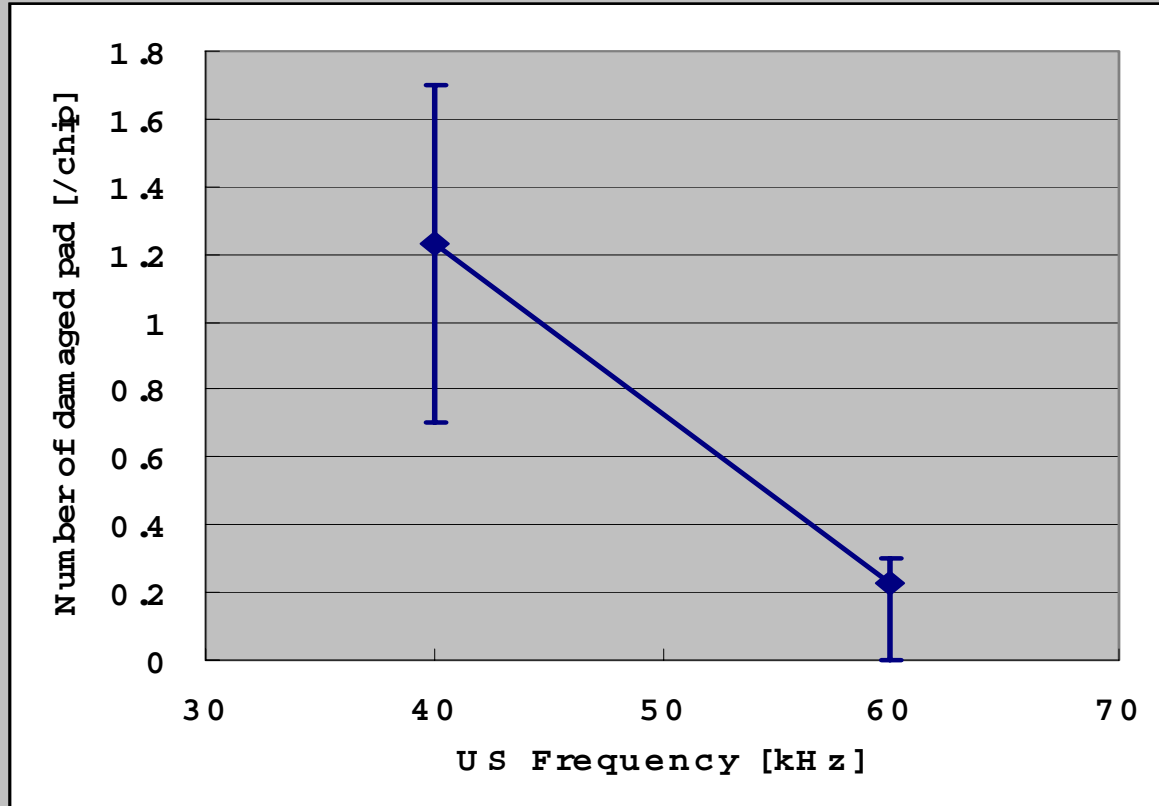
Die shear strength

IR image after IC bonding (Black points on the pad are pad cracks)

*substrate: FR4 IC: 10mm² 248bump (stud bump; without UBM)

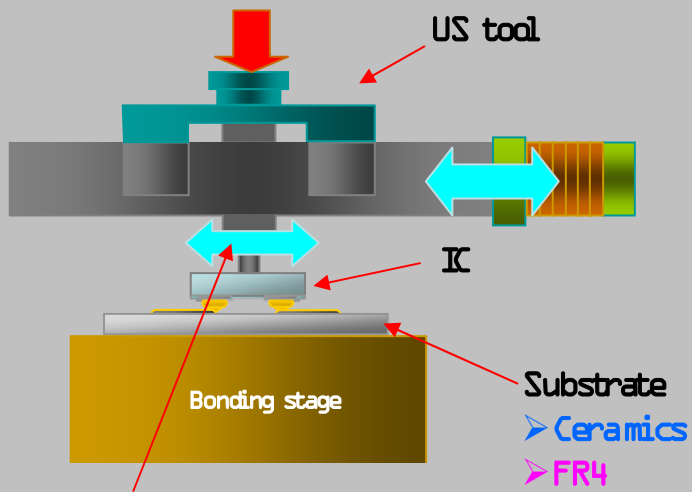
Die shear strength with lower power is remarkably improved with the chip heating. Pad damage can be reduced with combination of chip heating and lower power.

US frequency and the pad damage

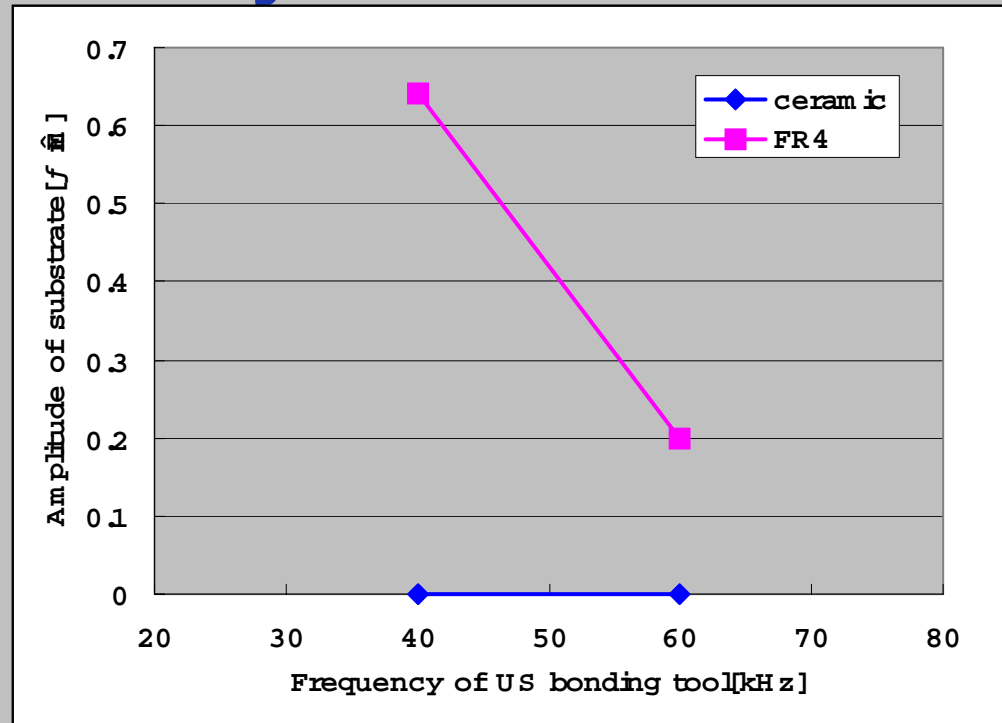


The number of damaged pad decrease
when US frequency becomes higher

The US transfer efficiency loss

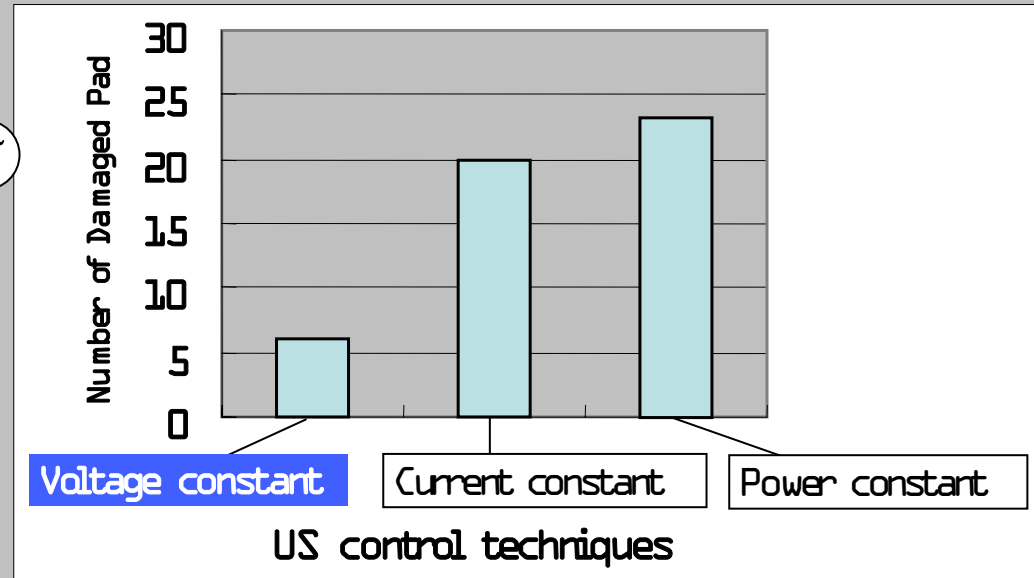
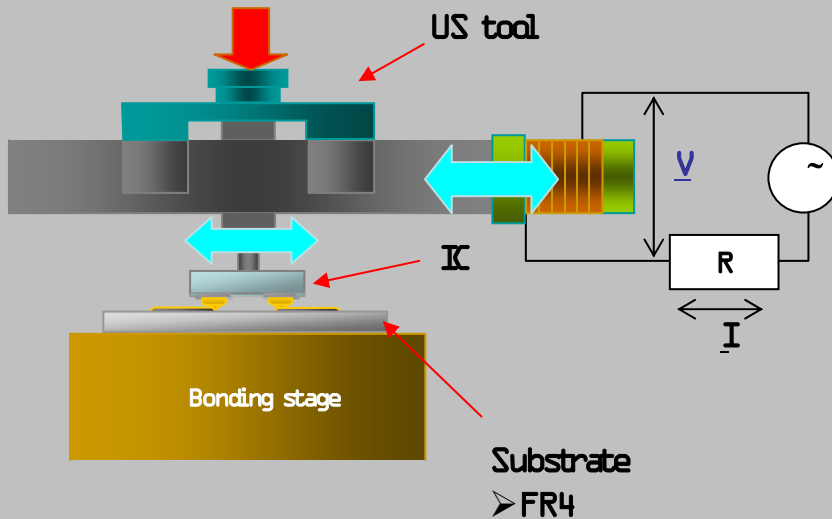
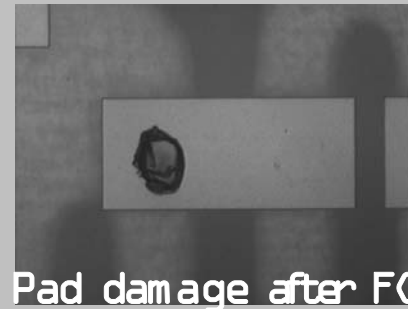


The amplitude of nozzle : $2\mu\text{m}$



Substrate shift decrease,
when US frequency becomes higher in organic substrate.
Smaller substrate shift makes US transfer efficiency better.

US control techniques and pad damage



Pad damage is quite sensitive to US control techniques.

Constant voltage is better to reduce the pad damage



The reliability of US-GGI to organic substrate

Making organic samples with GGI under process optimization

■ Precondition to TCT, PCT : Compliant with JEDEC level3

- Moisturizing : 40°C/60%RH, 72 hours

- Reflow : 3 times passed (peak 245°C)

■ TCT (- 40°C/ 125°C) : 1000 cycle Passed

■ PCT (121°C-100%RH) : 500 hours Passed

● Chip

Panasonic dummy Si chip

size: 10.16mm x 10.35mm

bump: GBC wire bump

192 bumps, 0.2mm pitch

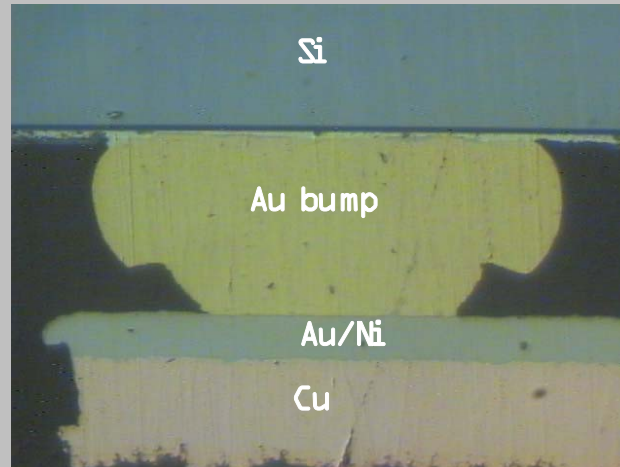
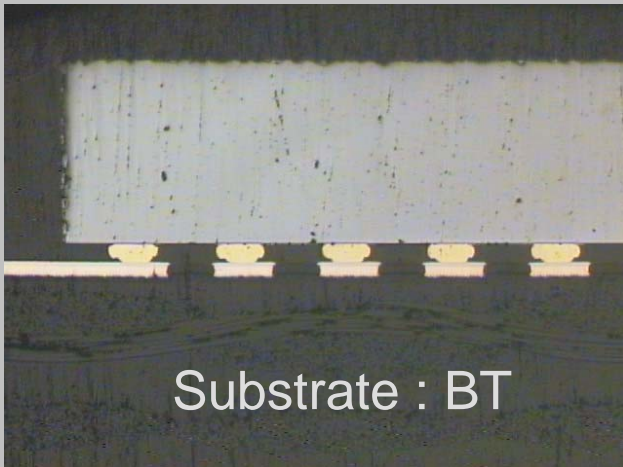
● PCB

Panasonic dummy BT (Organic)

Electrode: ENIG thin plating

thickness: 0.6mm

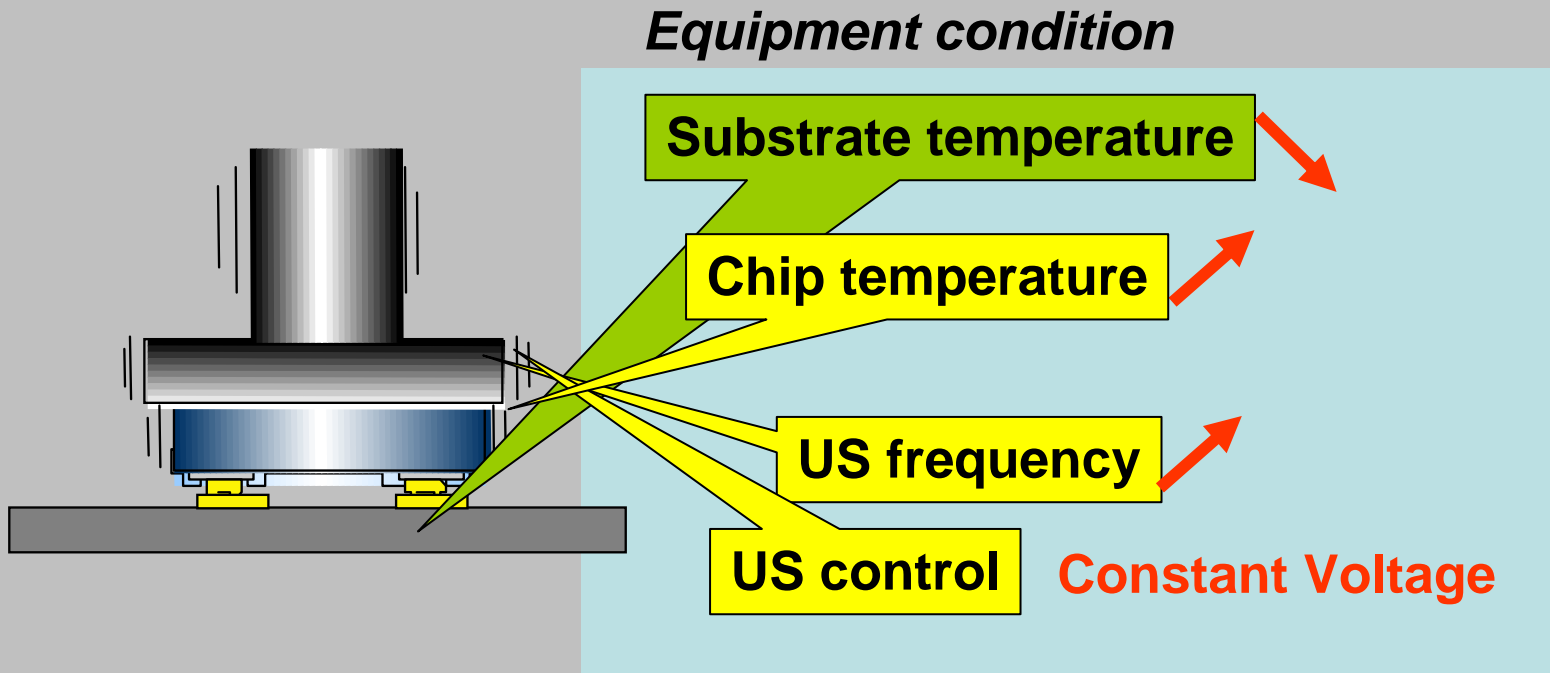
Plasma treatment applied



No failure, when process conditions are optimized.

Summary

Direction of each parameter to get good bond and to decrease pad damage



Thank you for your kind attention.