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To:

MITSUBISHI ELECTRIC Co. High Frequency &
Optical Device Works
Taking Charge of SiRF devices by MIYOSHI Electronics Co.
Electronics Devices Div.

Subject ; RA (H2S Package) RF Power module series substrate crack.

This document shows the conclusion for RA(H2S Package) series RF Power module substrate crack.

1. Substrate crack mechanism

   We show the substrate crack mechanism by theory , stress measurement results and thermal stress analysis by simulation.

   Tensile to substrate increase at a faster rate after the amount of bent reach to zero between module flange and chassis.

   When the tensility over the limit of substrate tensile, the substrate occur the crack.

   We seems that the substrate crack occur by excess stress by poor flatness of attached surface of module or faster temperature rise of module.

   Page 3 shows the substrate crack mechanism (Theory)

   Page 4 shows the measurement results of stress on the substrate with some conditions.

   Page 5 shows the thermal stress analysis by simulation.

2. Analysis results of crack place.

   We analysed the crack place by electron microscope.

   This results show the typical substrate crack by high temperature or excess stress.

   There are no signs in which have a small crack that is latent in the substrate.

   RA series module inspected 100% of HOT Po test.

   Hot Po test means that measure the output power on the high temperature(100Deg/C).

   Hot Po test can reject the micro crack and another poor assembling by heat stress.

   Page 6,7 shows the the place of crack by electron microscope.

   Page 8,9 shows the Hot po measurement equipment.

3. Calculation results with stress limit VS temperature rise.
   We calculated the stress limit of substrate by FEM.   FEM; Finite element method

   We measure the stress on the substrate with some temperature rising conditions.
   In this results we recommended to keep in the safety temperature rise area.

   Page 10 shows the stress limit VS temperature rise.
   Page 11 shows the safety area for temperature rise.

4. Example of poor flatness for attached surface of module.
   Page 12 shows the example of poor flatness of chassis.
   Page 13 shows the example of flatness improvement.

5. The test results of RoHS compliant module.
   We tested the RF on and off with extreme conditions for temperature rising.
   Following are test results.

r/n=8/8	Non RoHS compliant module	(All substrate crack at few cycles)
r/n=0/16	RoHS compliant module	(No substrate crack over 3000cycles)

   The reason is that the solder of RoHS compliant is hard than present solder.
   In this results, module flange difficult to drop away.

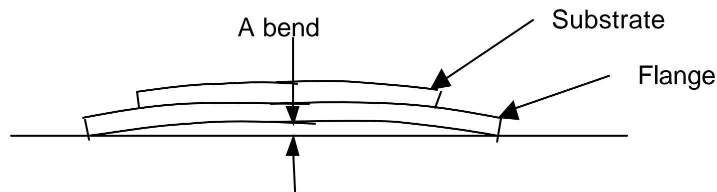
   Page 14 shows the RF on /off results with RoHS compliant ver.

Conclusion;

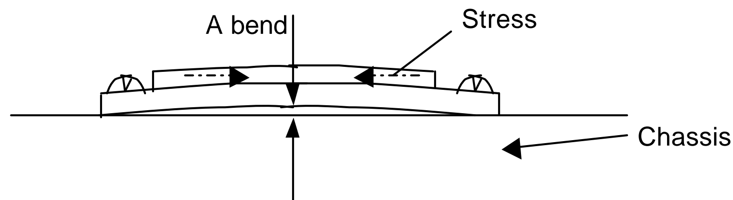
The present module have a enough strength with keep the flatness of chassis, temperature rising time and maximum temperature of module.
Additionally RoHS compliant ver. have a more high strength than non RoHS ver.
We think ,substrate crack problem will be clear by using RoHS compliant ver.
But Please keep the our recommendation for the flatness of chassis, temperature rising time and maximum temperature of module.

1.Substrate Crack Mechanism

1.Module flange and substrate have a bend by bimetal effect.

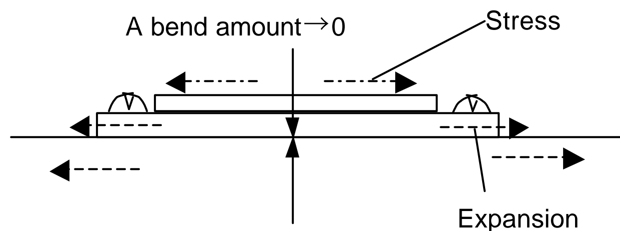


2.RF Power transmitting,
The temperature of flange and chassis is increase by loss.
The flange are extending by thermal at first and the amount of bend is drop away.

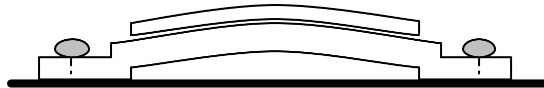


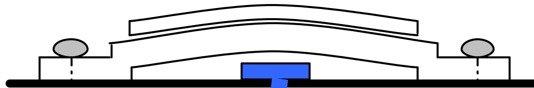
3.RF Power transmitting and the amount of bend to Zero.

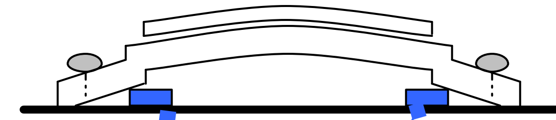
After the amount of bend reach to Zero,the substrate have a tensility to both side.
When the tensility over the limit of substrate tensile,the substrate occur the crack.

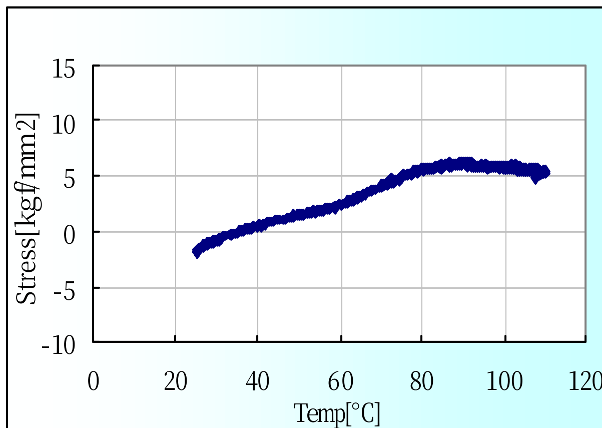


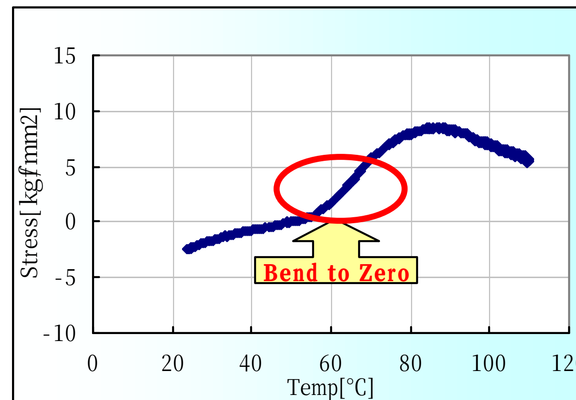
Measurement result of the stress

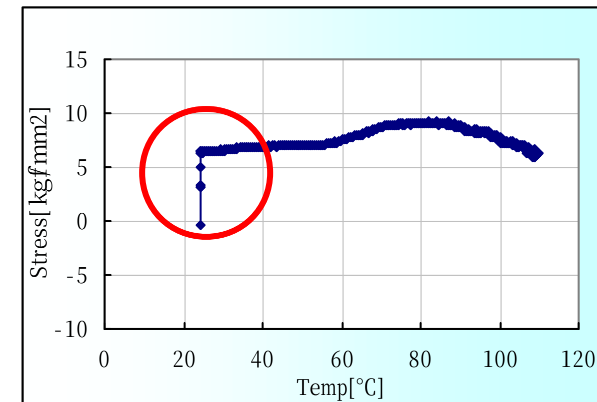










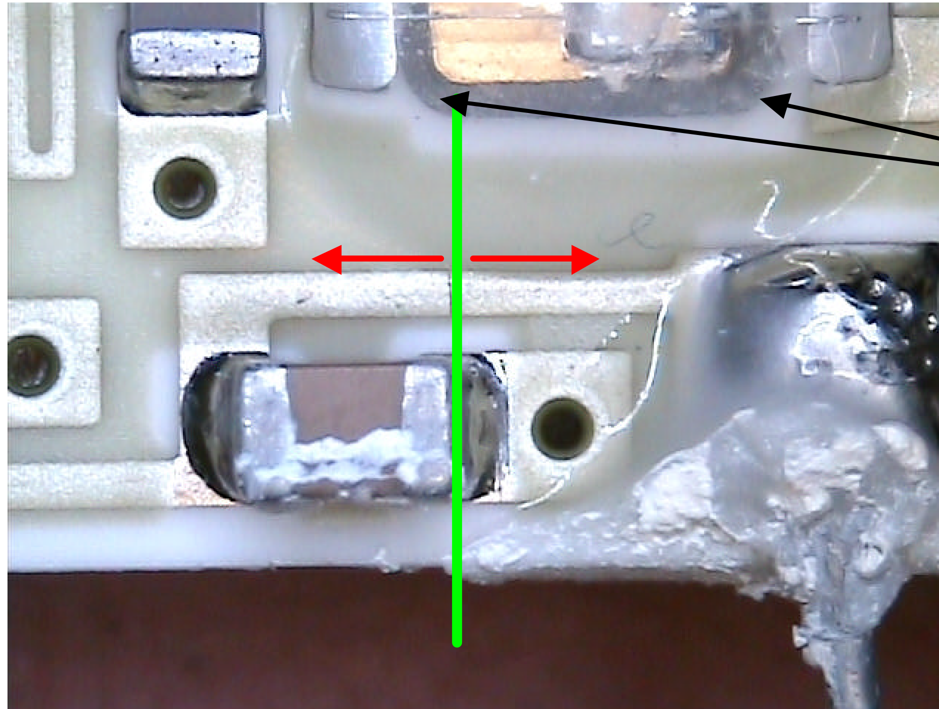


Simulate the good flatness

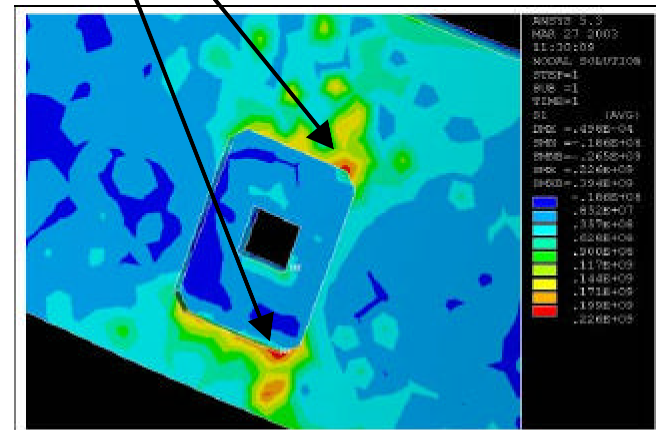
Simulate the poor flatness

Simulate the poor screw cramp

The example of thermal stress analysis



These corner are point to gather the stress by the heat.



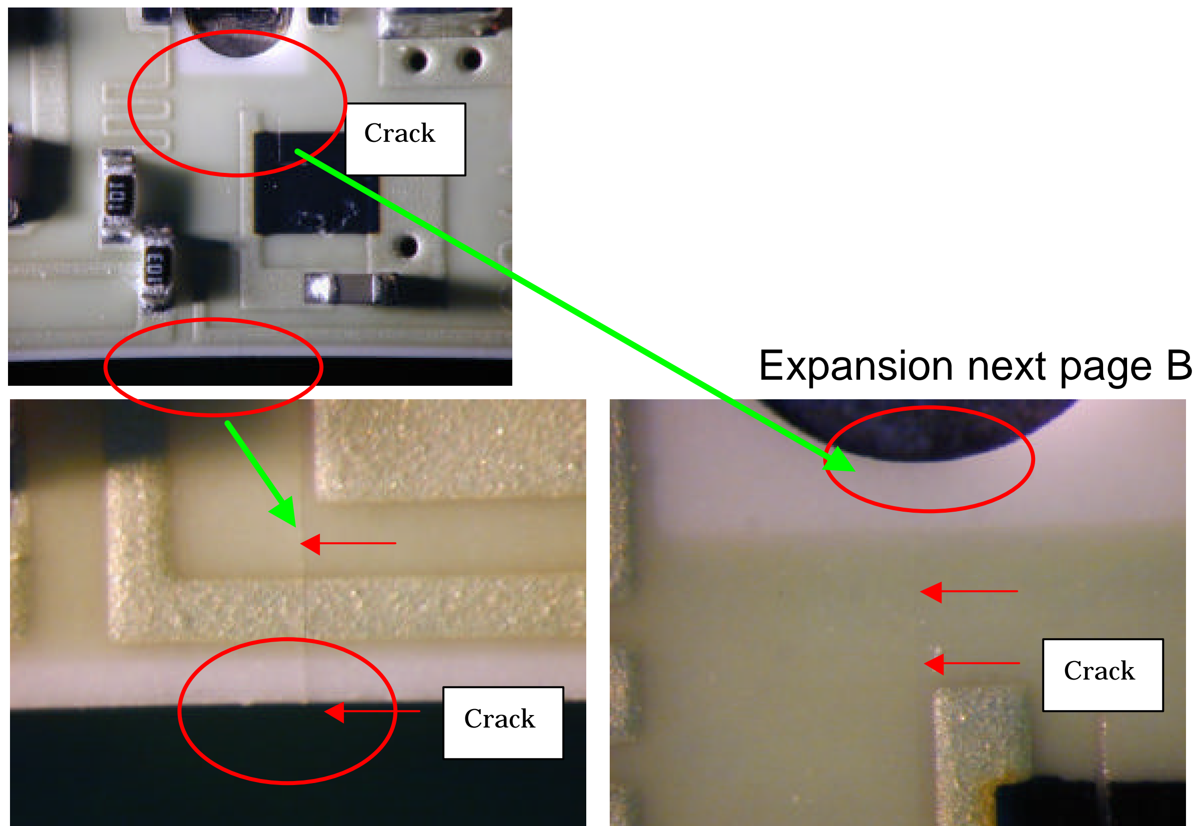
When heat is applied, a crack will spread.

Hot Po test can reject the crack by measuring the RF Power.

The Example of Thermal Stress Analysis

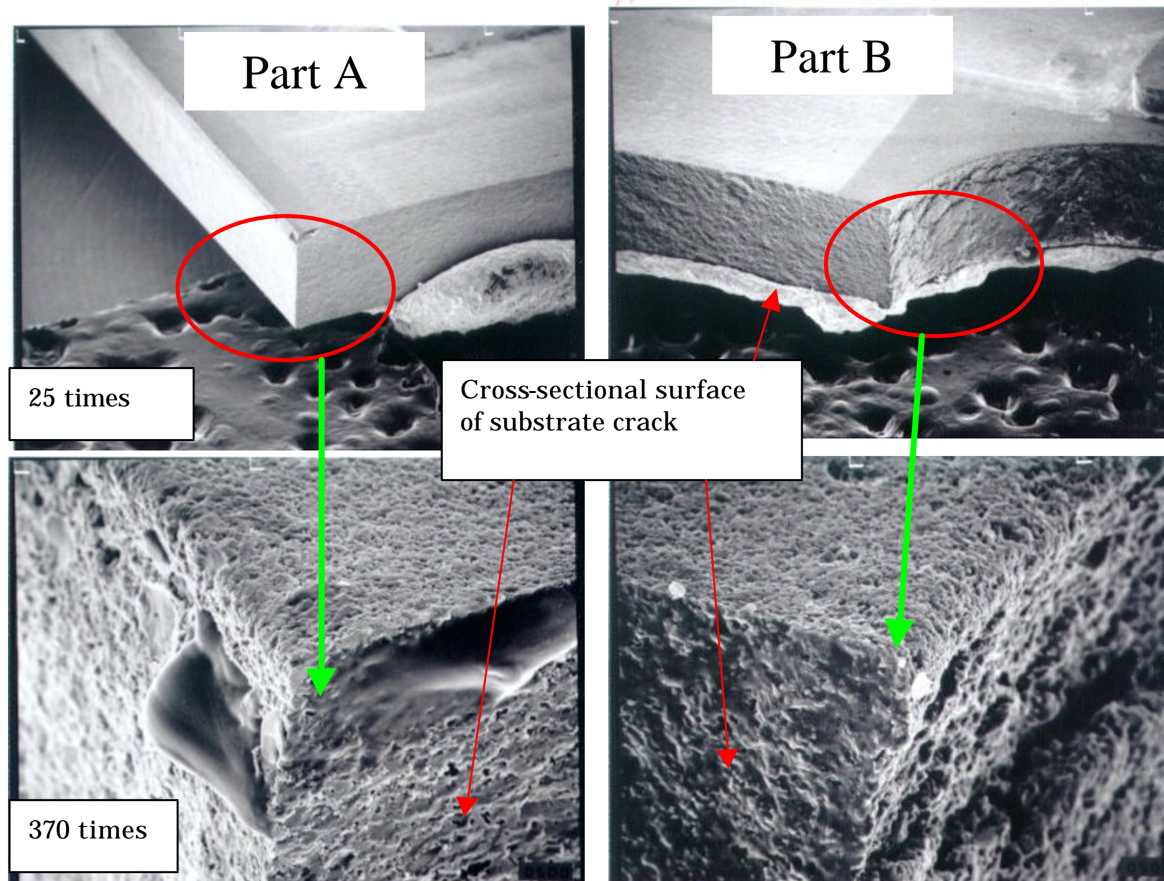
The check results of crack place

This is a typical substrate crack by high temperatures. There are no signs in which have a small crack that is latent in the substrate.



Expansion next page A

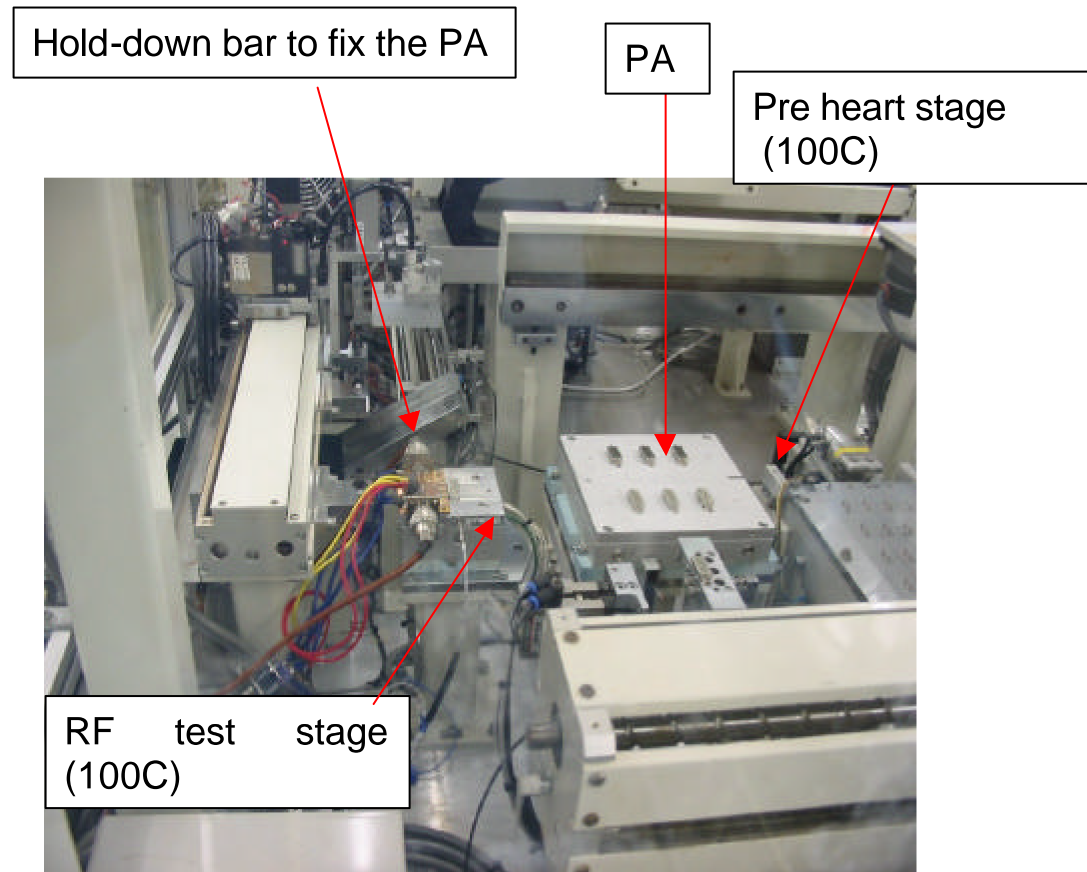
Expansion photo



Hot Po measurement equipment

The purpose of Hot Po

Hot Po test can reject the micro crack & another poor soldering by heat stress.



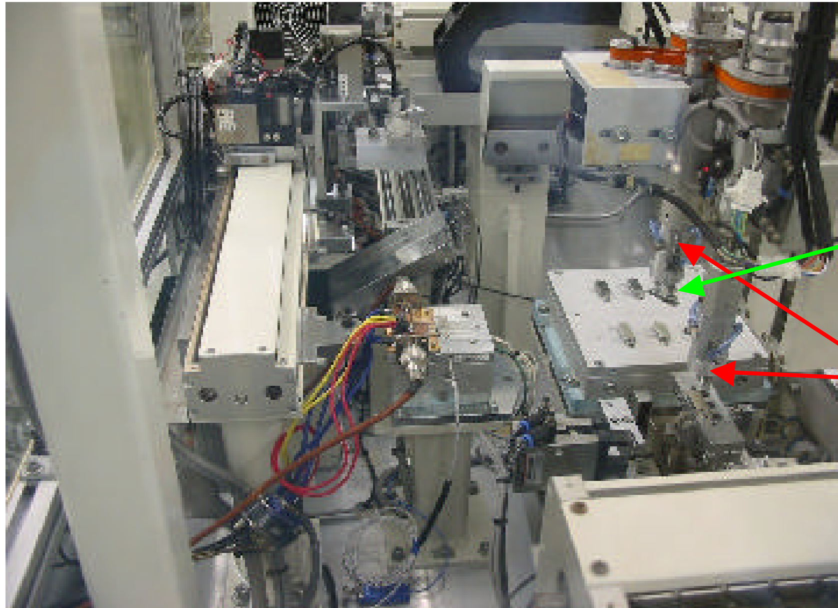
The outline of the test equipment

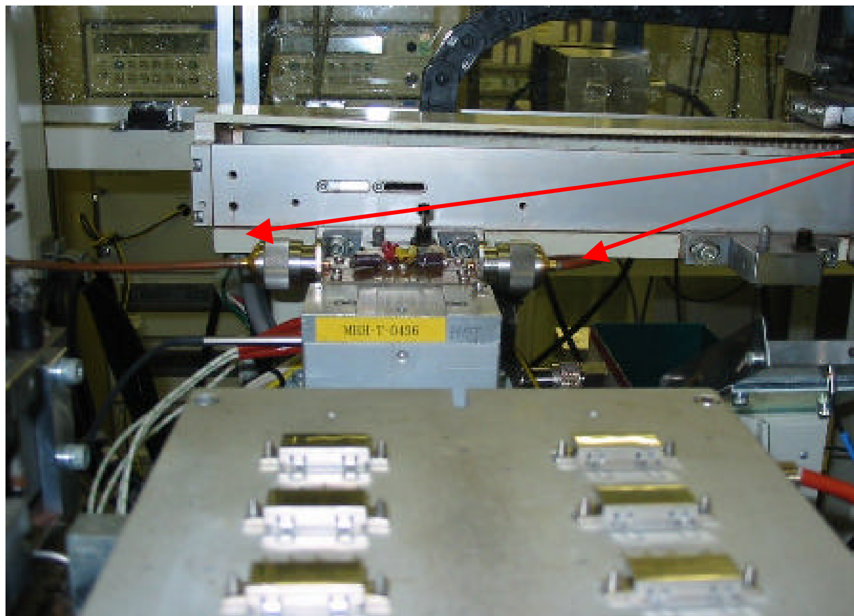
Operation

1.PA s are put on the pre heart stage. The temperature of PA becomes 100 degrees C.

2. PA is moved to the RF test stage.

3. PA is hold down to the RF test jig and test is started. RF power is checked.

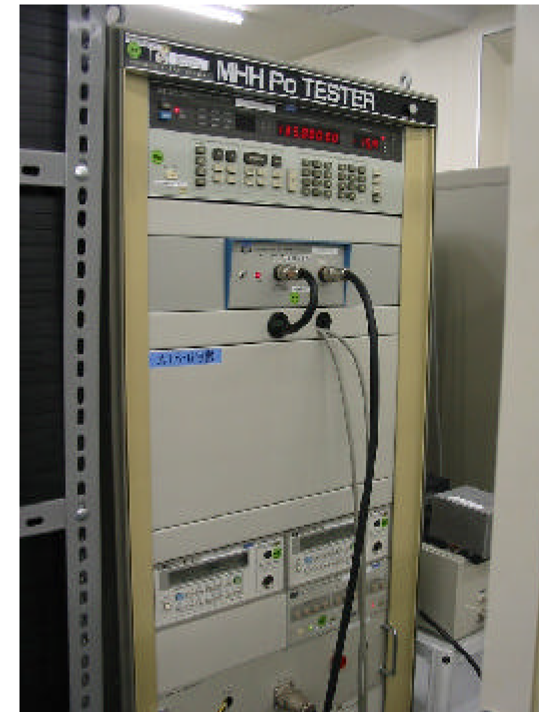




PA

Transfer mechanic

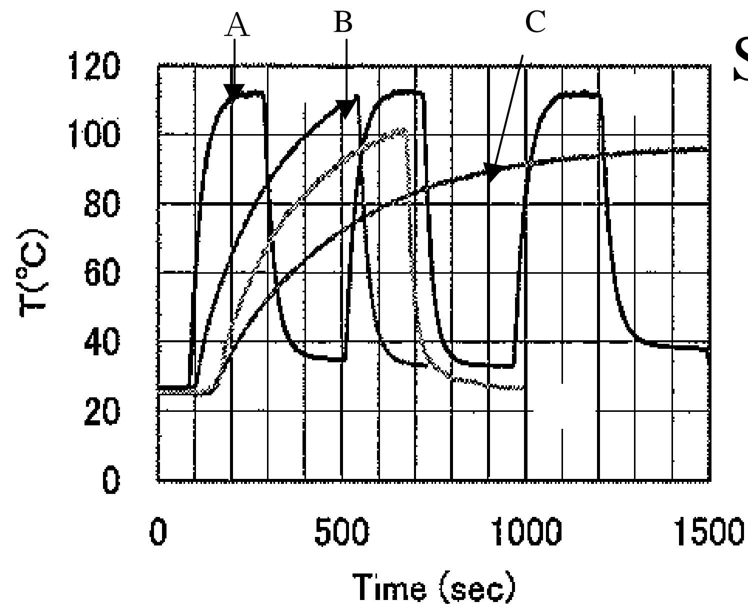
RF Cable



The outline of RF out put tester (Auto tester)

Stress limit VS temperature rise

		Substrate coefficient of variation η	0.1
		Reliability R	
The result of Calcuration by FEM	Sterss limit (kgf/mm)	99.9%	8.8
		99.99%	8.0
		99.999%	7.3
The result of Mesurement	Generated Thermal Stress σ(kgf/mm)	dT/dt=A	7.8
		dT/dt=B	6.0
		dT/dt=C	5.0



Safety temperature rise
B & C<Stress limit
7.3kgf/mm

4. THERMAL DESIGN

In order to keep high reliability of the equipment, it is better to keep the device temperature low. The case temperature of the module is recommended to keep lower than 90 deg. C under all conditions, and to keep lower than 60 deg. C under standard conditions.

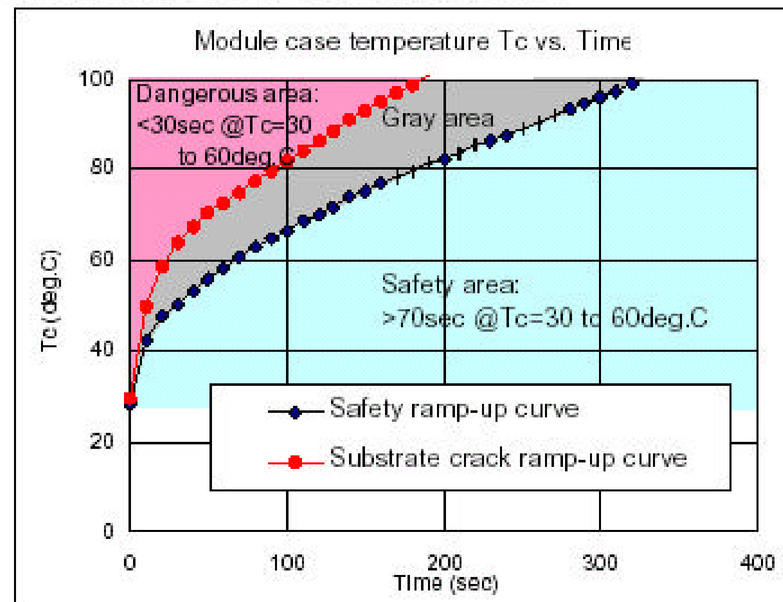
For discrete transistor, keep the operating junction temperature of Transistors Tj(op) less than specified temperature.

Ceramic substrate in the module may crack by excessive stress such as foreign object between Fin and chassis or expansion by thermal force.

For foreign object between Fin and chassis, recommendation is written in next item 5.

Concerning expansion by thermal force, MITSUBISHI recommend to design the ramp-up speed of module case temperature as below.

Customer needs to design the heat sink size and control the output power of the module in order to keep safety ramp-up curve.



Example of Poor Flatness

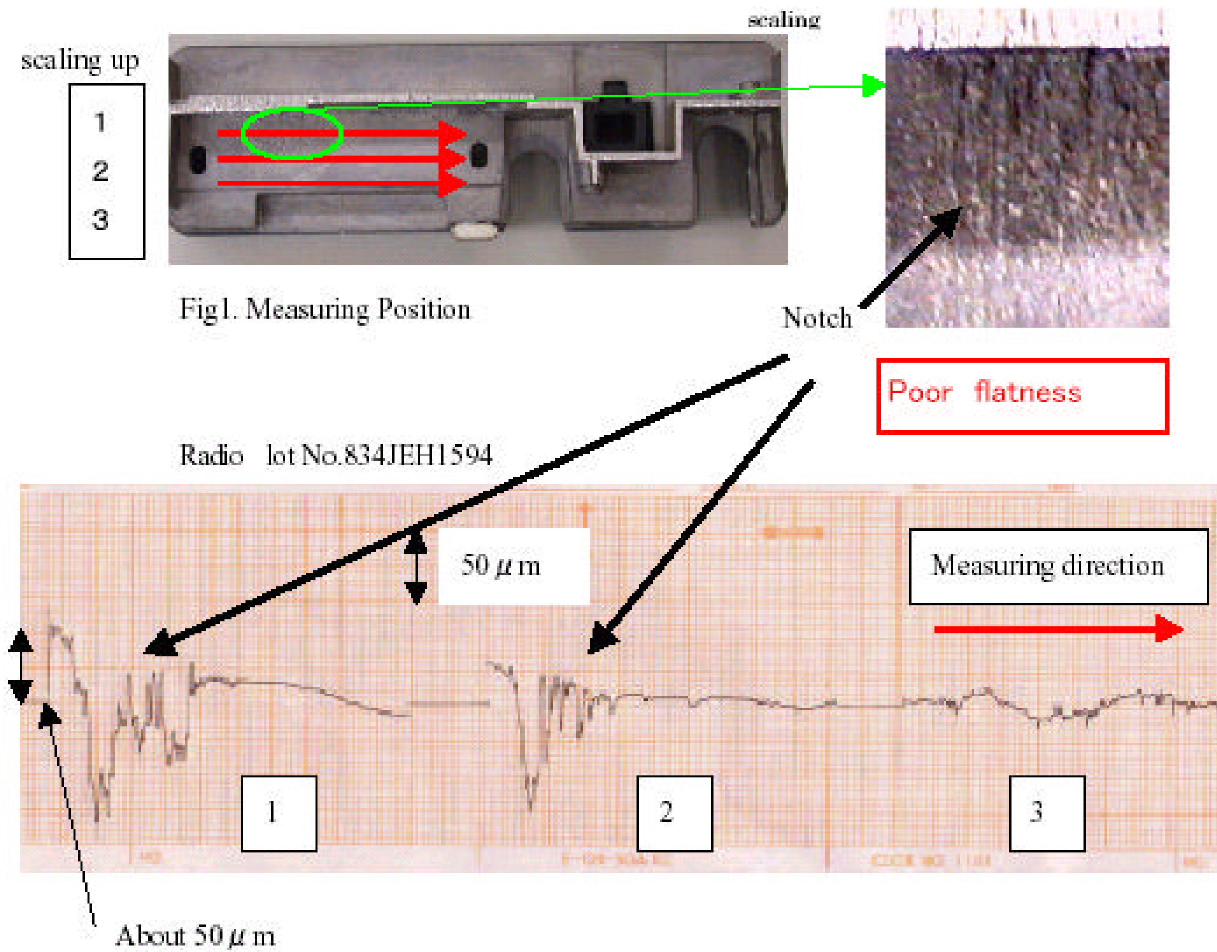


Fig1. Measuring Position

Fig2 Result of flatness of lot No.834JEH1594

Example of the Flatness improvement

Before Substrate
crack occurred

After Substrate
crack No issue

The RF on /off results with RoHS compliant ver.

RoHS model will be stronger than existing Pb Model.

Test sample RA45H4452M

RF on/off test result at extreme test condition

RoHS ver. r/n=0/16 （No substrate crack over 3000 cycles）

Existing ver. r/n=8/8 （All substrate crack at few cycles）