Operation of a Vacuum Reflow Oven

with Void Reduction Data

Originally given at SMTAI Rosemount,

Simplified and with the latest updates

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Vacuum Reflow

The science of using nothing to remove empty spaces from something

Outline

- Voids
- Why Vacuum Reflow?
- The Inline Vacuum Reflow Oven.
- The Vacuum Reflow Cycle.
- The APL Vacuum Trial
  - The test vehicle
  - Partial Results from the extended trial at the Universal Advanced Process Lab
- Things to Consider
- ACI Workshop - latest data

Void issues

Voiding is of particular concern for:

Thermal management of QFN

About keeping the chip cool by eliminating voids in Thermal Pads because empty spaces don't transfer heat

Flux ?

Voids in leads affecting high frequency signals

Typical reflow results in ~ 40% voids in thermal pads

"Low void" pastes have shown that void reduction is possible, but void levels are still higher than desired.

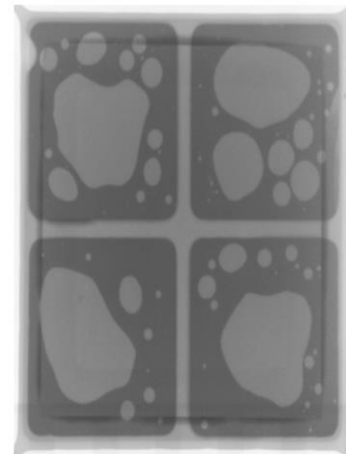
Why Vacuum reflow?

“Low void” pastes

Michael Meilunas, “Solder Joint Void Analysis: Effects of Paste and Reflow Parameters”
AREA Consortium

Atmosphere	Paste	Profile	MFL100
Air	Standard NC	STD	33%
	Low Void	Cold	19%
		Hot	13%
		very Hot	13%
Nitrogen	Low Void	Cold	18%
		Hot	13%
		very Hot	10%

Average Cumulative Void %



Standard Paste
Std Profile - Air

Low Void Paste
Very Hot Profile

Why Vacuum reflow?

- Voids are formed by flux resins and outgassing of flux, etc.

  And grow by merging.
  Then **if** they contact an exposed surface they escape the solder

- Large voids are more likely to contact exposed solder surfaces

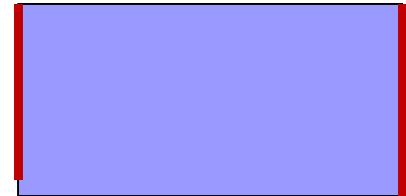
- Vacuum reflow has been shown to be effective at reducing solder voids
  - Voids grow as surrounding pressure decreases (Pascal's Law)
  - Large voids have an opportunity to combine and become larger voids and contact the surface.

Inline vacuum reflow oven

Vacuum Chamber is placed
between the last heated zone and cooling section of a convection reflow oven

with automated board transfer in and out of the chamber

Vacuum Chambers - either bell jar or door design

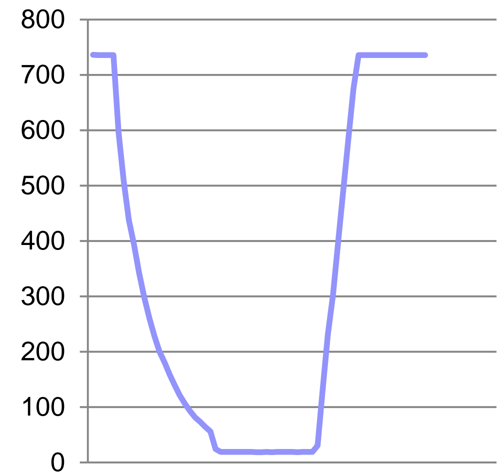


Four Basic Vacuum Process Steps

Not including transport

Pump Down

Rate at which vacuum is applied   Torr /sec



Vacuum level

The amount of vacuum   Torr

Hold time

The time at the chosen vacuum level   Seconds

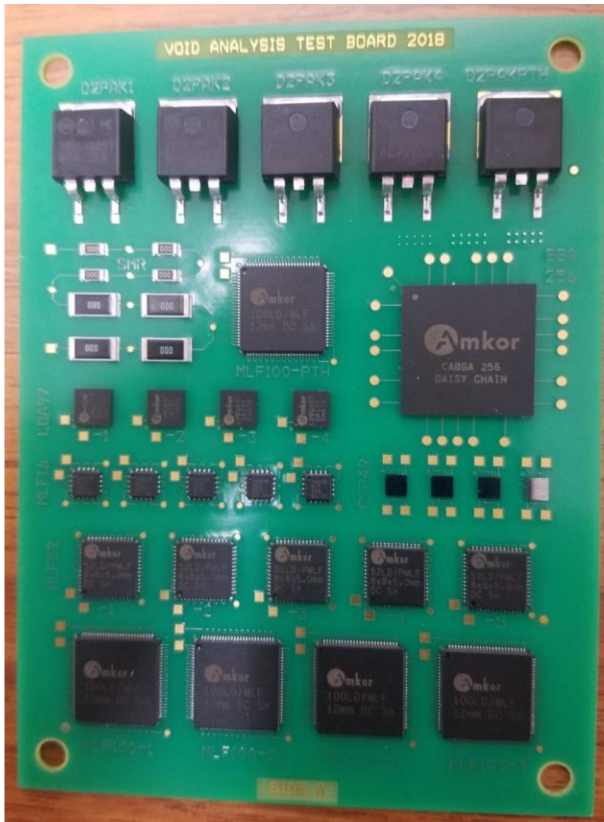
Equalization

The rate at which the chamber is returned to room atmosphere   Torr /sec

Trials at the Universal Instruments Advanced Process Lab

Mike Meilunas Universal Instruments APL

Arvind Srinivasan Karthikeyan Auburn University



Air & Nitrogen

Numerous pastes
- SAC 305
- Innolot
- Tin Lead

Three paste suppliers

Two board finishes

Two pad designs some with vias

Varied
- Vacuum level
- Hold time

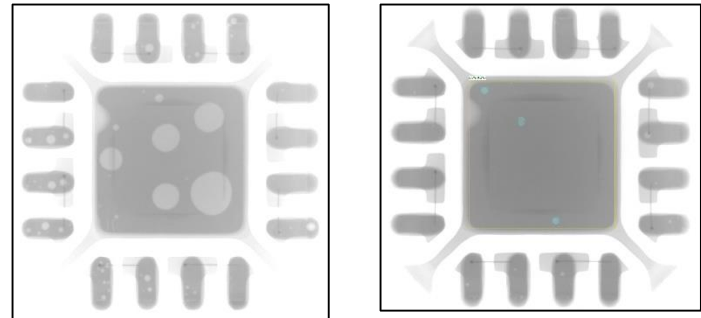
We ran over 200 boards

Results from MLFs 16 & 100

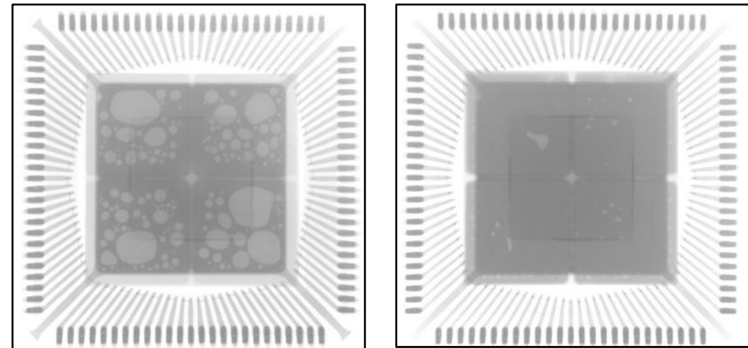
Atmosphere	**Nitrogen**
Solder paste	SAC 305
Board finish	ENIG
Profile	RTS - 240 peak
Pad Design	Window pane
Pump down rate	Fixed
Refill rate	Fixed

Multiple

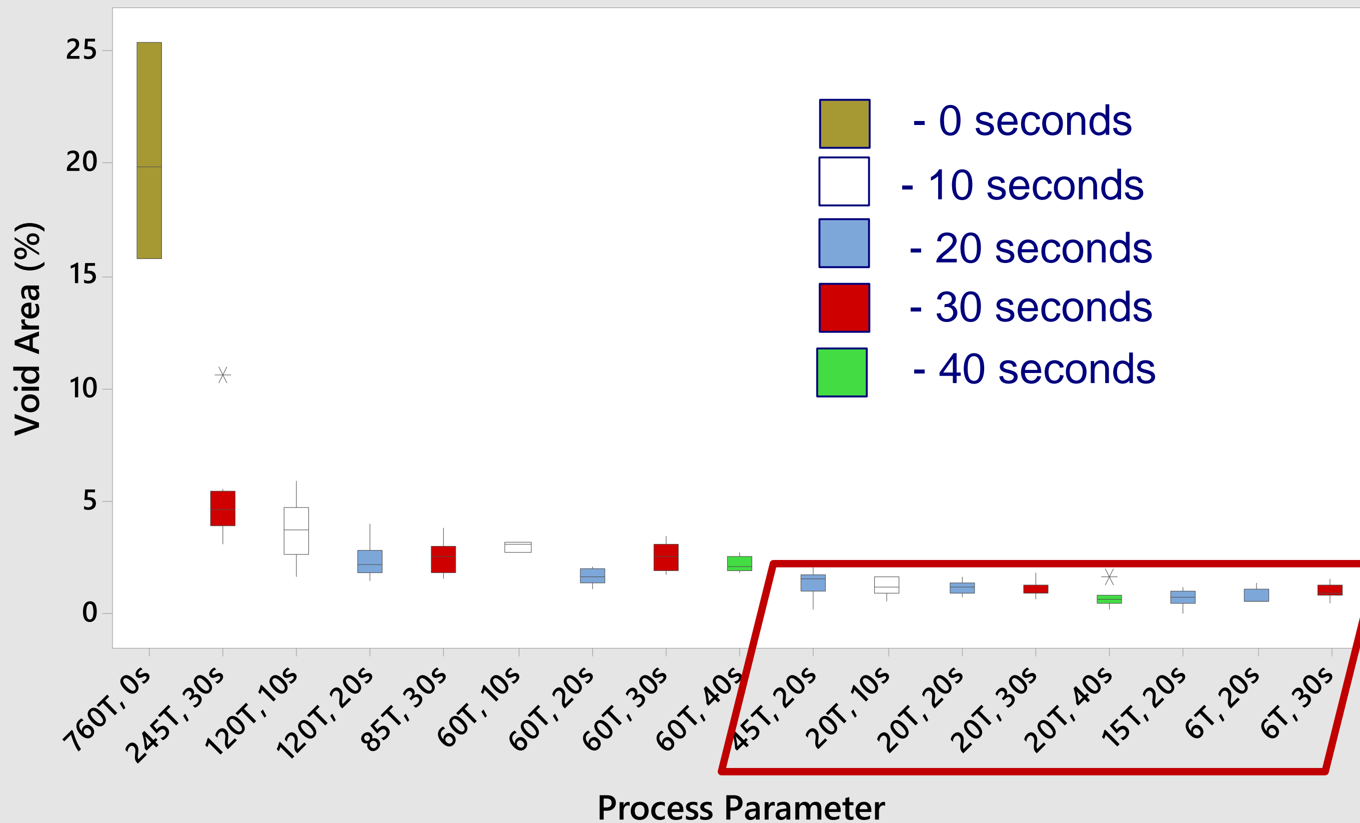
- Vacuum levels
- Hold Times



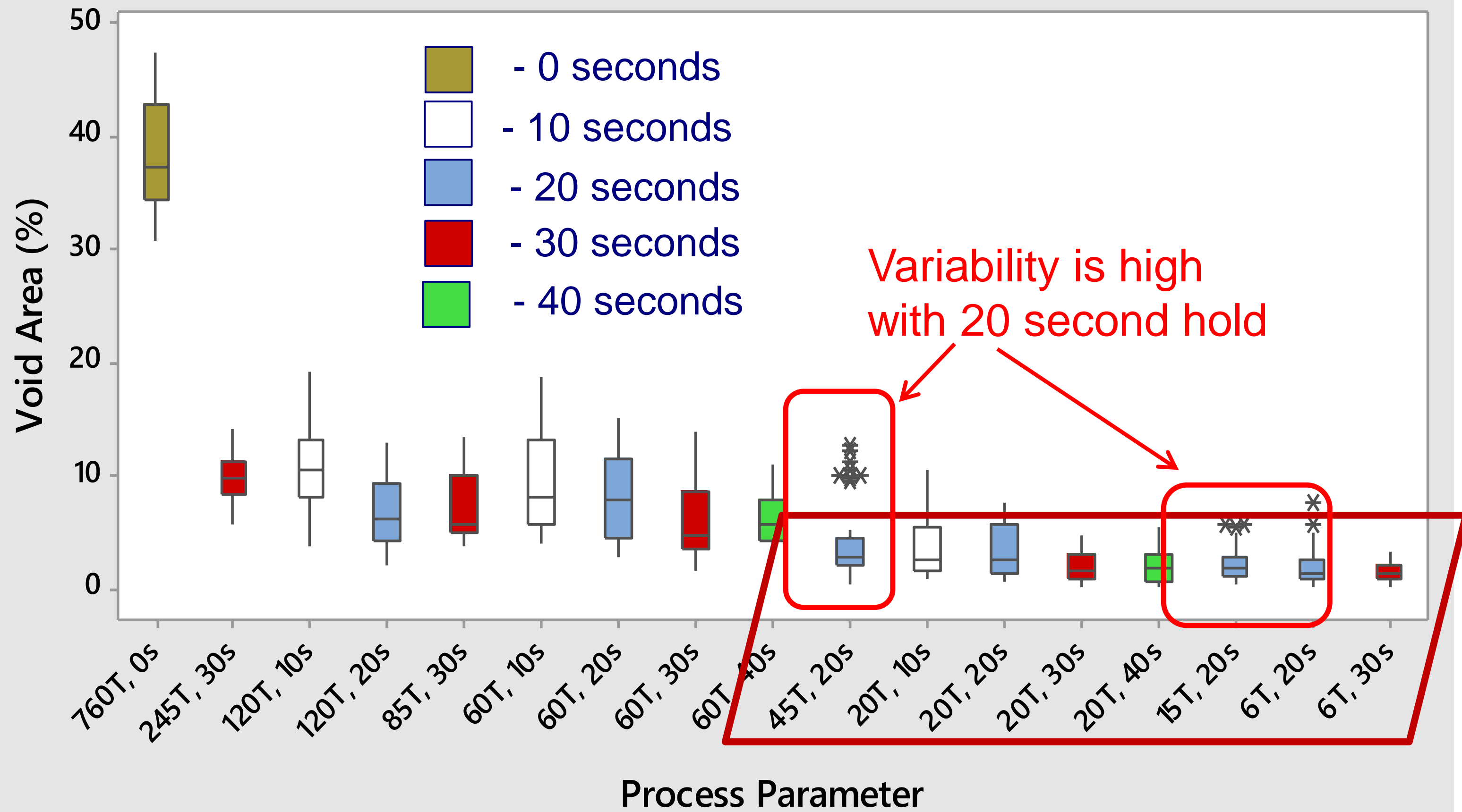
MLF 16 no vac vs vac



MLF 100 no vac vs vac



Cumulative voiding for MLF16
Void Area (%)
25
20
15
10
5
0
- 0 seconds
- 10 seconds
- 20 seconds
- 30 seconds
- 40 seconds
760T, 0s
245T, 30s
120T, 10s
120T, 20s
85T, 30s
60T, 10s
60T, 20s
60T, 30s
60T, 40s
45T, 20s
20T, 10s
20T, 20s
20T, 30s
20T, 40s
15T, 20s
6T, 20s
6T, 30s
Process Parameter


MLF100
Void Area (%)
50
40
30
20
10
0
- 0 seconds
- 10 seconds
- 20 seconds
- 30 seconds
- 40 seconds
Variability is high
with 20 second hold
760T, 0s
245T, 30s
120T, 10s
120T, 20s
85T, 30s
60T, 10s
60T, 20s
60T, 30s
60T, 40s
45T, 20s
20T, 10s
20T, 20s
20T, 30s
20T, 40s
15T, 20s
6T, 20s
6T, 30s
Process Parameter

Results:

Cumulative % Voids with 30 Sec hold time

Torr	Sec	MLF100	MLF52	MLF16
760	**0**	**38.54**	**27.81**	**20.37**
500	**30**	26.8		
245	**30**	9.79	5.62	5.21
85	**30**	7.4	3.1	2.5
20	**30**	1.93	0.72	1.04
6	**30**	1.5	0.66	0.96

> 10%
< 10%
< 3%

Things to consider

The real issue is Voids located at critical points ("hot spots")

Small voids may be OK

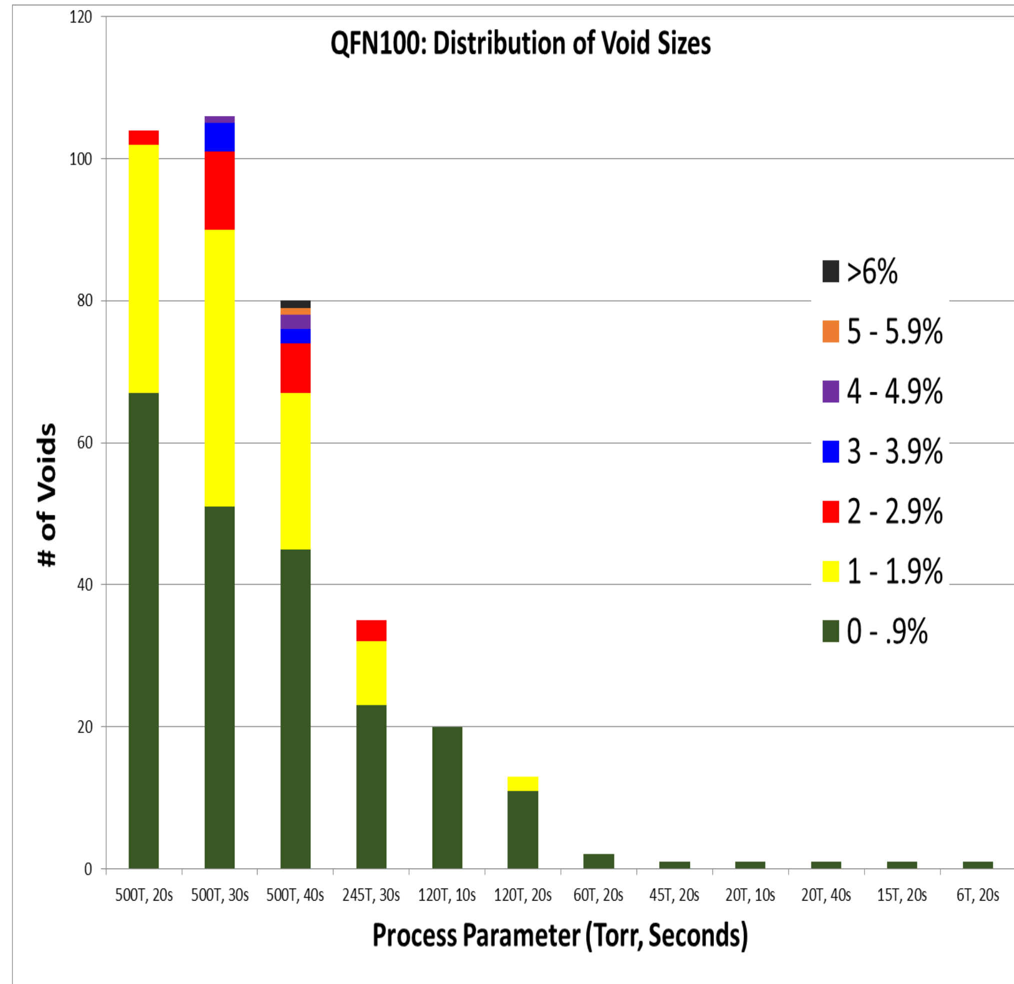
Cumulative voiding may only have a secondary affect

Large voids may be the problem

QFN Void Distribution Analysis: QFN100

At 120 Torr and lower vacuum levels, the odds of getting a void larger than 2% is small

60 Torr and below is even better



Presented at 2019 SMTAI Technical Conference in Rosemount IL

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The following data was recorded during
Vacuum Reflow Workshops at ACI

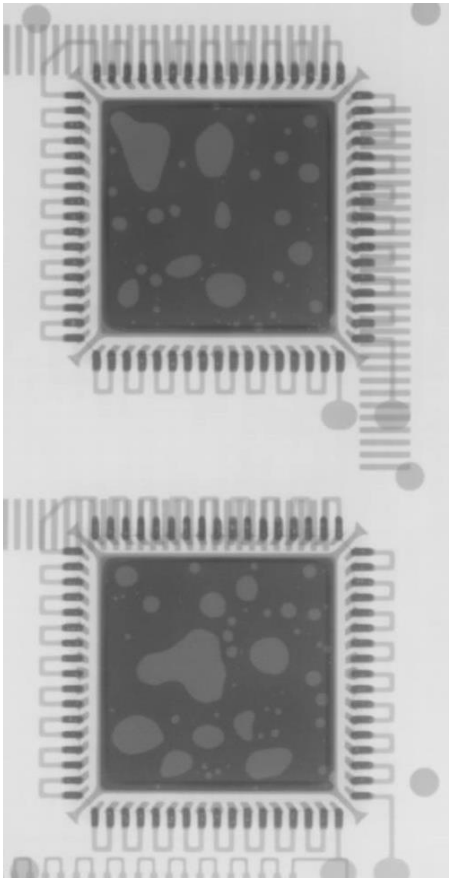
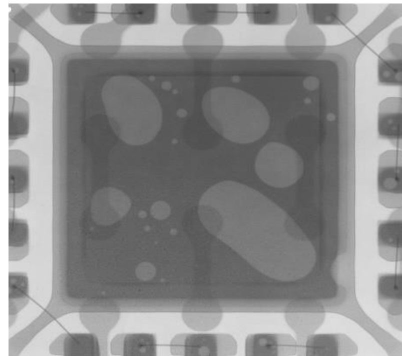
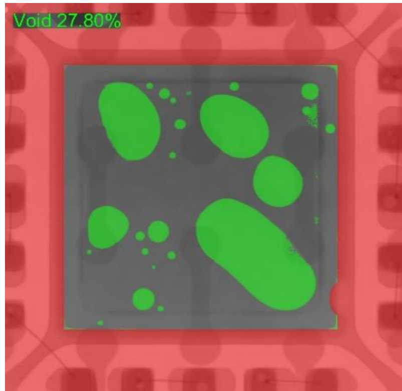
We did a direct comparison of boards that were reflowed in a
normal oven and the vacuum oven

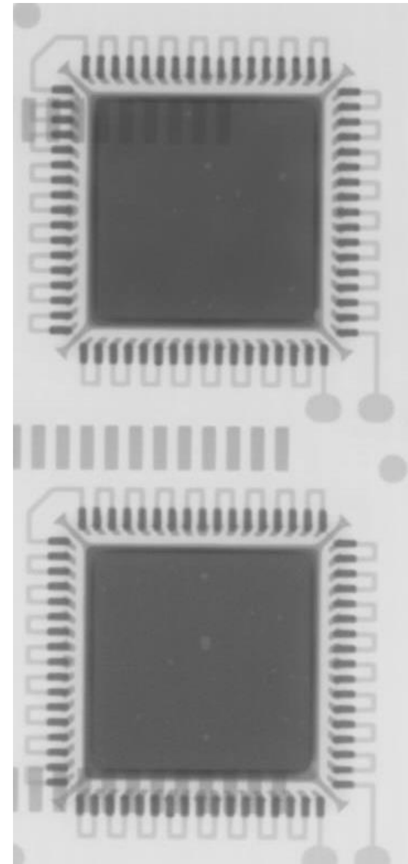
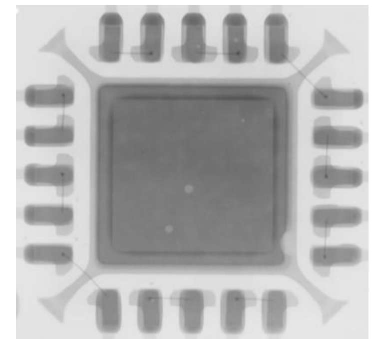
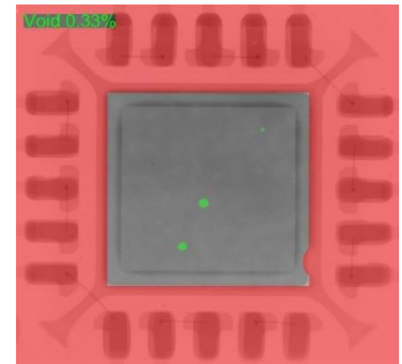
ACI Workshops

Placed 7 components on Practical test boards

SAC 305
20 torr 30 sec

Voids % from the Nov 2019 ACI Workshop

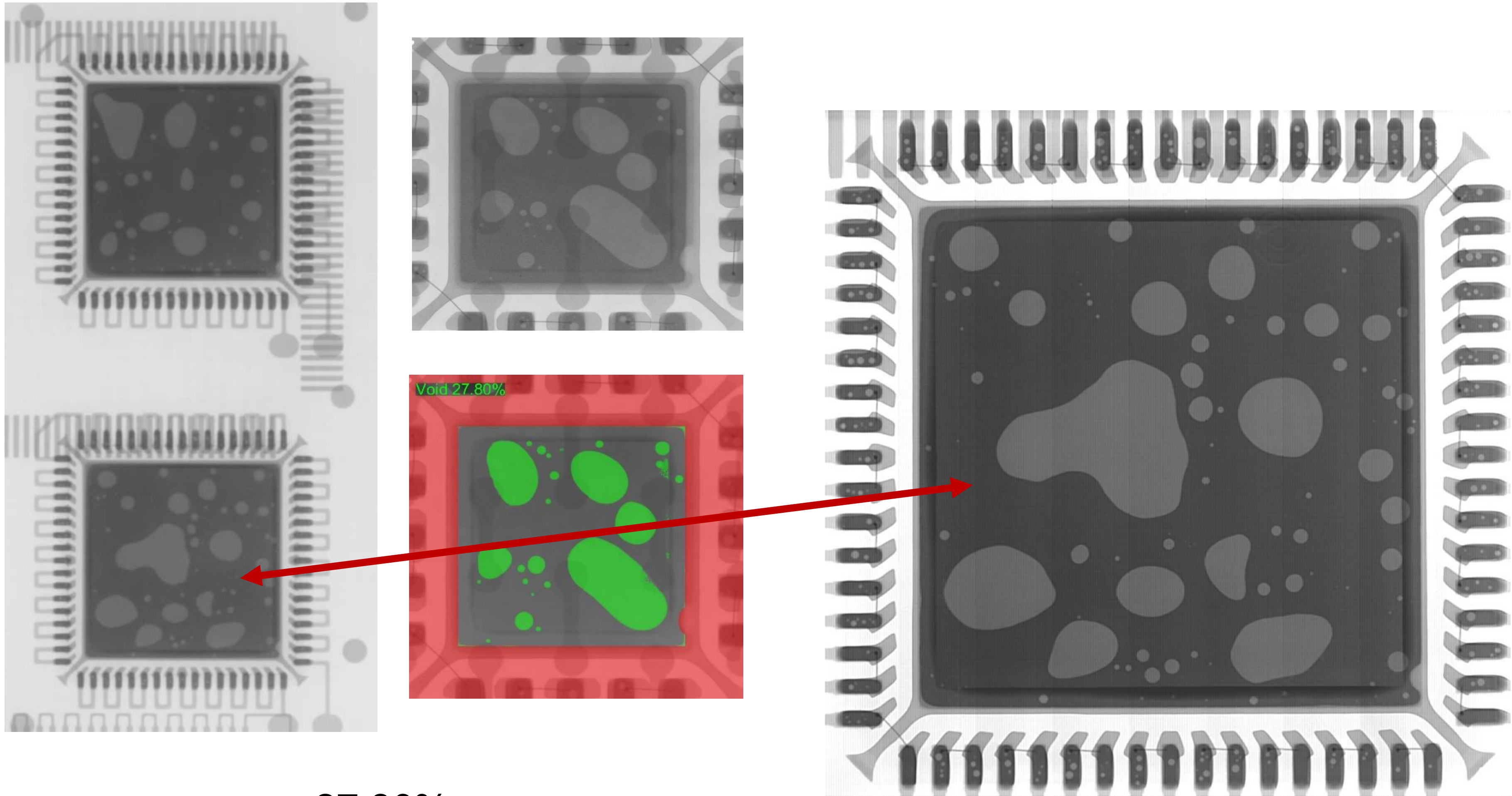




27.80%
No Vacuum

0.33%
20 torr 30 seconds

Rework Feb 2020 -- ACI Demo Board



27.80%
No Vacuum

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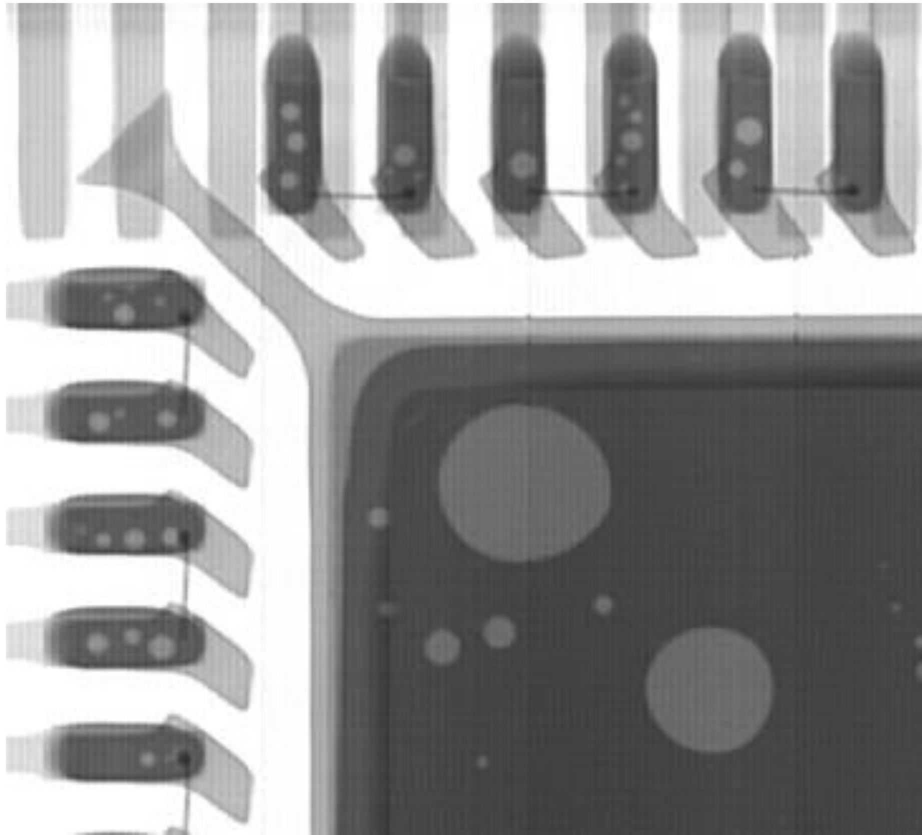

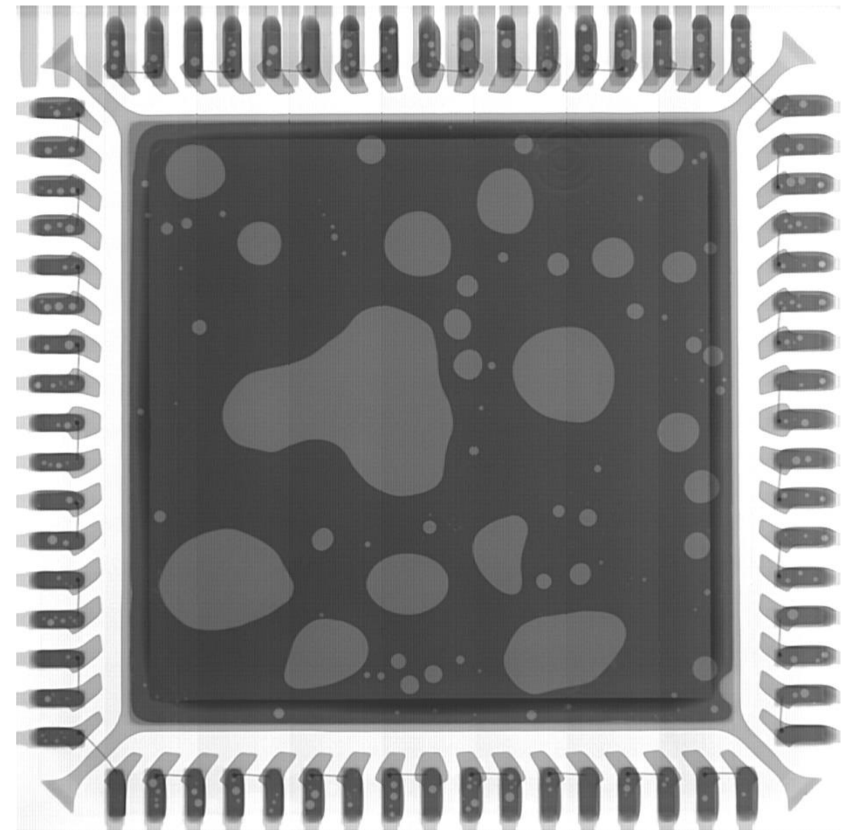

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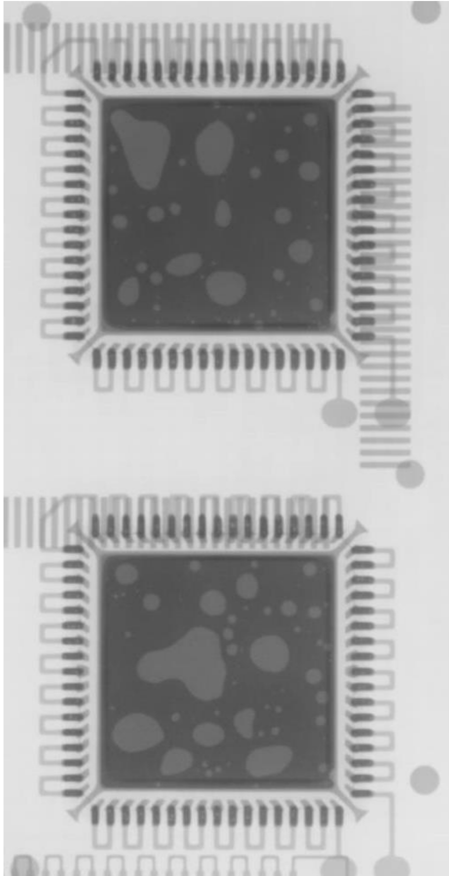

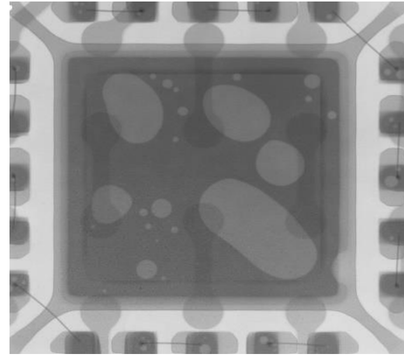

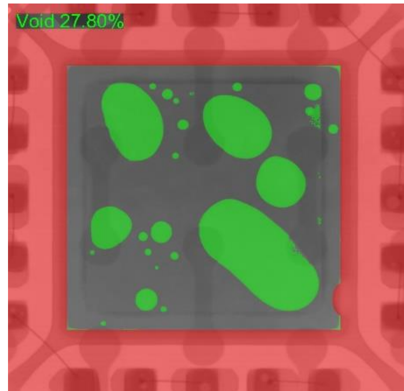

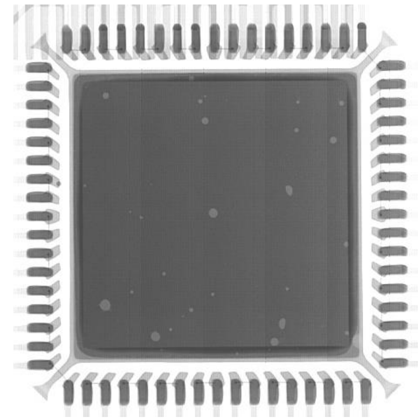

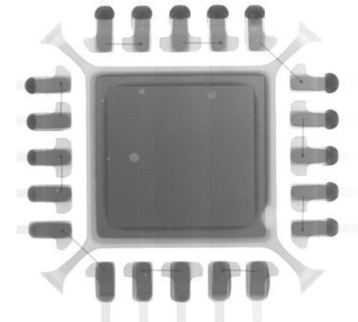

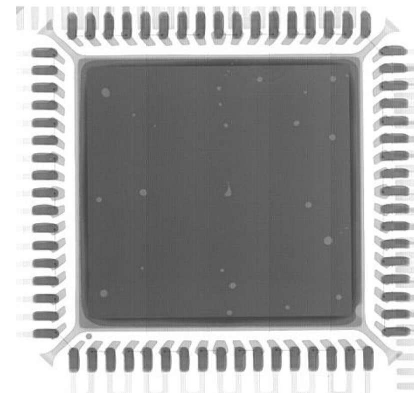

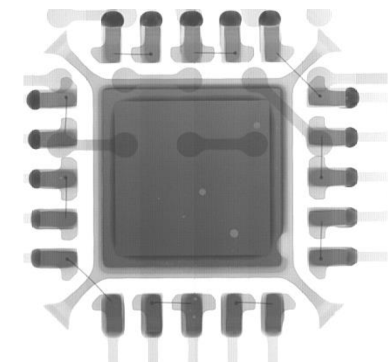

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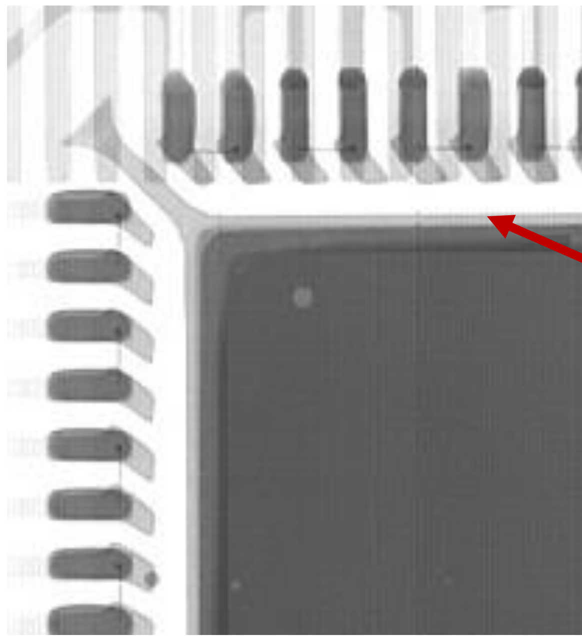

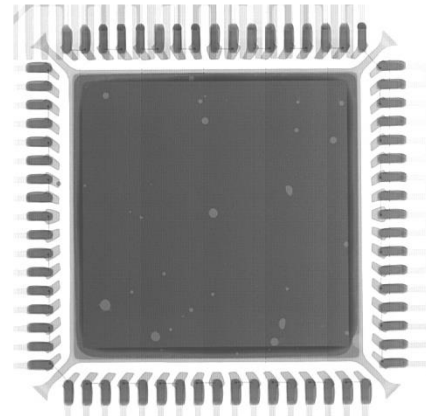

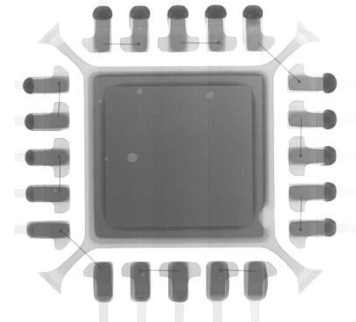

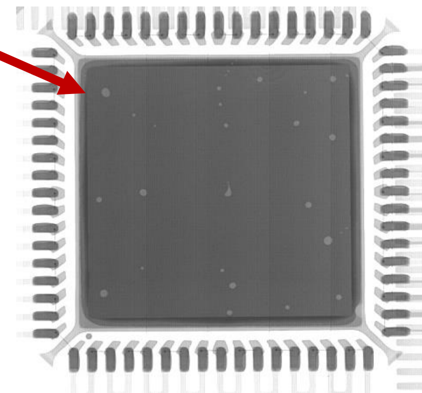

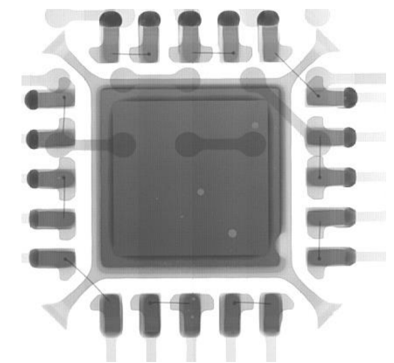

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Thank you!

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