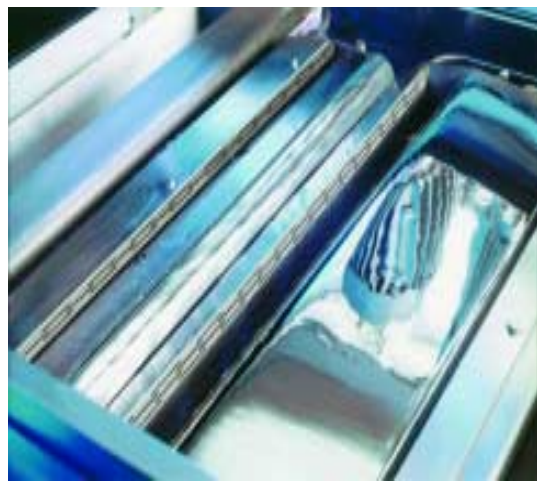
Inert Wave Soldering:



AIR LIQUIDE

What Is Nitrogen ?

- Air: 78% N_2, 21% O_2
- Non Toxic
- Will not Burn nor Sustain Life
- Extracted from Air, Sum-Zero
- Liquid at -183 C, -320 F
- 1 Gal Liquid = 632 Gals N2 Gas
- Flow in SCFH or m^3/h

AIR LIQUIDE

2 Modified Parameters Under Nitrogen

- Oxidation Rate → Wetting
- Surface Tension

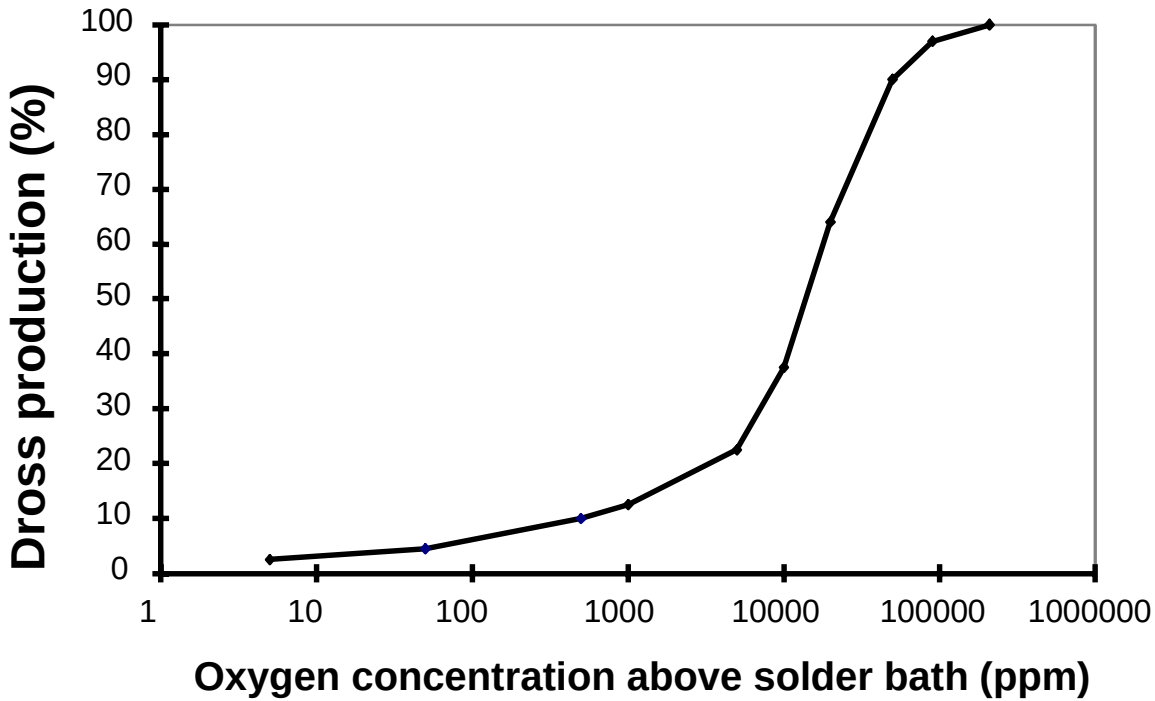
AIR LIQUIDE

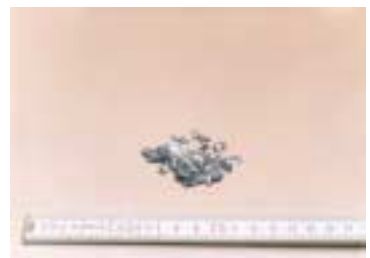
Oxidation Effect

- O_2 on Metal = Oxides
- Oxides Inhibit Wetting
- Flux Role to De-Oxidize
- Oxidation on Molten Sn-Pb = Dross

AIR LIQUIDE

Dross Production vs. Atmosphere





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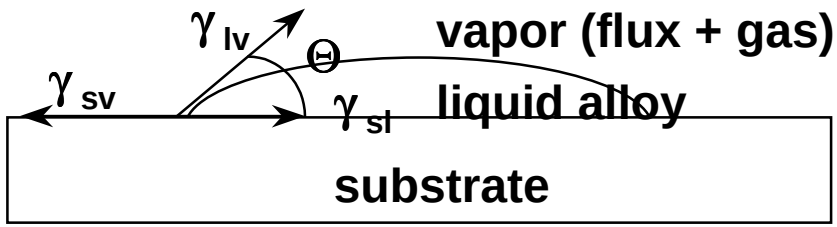
Wetting / Surface Tension Modification



Young's equation : $\cos\Theta = (\gamma_{sv} - \gamma_{sl}) / \gamma_{lv}$

$\gamma_{lv}(N_2) > \gamma_{lv}(air)$
$\gamma_{sv}(N_2) >> \gamma_{sv}(air)$

➔ Improved Wetting Under N_2,
Faster Wetting Under N_2

AIR LIQUIDE

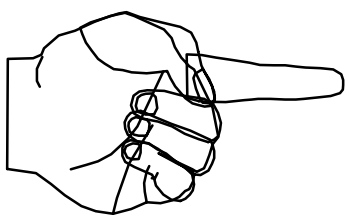
Process Window ?

- **Solderability:**

  1- Board 2- Components 3- Profile

Excellent Solderability ?
N2 will not Help!

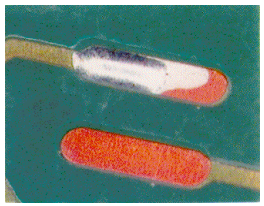
Varying Solderability:
N2 will Help! ←

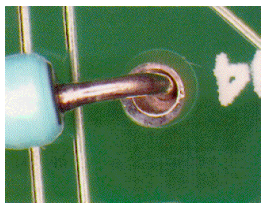


Wider Process Window →
N2 Forgives Process Variations

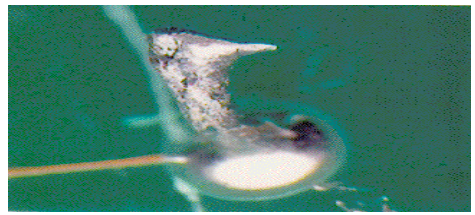
AIR LIQUIDE

Quality = Defects Reduction

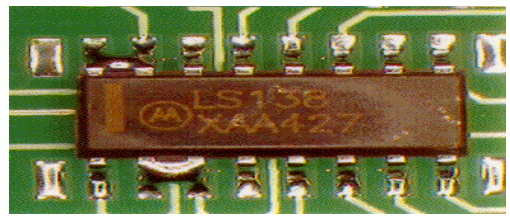




Wetting Defects
Poor Top-Side
Opens, Voids



Icicles



Bridging

High Solids WS → **Low Solids No-Clean**

Defects ↓

AIR LIQUIDE

Quality = Reliability

N2 Joints are Stronger ?:

- Lower Wetting Angle
- Better Wetting
- Finer Crystalline Structure

	Air	Nitrogen
Component 1	182	3
Component 2	302	100

Source: Siemens AG
Other Source: Lucent

AIR LIQUIDE

Quality = Better Product & Savings

Lower Defects

Reduced Touch-Up

Higher Joint Reliability

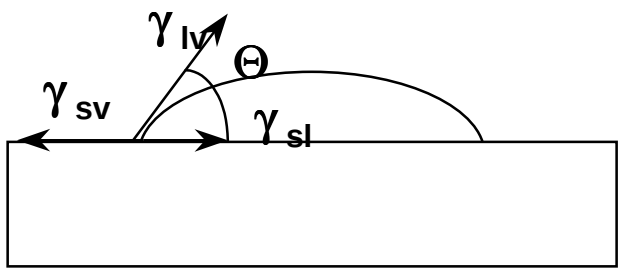
Increased Product Life Test Yield

Increased Life of Product

Lower Field Defect Rate

AIR LIQUIDE

Reduced Flux Requirements



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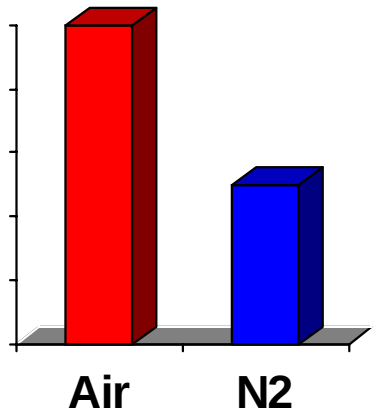


↑ More Wetting

↓ Less Oxides Formed During Process

* Opportunity to Reduce Flux: 30% - 60%
Spray Fluxer Only

AIR LIQUIDE

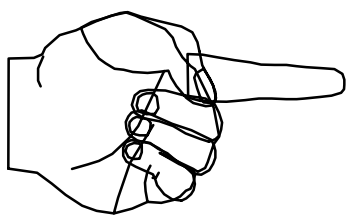
Benefits Of Inert Wave Soldering:

- Dross Reduction
- Reduced Maintenance - Higher Uptime
- Reduced Flux
- Flexibility - Wider ‘Process Window’
- Use of Low Solids
- ISO 14,000 Compliance
- Reduced Dross Related Defects
- Reduced Defects / Increased Yield

AIR LIQUIDE

Motivations to Adopt N2:

- Dross Reduction
- No-Clean vs. Clean
- Lead-Free *** N2 Mandatory
- OSPs
- Multiple Passes
- Defects & Reliability



Cost & Environment

AIR LIQUIDE

Dross Production vs. Lead-Free

- New Alloys
- Higher Temperature

→

- Oxidation ↑
- Dross ↑
- Solder Cost ↑

Example:

Alloy	Brand Name	Melting T: (C) *	Metal Cost: ($ / lb) *	Metal Cost (in3) ($ / in3) *	Dross Production: (lbs/hr) **		Cost of Dross: ($ / hour) * & **	
					Air	N2	Air	N2
Sn63/Pb37	-	183	2.37	0.75	3	0.65	**7.11**	**1.54**
Sn96.7/Ag2.0/Cu0.8/Sb0.5	Castin	213-219	5.48	1.46	3.42	0.85	**18.74**	**4.65**

Source: * Alpha Metals / Circuit Assembly - August 1999
**** ITRI / Air Liquide R&D Test**

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Inert Reflow Soldering:

AIR LIQUIDE

2 Modified Parameters Under Nitrogen

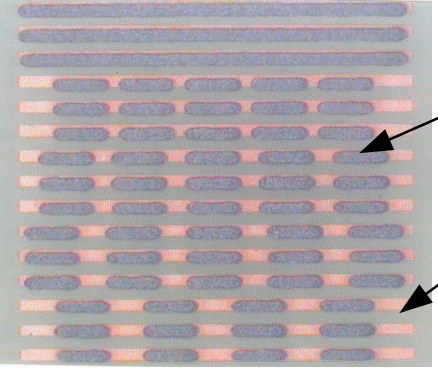
- Oxidation Rate → Wetting
- Surface Tension

AIR LIQUIDE

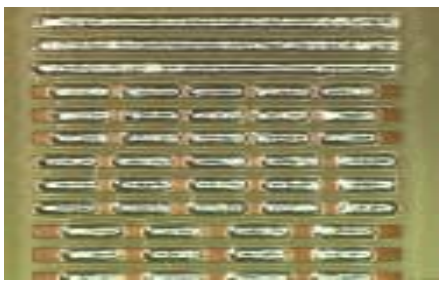
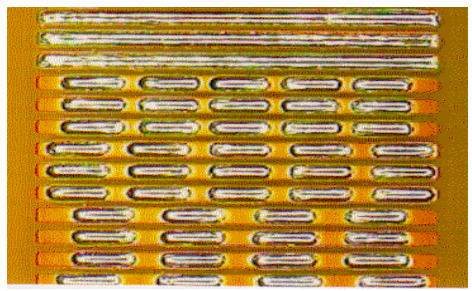
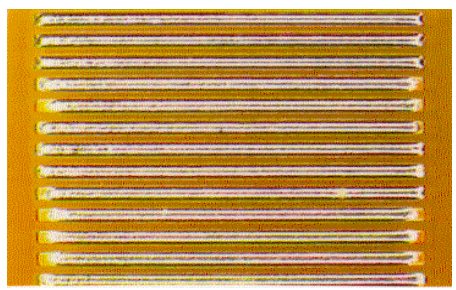
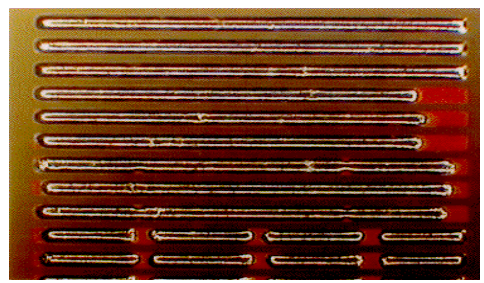
Oxidation Effect

- O_2 on Metal = Oxides
- Oxides Inhibit Wetting
- Flux Role to De-Oxidize

AIR LIQUIDE



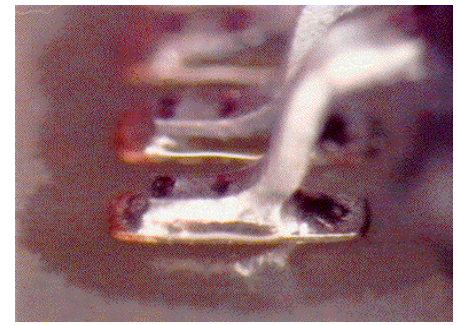
N2 Increases Wetting

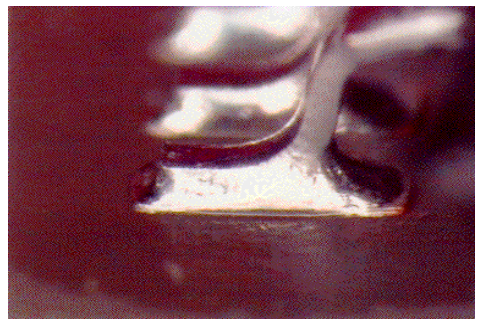
	Typical RMA - WS	Typical Low Residue	Typical Very Low Residue
AIR			
N_2			

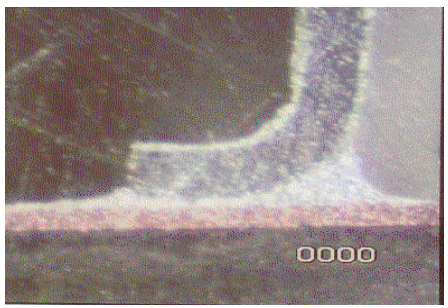
Photos: U of Bordeaux, FR., Microelectronics Lab

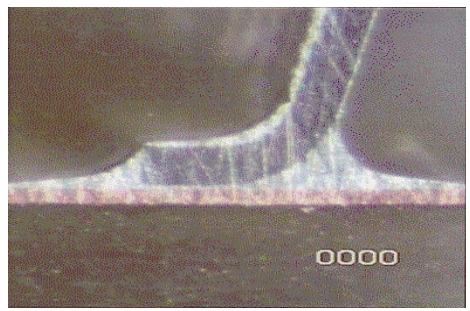
Increased Fillet and Wetting Angle

QFP64 - Double Reflow, HASL









Air

N2 - 100 PPM

Source: Canon
Nepcon W. 1997

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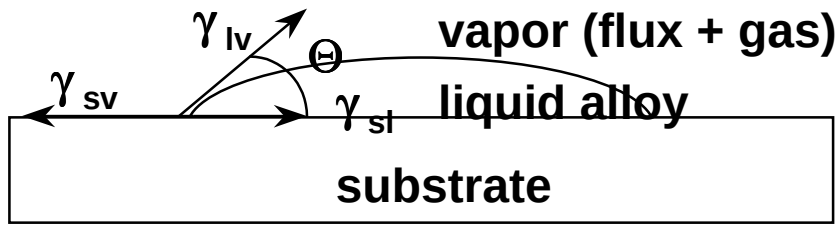
Surface Tension Modification



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➔ Improved Wetting Under N_2,
Faster Wetting Under N_2

AIR LIQUIDE

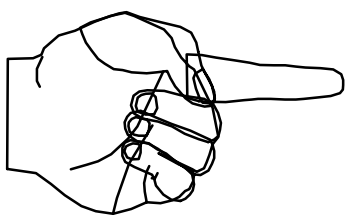
Process Window ?

- **Solderability:**

  1- Board 2- Components 3- Profile

Excellent Solderability ?
N2 will not Help!

Varying Solderability:
N2 will Help! ←



Wider Process Window →
N2 Forgives Process Variations

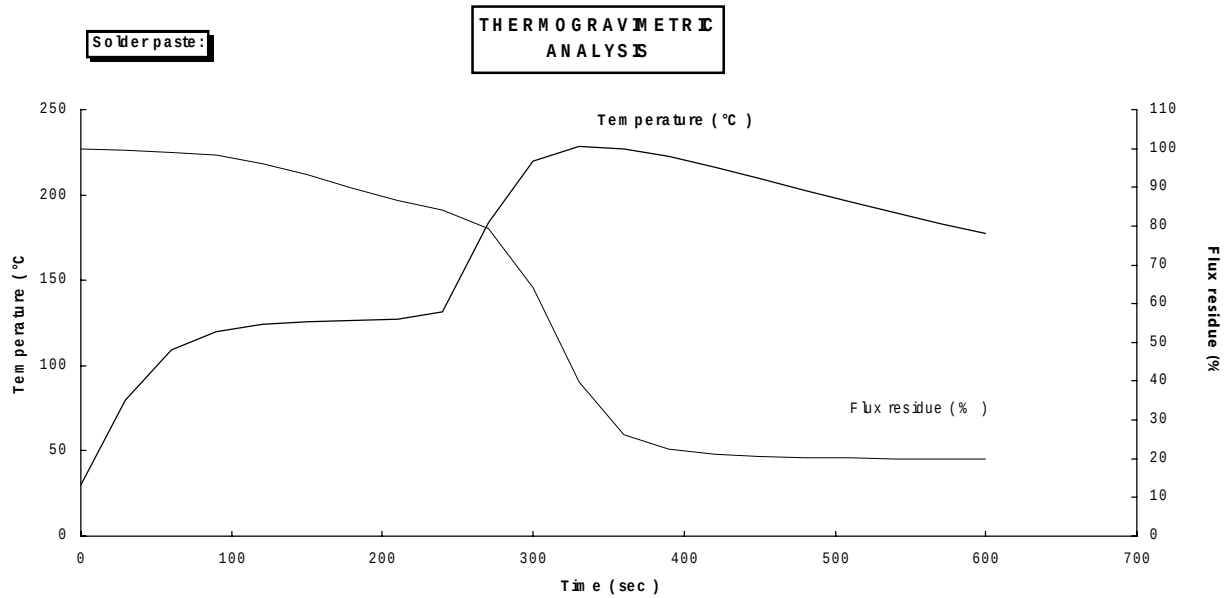
AIR LIQUIDE

Key Reflow Considerations

- Cleanliness:
  - Ability to Clean
  - Level of Residues
- Quality:
  - Defects
  - Reliability

AIR LIQUIDE

Reduced Residue Levels with N2



RMA / WS:
up to 45%
Less Residues
Under N2

Low Residue:
up to 65%
Less Residues
Under N2

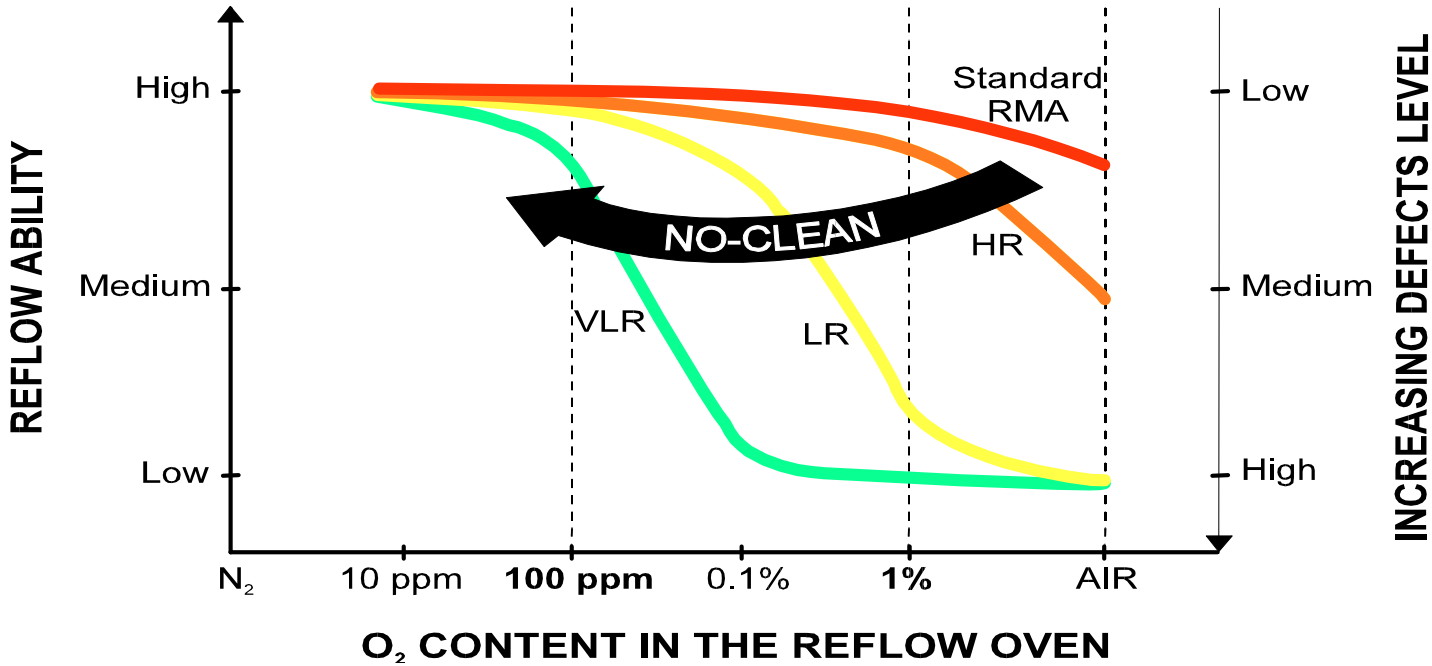
Very Low Residue:
up to 75%
Less Residues
Under N2

*** Varies by Paste Manufacturer - Paste Specific**

Source: ESP Solder / Nepcon W. 1997

AIR LIQUIDE

Quality = Defects



High Solids WS

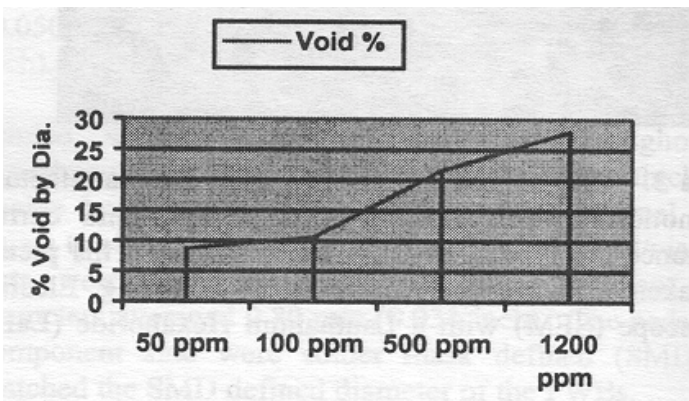
Low Solids No-Clean

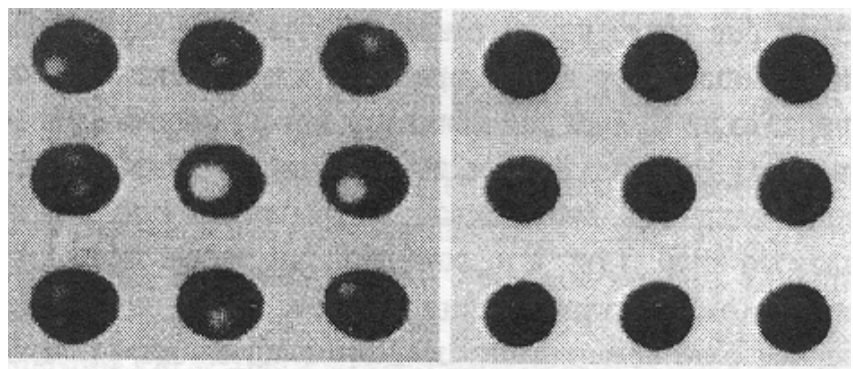
Defects ↓

AIR LIQUIDE

BGA Voiding Reduction

- Voiding = Entrapped Gas
- Oxide Crust on Ball
- Voiding f() Oxygen
- Reduction 60%+ Air vs. N2





Source: Casey, Proceedings SMI 1998

AIR LIQUIDE

Quality = Reliability

N2 Joints are Stronger ?:

- Lower Wetting Angle
- Better Wetting
- Finer Crystalline Structure

	Air	Nitrogen
Component 1	182	3
Component 2	302	100

Source: Siemens AG
Other Source: Lucent

AIR LIQUIDE

Quality = Better Product & Savings

Lower Defects

Reduced Touch-Up

Higher Joint Reliability

Increased Product Life Test Yield

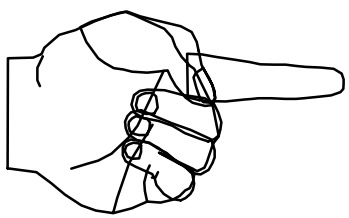
Increased Life of Product

Lower Field Defect Rate

AIR LIQUIDE

Benefits Of Inert Reflow Soldering

- Aesthetics - Shinny Joints
- Flexibility - Wider 'Process Window'
- Use of Low Solids
- Easy Cleaning - Residues not Polymerized
- Reduced Automatic Testing False Fails
- BGA Voiding - 60%+ Less
- Reduced Defects / Increased Yield



Level of Benefits Depends on Process Conditions

AIR LIQUIDE

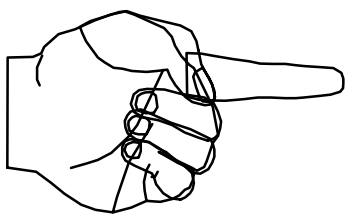
Conditions of Using Nitrogen - Reflow

Conditions Optimized by Nitrogen	Conditions Less Optimized by Nitrogen
- Expensive & Integrated Component Assembly (BGA, CSP, COB, …) - Fine Pitch <20 mil - Low Volume/Prototype - Non Reworkable Components	- Standard Components & Packages - Conventional Pitch - Mature Assemblies - Easily Reworkable Components
- OSP - Bare Copper - Old/Oxidized Boards	- Standard Finishes
- No Clean - Residues a Concern - Automatic Testability Process	- Aqueous - Residues not a Concern - Standard Testing
- High Temperature Solder - Multi-Pass Assemblies	- Single-Pass Assemblies
- Reliability a Priority	- Reliability not a Priority

AIR LIQUIDE

Motivations to Adopt N2:

- Cleanliness - Residues
- No-Clean vs. Clean
- Lead-Free *** N2 Mandatory ?
- OSPs, Multiple Heat Incursions
- Pin-in-Paste Reflow (PTH Reflow)
- Finer-Pitch, Flip-Chips, CSPs, µBGA, ...
- Defects & Reliability



Cost & Environment

AIR LIQUIDE