Ultra-Low and Near-Zero Residue Flip-Chip Fluxes

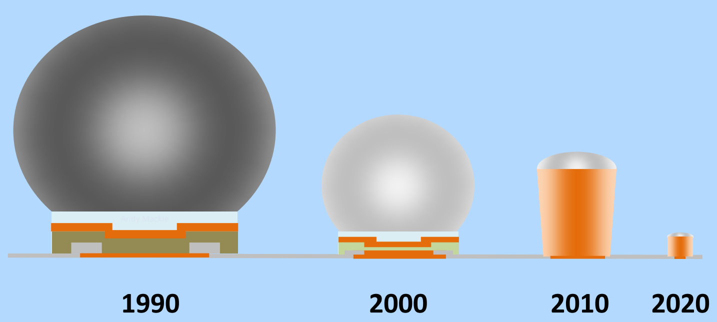
Introduction

Indium Corporation's **Ultra-Low and Near-Zero Residue (ULR/NZR) Flip-Chip Fluxes** are halogen-free, no-clean dipping fluxes, designed to leave a very small amount of a benign, solid, clear residue after reflow. By reducing the residue quantity, the flux allows the flow of capillary or molded underfills (CUF/MUF) without underfill voiding, and its benign chemical nature optimizes the strength of the flux/underfill interface. By eliminating the cleaning process, these fluxes also eliminate the excessive stresses on the die and solder joints caused by every aspect of flux cleaning: jet impingement, ultrasonic and megasonic vibration, air-knife drying, warpage during drying, and unnecessary handling.

Features

- Copper-pillar and standard bump flip-chip dipping
- Suited for high-tin alloys
- Ultra-low or near-zero residue levels (ULR/NZR) post-reflow
- Halogen-free (NIA)
- No-clean
- Residues compatible with CUF/MUF

Flip-Chip Solder Bump Evolution



Physical Properties

Properties	Flux Name: NC-699	NC-26-A	NC-26S	Test Method
Flux Type	REL0	REL0	REL1	J-STD-004 (IPC-TM-650: 2.3.32 and 2.3.33)
Color	Light Yellow	Light Tan	Light Yellow	Visual
Typical Viscosity and Test Method	1.5kcps	4kcps	13kcps	
	Brookfield DV-1. 40CPE Spindle @ 10rpm after 3 mins	Brookfield DV-1. 51CPE Spindle @ 10rpm after 5 mins	Brookfield DV-1. 51CPE Spindle @ 20rpm after 5 mins	
Typical Acid Value	39mg KOH/g	36mg KOH/g	39mg KOH/g	Titration
SIR Test	Pass	Pass	Pass	J-STD-004 (IPC-TM-650: 2.6.3.3 IPC-B-24)
Typical Post Reflow Residue Weight	<2%	~5%	<10%	TGA Data
Working Life	≥ 8 hr	≥ 8 hr	≥ 8 hr	Customer Experience (Flip-Chip)
Shelf Life	12 months when stored at 0 to 30°C	6 months when stored at 0 to 30°C	6 months when stored at 0 to 30°C	Viscosity Change/ Microscopic Examination

www.indium.com askus@indium.com

ASIA: Singapore, Cheongju, Malaysia: +65 6268 8678
CHINA: Suzhou, Shenzhen: +86 (0)512 628 34900
EUROPE: Milton Keynes, Torino: +44 (0) 1908 580400
USA: Utica, Clinton, Chicago, Rome: +1 315 853 4900

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Ultra-Low and Near-Zero Residue Flip-Chip Fluxes

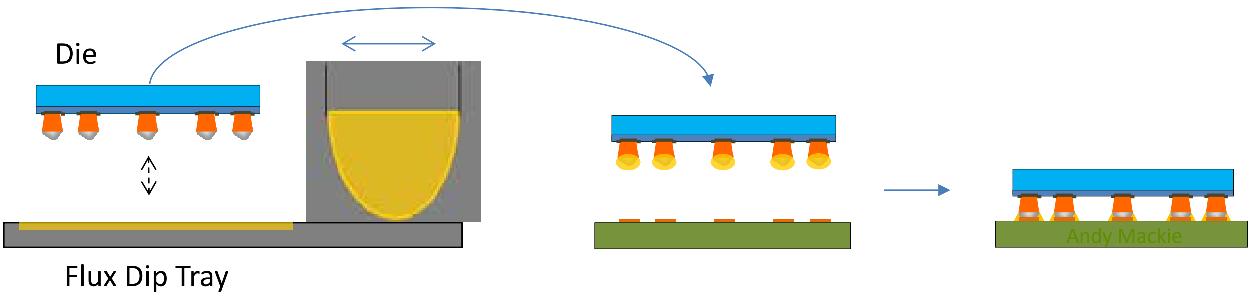
Application

Good | Average | Not Good

	NC-699	NC-26-A	NC-26S	Standard No-Clean Flux
Solderability	Good	Good	Good	Good
Residue level	Good	Good	Average	Not Good
Allows easy underfilling with CUF/MUF	Good	Good	Good	Not Good
Compatibility with CUF/MUF	Good	Good	Good	Not Good
Holds large die in place during reflow	Average	Good	Good	Good
Use in volume by major OSAT/ODM for thin devices	Memory	Logic	Logic	Not Good

Dipping Process

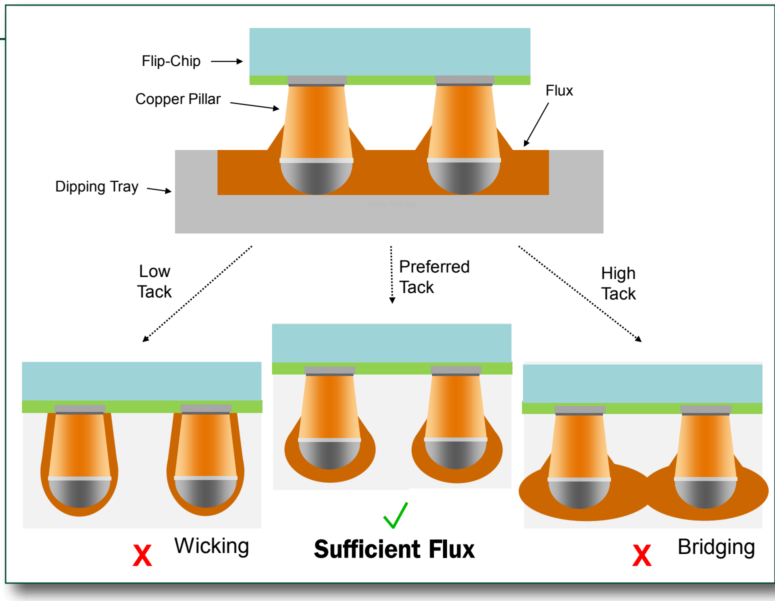
The dipping process is relatively simple, but must be adjusted according to the process needs.

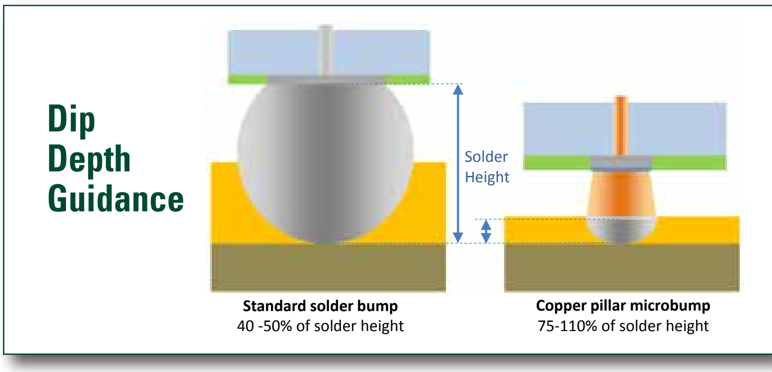


Flux Rheology is Critical

Major Control Variables

- **Dipping speed (insertion into dip tray)**
  - "Center splash" phenomenon can occur in depopulated areas, as a "wave" of flux touches the bottom of the die
- **Dwell time in dip tray**
  - Not a major effect except if "wicking" up fine pitch copper pillars is seen
- **Withdrawal speed**
  - Affects amount of flux picked up
- **Head deceleration after dip**
  - Momentum of flux may carry flux up copper pillars if deceleration is sudden after fast withdrawal speed from flux reservoir
- **Time of flux in dip tray:**
  - Longer time under shear means lower viscosity, until equilibrium viscosity is reached
  - Line stoppage will lead to slow flux viscosity increase
  - Time also affects solvent loss (irreversible "drying")





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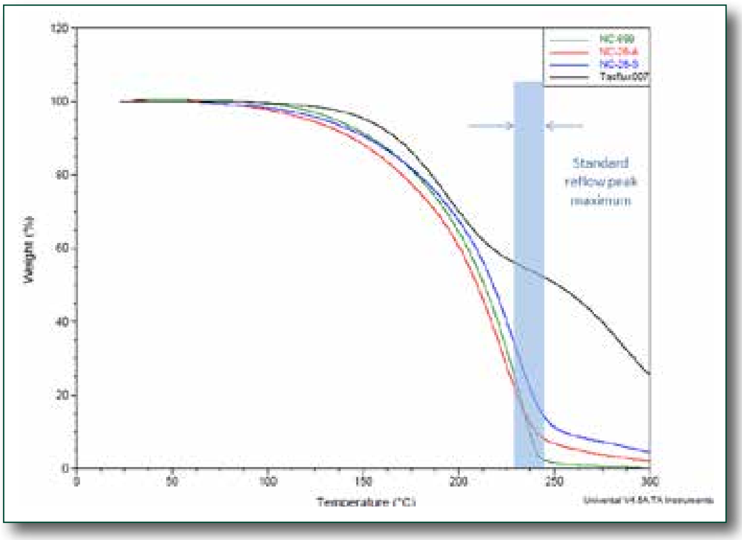
Residue Levels



Thermogravimetric analysis (TGA) allows a small sample of a material to be subjected to controlled heating as the mass of the sample is simultaneously measured.

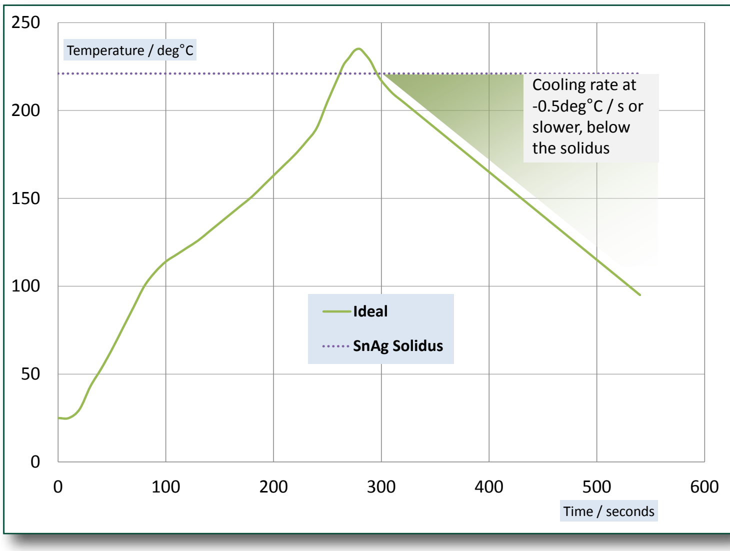
Shown on the left are the TGA curves of the three flip-chip fluxes compared to a standard flux (TACFlux®007).

Reflow Profile

Indium Corporation ULR/NZR fluxes are designed to be reflowed in nitrogen, at an oxygen (O_2) level significantly less than 100ppm O_2. This allows for good solderability onto pads and copper traces.

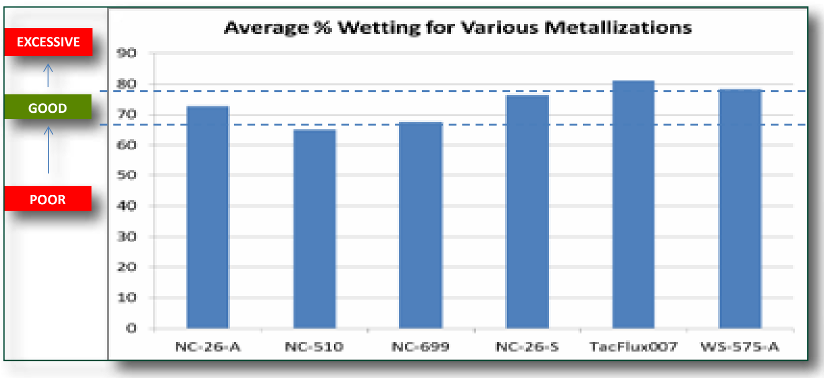
A standard profile for thinned die and substrates is shown on the right. Oven reflow manufacturers are now designing flip-chip reflow ovens with strong exhausts in the center of the oven (for example, zone 4 of a 7 heated-zone oven), in order to accommodate for the excess flux volatiles that are produced by placing the peak ("spike") heater zone in this location. Slow, controlled cooling allows die and joint damage caused by thinned substrate warpage to be minimized.

The removal of all volatiles from the flux residue is more challenging for larger die, with low clearance (die-substrate distance) and fine pitch. A reflow profile with a higher peak temperature, and a slower cool down rate will allow the volatile materials in these **ULR/NZR fluxes** to be removed more completely.



Profile optimized for thin die/thin substrate flip-chip.

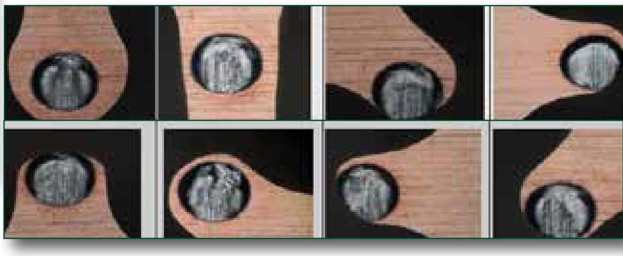
Reflow and Solderability (Wetting)



Indium Corporation ULR and NZR fluxes allow void-free wetting without bridging.

Wetting must be controlled, and balance between:

- **Excessive:** leading to bridging or solder joint starvation
- **Poor:** leading to non-wetting or weak solder joints with voids



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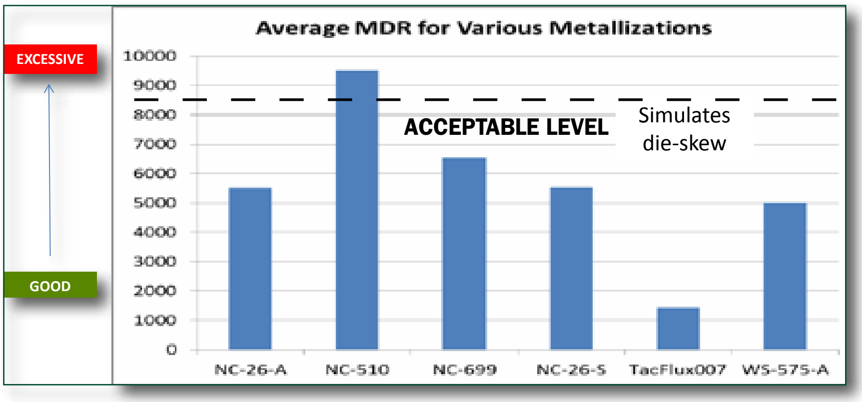
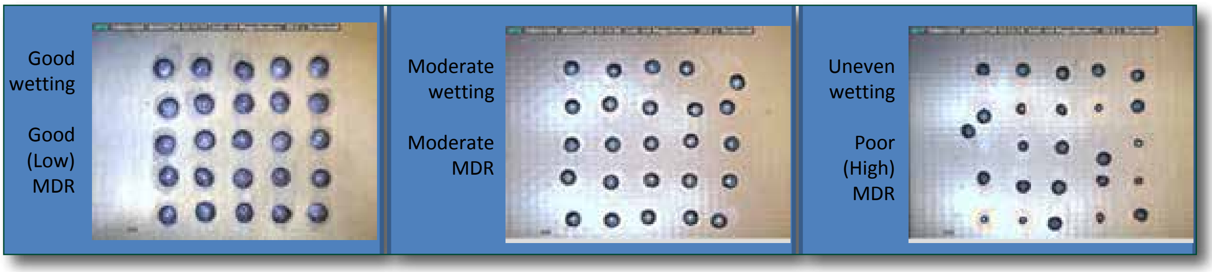
Movement During Reflow



In a standard mass reflow process, the flux must both hold the die in place and also solder quickly, to minimize the die movement during reflow (MDR). MDR results in die misalignment, skew or die tilt. The MDR test method uses solder spheres precisely mounted in flux; these are then reflowed in place, and the extent of movement away from their centers after reflow.



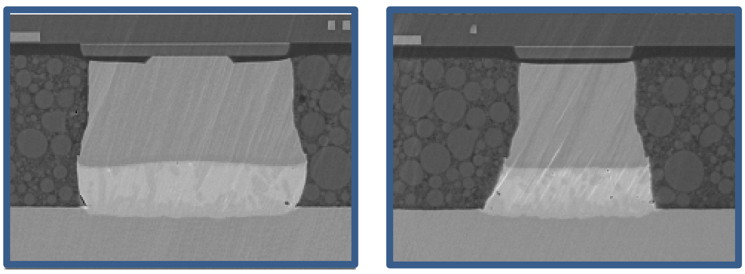
Indium Corporation ULR and NZR fluxes holde die in place during reflow without skewing.

CUF/MUF Compatibility

Delamination at any of the interfaces between the underfill material and the chip can be a source of joint failure during thermal cycling (TC) or thermal shock (TS) testing of the underfilled die. Until now, fluxes have been cleaned away using water or solvent, as they have not been compatible with underfills. Now, with Indium Corporation ULR and NZR fluxes, compatibility with uncleaned residues can be achieved. Customer data has proven that even the most demanding molded underfill can be compatible with ULR flux residues after curing and TC.

Compatibility After 1000 Thermal Cycles (-55/+125C)

Flip-Chip Flux NC-26-A with Molded Underfill (MUF)



No delamination

www.indium.com askus@indium.com

ASIA: Singapore, Cheongju, Malaysia: +65 6268 8678
CHINA: Suzhou, Shenzhen: +86 (0)512 628 34900
EUROPE: Milton Keynes, Torino: +44 (0) 1908 580400
USA: Utica, Clinton, Chicago, Rome: +1 315 853 4900

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