PRODUCT DATA SHEET

WS-446HF Flux

Introduction

WS-446HF Flux is a robust, halogen-free, water-wash flux that was designed to provide one simple solution to complicated applications, especially those with a single cleaning step for both BGA ball-attach and flip-chip processes. It has a powerful activator system to promote good wetting on even the most demanding substrate metalizations such as Cu OSP, ENEPIG, and ENIG. Its rheology is suitable for dipping flip-chip applications, as well as pin transfer or printing BGA ball-attach applications, for sphere sizes 0.25mm and above. **WS-446HF** helps to improve production yield by minimizing non-wet-open defects, missing balls, and electrochemical migration (ECM).

Features

- Designed for flip-chip dipping and BGA ball-attach pin transfer/printing applications
- Promotes excellent solderability and wetting on a wide range of surfaces
  - Good results on AuNi and even on oxidized Cu OSP (up to 0.3mm thick OSP)
- Cleans well with room temperature DI water
  - Saves money on water heating
  - Avoids formation of white residue
- Eliminates ECM or dendrite formation caused by residue
- Designed for Pb-free applications
  - Suitable for all high-tin solders
- Halogen-free – per IPC and IEC specifications
- Ensures consistent joint quality by providing consistent dipping, pin transfer, and printing performance over extended periods
- Promotes strong, low-voiding joints
- Minimizes die skew, non-wet-open, and "missing balls"
  - Maintained tackiness during heating results in faster soldering
- Eliminates warpage due to "prefluxing" with lower process costs
- Reflows in air or nitrogen
- Stable at room temperature for up to 1 year
  - Ease of storage and use without crystals or gel balls
  - Ready to use, straight from the jar or cartridge

Cleaning

WS-446HF residue can be cleaned with DI water, or water with an added cleaner. Ideal conditions for spray-cleaning: 25°C (room temperature) to 40°C for >1 minute at 60psi or higher.

Packaging

WS-446HF is available airlessly packaged in 10 and 30cc syringes, and is also available in jars or cartridges, on customer request.

Storage

For maximum shelf life, **WS-446HF** syringes and cartridges should be stored tip down. Storage temperatures should not exceed 30°C. If using cold storage, **WS-446HF** should be allowed to stand for at least 4 hours at room temperature before using.

Technical Support

Indium Corporation sets the industry standard in providing rapid response, onsite technical support for our customers worldwide. Indium Corporation's team of Technical Support Engineers can provide expertise in all aspects of materials science and semiconductor packaging process applications.

Safety Data Sheets

Please refer to the SDS document within the product shipment, or contact our local team to receive a copy.

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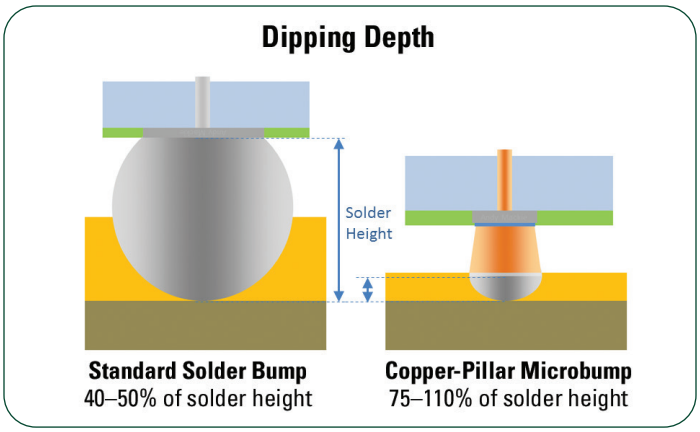
Flip-Chip Application

WS-446HF is intended to be used in an air or nitrogen reflow environment of 50ppm oxygen or less. **WS-446HF** can be used on many surface finishes. **WS-446HF** has been developed to allow tin and tin/silver solder bumps, in both standard bump shapes and as microbumps on copper pillars, to solder well to any quality of substrate metallization. **WS-446HF** also allows poor-quality OSP to be soldered to, without non-wet open solder joints.

Flip-Chip Flux Dipping Process

The dipping depth should be adjusted to exact needs. Guidelines are given in the illustration below. The flux reservoir (dip tray) should be cleaned and replenished every shift.



Properties

	Value	Test Method
Typical Viscosity	21kcps (5 minutes)	Brookfield HB DVII+-CP @ 5rpm
Typical Acid Number	93mg KOH/g	Titration
Typical Tack Strength	150gf	J-STD-005 (IPC-TM.650: 2.4.44)
Shelf Life	12 months at 0–30°C	Viscosity change/ microscope examination

Industry Standard Test Results and Classification	
Flux Classification	ORH0*
Based on the testing required by IPC J-STD-004A.	
Halogen-free per IEC 61249-2-21, Test Method EN14582	<900ppm Cl <900ppm Br <1,500ppm total

All information is for reference only.
Not to be used as incoming product specifications.

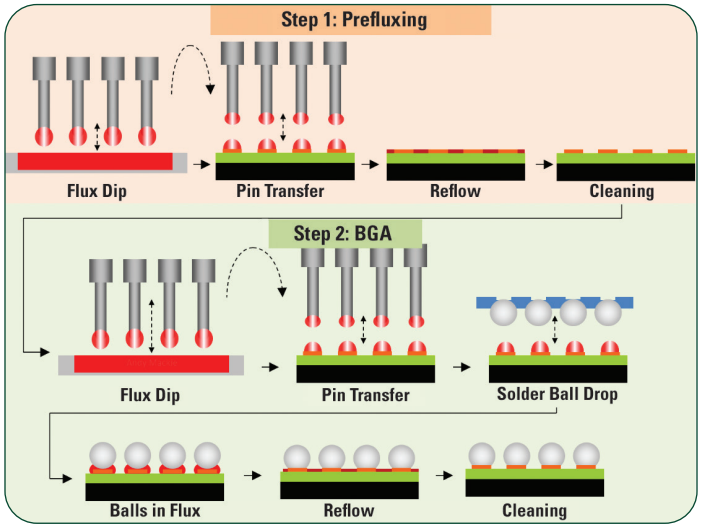
Ball-Attach Application

WS-446HF's special activator package promotes good wetting on the most demanding surfaces such as Cu OSP. Typically, ball-attach for BGA application is the last step in the assembly process as, at this stage, the pads have gone through multiple heat cycles, wash cycles, etc. These pads are therefore heavily oxidized or contaminated, which affects the solderability of the sphere onto the pad. Good wetting performance of the flux is necessary to ensure final strong joints.

WS-446HF proves to be a true single-step ball-attach flux to eliminate the preflux process, thus to avoid the costly, wasteful, and warpage-inducing effects.

The "Standard Ball-Attach Process" diagram shows the typical two-step flux processing that is needed to create reliable, ball-to-pad joints from final BGA balling. The prefluxing step can only be eliminated if the flux has sufficient activity to overcome the extent of the oxidation on copper, and create strong solder joints.

Ball-Attach Process



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WS-446HF Flux

Proven Flux Rheology Consistency

Viscosity Test Method

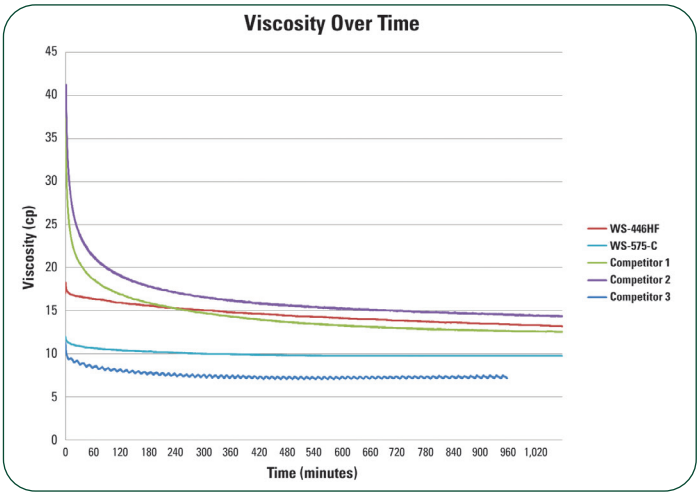
- **Equipment**
  - Brookfield Cone & Plate
  - Model: DV3THBCB
- **Parameters**
  - Spindle: CP-51
  - Temperature: 25°C
  - Rpms: 10rpm

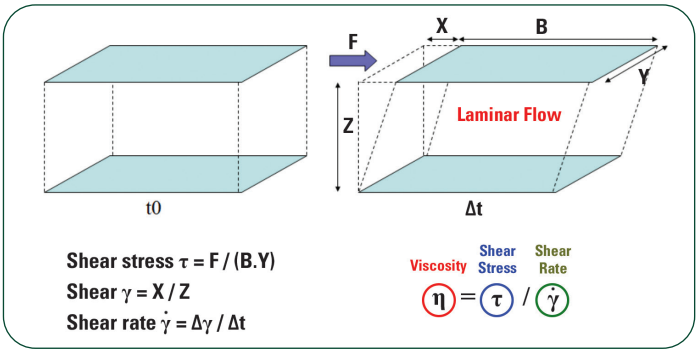
Tack Test Method

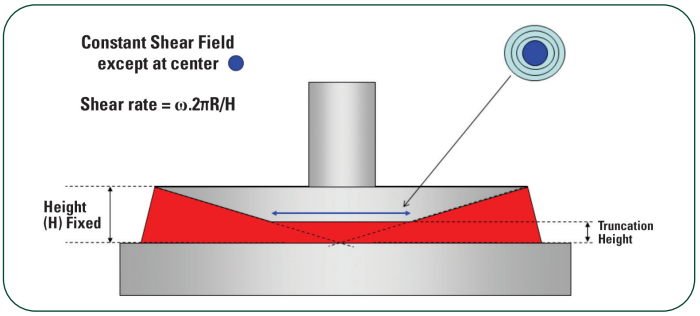
- **Equipment**
  - Texture technologies TA.XT2
- **Parameters**
  - Ambient conditions
  - Humidity: 50% ± 3%
  - Room temperature: 21.5°C ± 2°C

Viscosity as a Function of Time

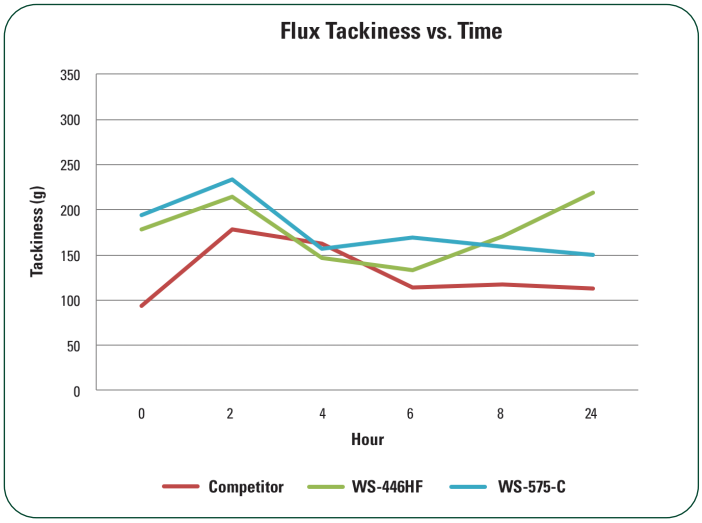
Viscosity Controls







Tack as a Function of Time



Consistent Flux Rheology Over Time

WS-446HF's consistent viscosity and tack ensure uniform flux volume on all solder joints. This assures consistent joint quality and a consistent process for better control over time.

- Flip-chip application
  - Holds die in place, minimizing die skew and non-wet open defects
- Ball-attach application
  - Holds spheres well to eliminate "missing ball"

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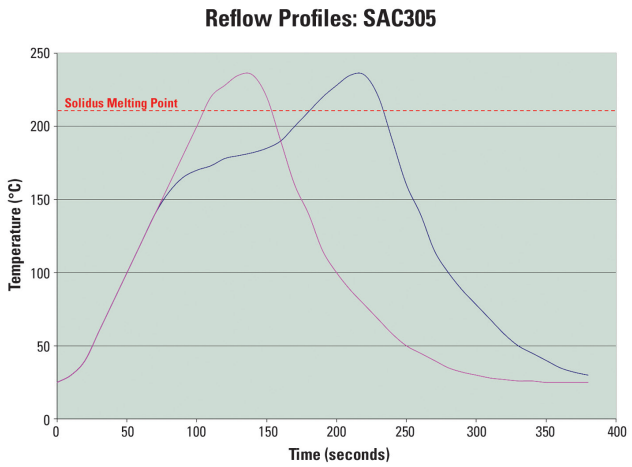
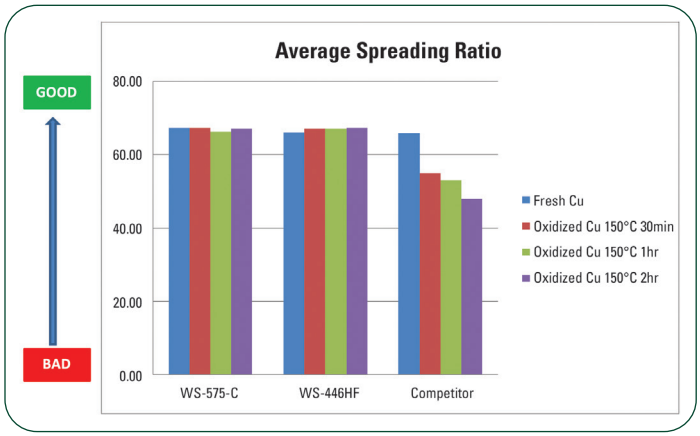
WS-446HF Flux

Reflow

Recommended Profile



WS-446HF is suitable for air and nitrogen reflow, and can work well in a variety of reflow profiles.

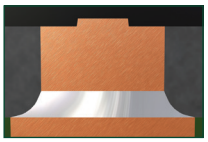


Increase Joint Strength

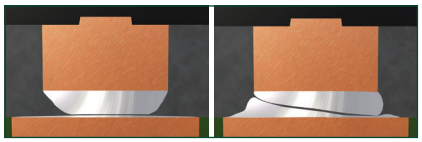
Joint strength is high due to good wetting. From the solderability testing results, the spreading ratio of **WS-446HF** is excellent even on a heavily oxidized Cu test coupon. This ensures the solder bump or sphere has good wetting even on demanding surfaces.

Reduce Open Joint

- Good wetting
- Good tack to hold FC die in place even though there is warpage issue



Good Wetting



Reduces Open Joint and HIP

$$S_R = \frac{D - H}{D} \times 100 \quad \text{.....(16)}$$

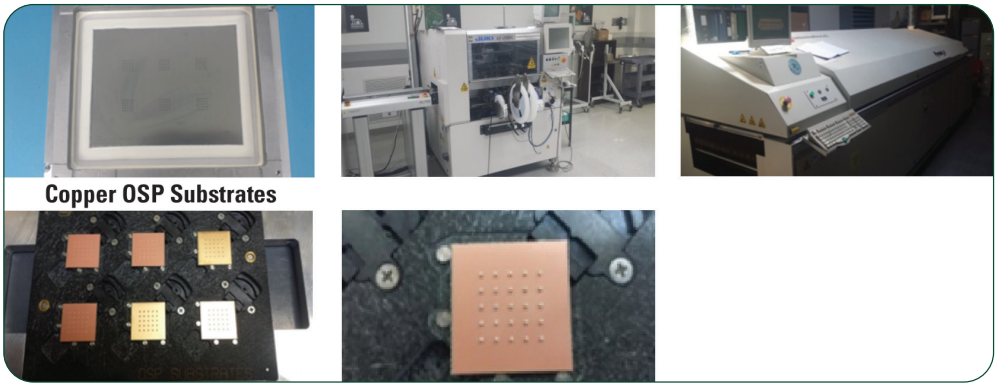
where, S_R: spreading ratio (%)

H: height of the spread solder (mm)

D: diameter of the solder, when it is assumed to be a sphere (mm)

$D = 1.24V^{1/3}$

V: mass (12)/density of tested solder



Solderability Test Method

- Print flux onto metalized surface
- Place spheres onto flux deposit
- Reflow (air or N_2 [typical])
- Measure reflowed height deposit
- Calculate spreading ratio (wetting)

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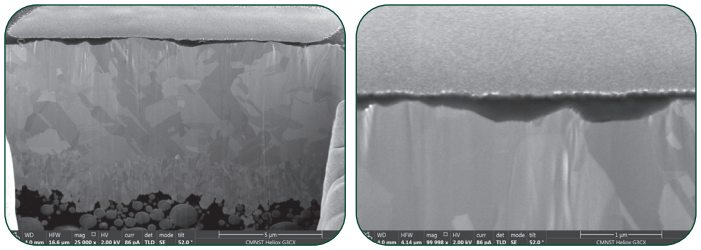
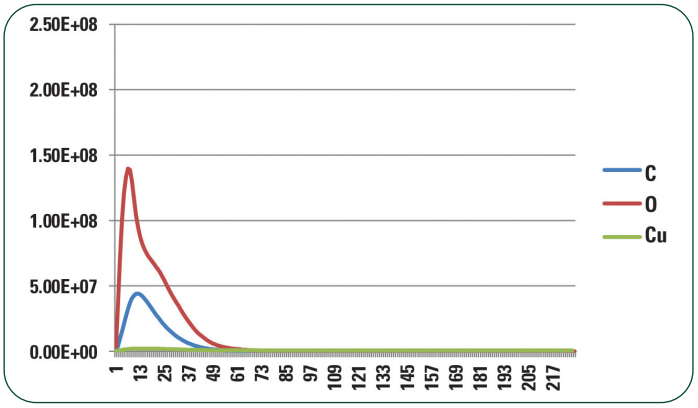
WS-446HF Flux

Cleaning

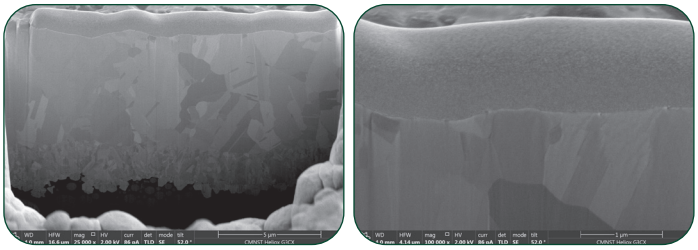
FIB (Focused Ion Beam) and SIMS (Secondary Ion Mass Spectrometry) Analysis on Cu OSP Substrate

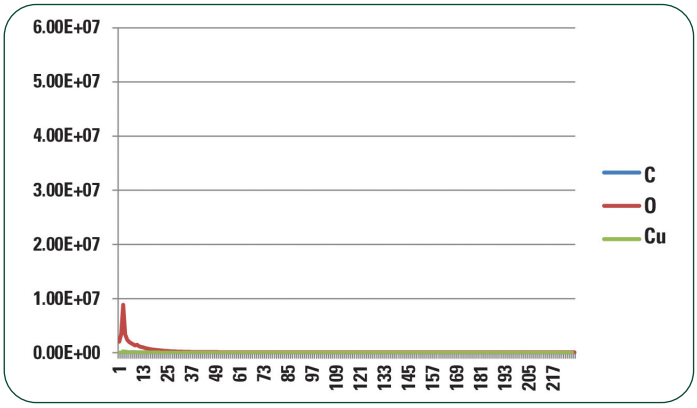
Fresh Cu OSP Substrate





Cu OSP Substrate after WS-446HF Flux Clean



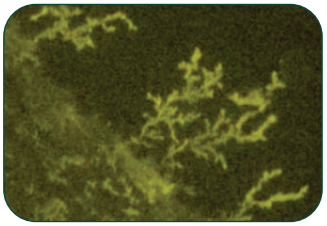


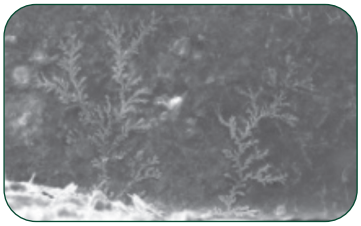
Simplified, Low-Cost Cleaning

WS-446HF is cleanable with room temperature deionized (DI) water only, eliminating chemical cleaning costs and costs of heating water.

Eliminate Dendrite

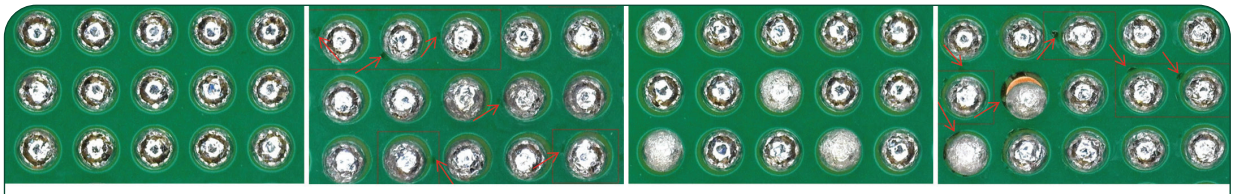
- Good cleanability with non-conductive residue





Cleaning Test

- **Very mild (forcing) condition**
  - Deionized water
  - Deionized water conductivity ≤1.00µS/cm
  - Zero pressure
  - Flow rate 5cc/minute



WS-446HF 1.5 minutes @ 25°C DI Water No Residue	Competitor 2+ minutes @ 25°C DI Water Residue Observed	WS-446HF 30 seconds @ 50°C DI Water No Residue	Competitor 45 seconds @ 50°C DI Water Residue Observed

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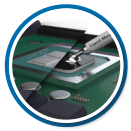
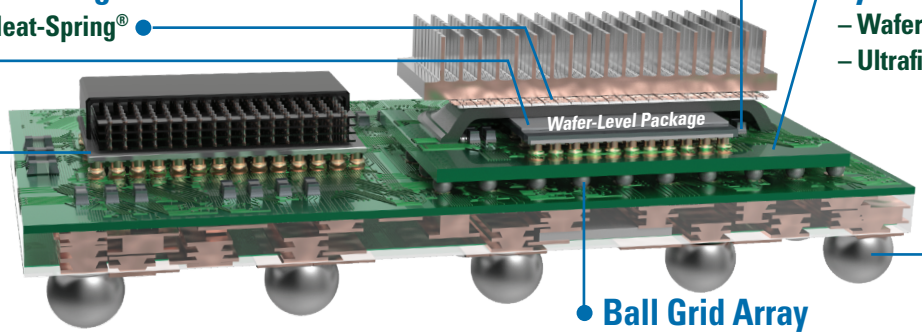
Heterogeneous Integration & Assembly Materials



Thermal Management
– TIM2 / Heat-Spring®
– TIM1

Ultra-Small Passives

System-in-Package
– Wafer-Level Ball-Attach Flux
– Ultrafine-Pitch Solder Paste



Memory and Flip-Chip / 3D Logic
– Wafer Bumping (Bump Fusion) Flux
– Flip-Chip Flux

SMT
– Solder Paste
– Solder Wire
– Solder Flux
– Preforms
– Bar Solder

Ball Grid Array
– Ball-Attach Flux

Recommended Semiconductor Fluxes and Solder Pastes

Material Group	Material Type	Material Name	Flux Type	Halogen-Free	Application	Comments
FLUX	Wafer Bumping Flux	SC-5R	Solvent-clean	Yes	Spin coating	High Pb, Sn/Pb Eutectic and SnAg solder bumps
		WS-3543	Water-wash	Yes	Spin coating	High viscosity for taller copper-pillars and larger bumps (>40 microns)
		WS-3401	Water-wash	Yes	Spin coating	Low viscosity for smaller pillars and bumps
	Wafer-Level or Panel-Level Packaging Flux	WS-676	Water-wash	Yes	Printing	0.5mm and smaller pitch wafer-level or panel level package
		WS-759				
		WS-829				
	Flip-Chip Flux	WS-575-SP	Water-wash	Yes	Jetting/Spraying	Sn/Pb Eutectic and SnAg onto SOP for logic flip-chip
		FC-NC-HT-A1	No-clean	Yes	Jetting/Spraying	Mass reflow flux compatible with CUF
		WS-446	Water-wash	No	Dipping	Best flux for poor solderability
		WS-688	Water-wash	Yes	Dipping	General purpose for multi-core logic flip-chip
		WS-641	Water-wash	Yes	Dipping	For chip-on-wafer, high-density Cu-pillar application
		NC-26-A	Ultra-low residue no-clean	Yes	Dipping	Best compatibility with CUF/MUF
		NC-26S	Ultra-low residue no-clean	Yes	Dipping	Avoids capillary flow up to die surface for fine-pitch devices
		NC-699	Near-zero residue	Yes	Dipping	Controlled solderability, compatible with wide variety of CUF/MUF
	Ball-Attach Flux	WS-446-AL	Water-wash	No	Pin Transfer	Best flux for poor solderability
		WS-823	Water-wash	Yes	Pin Transfer	Best all-around halogen-free ball-attach flux, easily cleaned
		WS-829	Water-wash	Yes	Printing and pin transfer	For sphere size <0.25mm and fine-pitch high-density ball-attach, best cleanability
		NC-585	No-clean	Compliant	Pin Transfer	Good wetting onto bare nickel for 0.5mm pitch or lower BGA/PGA
		WS-575-C-RT	Water-wash	NIA	Pin Transfer	Best ball-attach flux for missing ball Eliminates the prefluxing step for OSP
	Flip-Chip and Ball-Attach Flux	NC-809	Ultra-low residue no-clean	Yes	Dipping	Enhanced wetting, compatible with wide variety of CUF/MUF
					Printing and pin transfer	Suitable for no-clean process, good wetting onto gold surface
		WS-446HF	Water-wash	Yes	Dipping	Best all-around halogen-free flip-chip flux, easily cleaned
					Pin Transfer	Suitable for one-step Cu OSP process for sphere size 0.25mm and above
SOLDER PASTE	Jetting Paste	PicoShot® WS-5M	Water-wash	Yes	Jetting	For dot jetting of 300µm diameter and above, and fine-line dispensing for metal lid-attach
		PicoShot® NC-5M	Solvent- or aqueous-based chemistry or no-clean	Yes	Jetting	For dot jetting of 300µm diameter and above, and fine-line dispensing for metal lid-attach
		Indium12.8HF			Jetting and Microdispensing	For dot jetting down to 80µm diameter and above, and fine-line dispensing for metal lid-attach
	SiPaste® Solder Paste	SiPaste® 3.2HF	Water-wash	Yes	Printing	Type 6, Type 7, and Type 8 solder paste suitable for ultrafine-pitch printing
		SiPaste® C201HF	DI water + saponifier or semi-aqueous chemistry			
		SiPaste® SMQ77	No-clean			
OTHER	Adhesive Solution	NC-702	Minimal to no residue	Yes	Dipping/Dispensing/ Jetting	Holding die, chip, and preform in place, for formic acid reflow

All of Indium Corporation's solder paste and preform manufacturing facilities are IATF 16949:2016 certified.
Indium Corporation is an ISO 9001:2015 registered company.

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