**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.

Ball-Attach Application
WS-446HF’s special activator package promotes good wetting on the most demanding surfaces such as Cu OSP. Typically, ball-attachment 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

Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical Viscosity</td>
<td>21k cps (5 minutes)</td>
<td>Brookfield HB DVII+ CP @ 5rpm</td>
</tr>
<tr>
<td>Typical Acid Number</td>
<td>93 mg KOH/g</td>
<td>Titration</td>
</tr>
<tr>
<td>Typical Tack Strength</td>
<td>150 gf</td>
<td>J-STD-005 (IPC-TM-650: 2.4.44)</td>
</tr>
<tr>
<td>Shelf Life</td>
<td>12 months at 0–30°C</td>
<td>Viscosity change/ microscope examination</td>
</tr>
</tbody>
</table>

Industry Standard Test Results and Classification

<table>
<thead>
<tr>
<th>Flux Classification</th>
<th>ORH0*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Based on the testing required by IPC J-STD-004A.</td>
<td></td>
</tr>
</tbody>
</table>

| Halogen-free per             |                     |
| IEC 61249-2-21, Test Method EN14582 | <900 ppm Cl |
|                             | <900 ppm Br        |
|                             | <1,500 ppm total   |

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

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”

Tack as a Function of Time
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Reflow

Recommended Profile

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

Reduce Open Joint

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

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.

\[ S_R = \frac{D - H}{D} \times 100 \]

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)
- \( V \): mass (12)/density of tested solder

Solderability Test Method

- Print flux onto metalized surface
- Place spheres onto flux deposit
- Reflow (air or \( \text{N}_2 \), typical)
- Measure reflowed height deposit
- Calculate spreading ratio (wetting)
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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

Cleaning Test

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

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

Contact our engineers: askus@indium.com
Learn more: www.indium.com
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### Recommended Semiconductor Fluxes and Solder Pastes

<table>
<thead>
<tr>
<th>Material Group</th>
<th>Material Type</th>
<th>Material Name</th>
<th>Flux Type</th>
<th>Application</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wafer Bumping Flux</strong></td>
<td>Solvent-clean</td>
<td>SC-5R</td>
<td>Yes</td>
<td>Spin coating</td>
<td>High Pb, Sn/Pb Eutectic and SnAg solder bumps</td>
</tr>
<tr>
<td></td>
<td>Water-wash</td>
<td>WS-3543</td>
<td>Yes</td>
<td>Spin coating</td>
<td>High viscosity for taller copper-pillars and larger bumps (&gt;40 microns)</td>
</tr>
<tr>
<td></td>
<td>Water-wash</td>
<td>WS-3401</td>
<td>Yes</td>
<td>Spin coating</td>
<td>Low viscosity for smaller pillars and bumps</td>
</tr>
<tr>
<td><strong>Wafer-Level or Panel-Level Packaging Flux</strong></td>
<td>Water-wash</td>
<td>WS-876</td>
<td>Yes</td>
<td>Spin coating</td>
<td>0.5mm and smaller pitch wafer-level or panel level packaging</td>
</tr>
<tr>
<td></td>
<td>Water-wash</td>
<td>WS-759</td>
<td>Yes</td>
<td>Printing</td>
<td>0.5mm and smaller pitch wafer-level or panel level packaging</td>
</tr>
<tr>
<td><strong>Flip-Chip Flux</strong></td>
<td>Water-wash</td>
<td>WS-575-SP</td>
<td>Yes</td>
<td>Jetting/Spraying</td>
<td>Sn/Pb Eutectic and SnAg onto SOG for logic flip-chip</td>
</tr>
<tr>
<td></td>
<td>No-clean</td>
<td>FC-NC-HT-A1</td>
<td>Yes</td>
<td>Jetting/Spraying</td>
<td>Mass reflow flux compatible with CuF</td>
</tr>
<tr>
<td></td>
<td>Water-wash</td>
<td>WS-446</td>
<td>No</td>
<td>Dipping</td>
<td>Best flux for poor solderability</td>
</tr>
<tr>
<td></td>
<td>Water-wash</td>
<td>WS-888</td>
<td>Yes</td>
<td>Dipping</td>
<td>General purpose for multi-core logic flip-chip</td>
</tr>
<tr>
<td></td>
<td>Water-wash</td>
<td>WS-641</td>
<td>Yes</td>
<td>Dipping</td>
<td>For chip-on-wafer, high-density Cu-pillar application</td>
</tr>
<tr>
<td><strong>Ball-Attach Flux</strong></td>
<td>Ultra-low residue no-clean</td>
<td>NC-26-A</td>
<td>Yes</td>
<td>Dipping</td>
<td>Best compatibility with CuF/MUF</td>
</tr>
<tr>
<td></td>
<td>Ultra-low residue no-clean</td>
<td>NC-265</td>
<td>Yes</td>
<td>Dipping</td>
<td>Avoids capillary flow up to die surface for fine-pitch devices</td>
</tr>
<tr>
<td></td>
<td>Near-zero residue</td>
<td>NC-699</td>
<td>Yes</td>
<td>Dipping</td>
<td>Controlled solderability, compatible with wide variety of CuF/MUF</td>
</tr>
<tr>
<td></td>
<td>Water-wash</td>
<td>WS-446-AL</td>
<td>No</td>
<td>Pin Transfer</td>
<td>Best flux for poor solderability</td>
</tr>
<tr>
<td></td>
<td>Water-wash</td>
<td>WS-823</td>
<td>Yes</td>
<td>Pin Transfer</td>
<td>Best all-around halogen-free ball-attach flux, easily cleaned</td>
</tr>
<tr>
<td></td>
<td>Water-wash</td>
<td>WS-829</td>
<td>Yes</td>
<td>Printing and pin transfer</td>
<td>For sphere size &lt;0.25mm and fine-pitch high-density ball-attach, best cleanliness</td>
</tr>
<tr>
<td><strong>Flip-Chip and Ball-Attach Flux</strong></td>
<td>Water-wash</td>
<td>NC-585</td>
<td>No-clean</td>
<td>Pin Transfer</td>
<td>Good wetting onto bare nickel for 0.5mm pitch or lower BGA/PGA</td>
</tr>
<tr>
<td></td>
<td>Water-wash</td>
<td>WS-575-C-RT</td>
<td>N/A</td>
<td>Pin Transfer</td>
<td>Best ball-attach flux for missing ball</td>
</tr>
<tr>
<td></td>
<td>Ultra-low residue no-clean</td>
<td>NC-809</td>
<td>Yes</td>
<td>Dipping</td>
<td>Enhanced wetting, compatible with wide variety of CuF/MUF</td>
</tr>
<tr>
<td></td>
<td>Water-wash</td>
<td>WS-446HF</td>
<td>Yes</td>
<td>Dipping</td>
<td>Best all-around halogen-free flip-chip flux, easily cleaned</td>
</tr>
</tbody>
</table>

### Flux

- **PicoShot® WS-5M**: Water-wash, Jetting
- **PicoShot® NC-5M**: Solvent- or aqueous-based chemistry, Jetting
- **Indium12.8HF**: Solvent or semi-aqueous chemistry, Microdispensing
- **SiPaste® 3.2HF**: Water-wash

### Solder Paste

- **SiPaste® C201HF**: DI water + saponifier or semi-aqueous chemistry, Printing
- **SiPaste® SMQ77**: No-clean

### Other

- **NC-702**: Minimal to no residue, Dipping/Dispensing/Or Jettering

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All Indium Corporation’s products and solutions are designed to be commercially available unless specifically stated otherwise.

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

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