Abstract
Flexible circuits make up a US$ 10 billion plus market. (1) As in most markets, there is an ongoing drive for better performance at lower prices. The majority of flexible circuits are made by patterning copper metal that is laminated to a flexible substrate, which is usually polyimide film of varying thickness. Averatek ALD ink technology addresses the needs of this segment with denser circuits by being purely additive, and by using cheaper processes that run in a non-vacuum environment. Another way to meet the need for cheaper circuits is by using aluminum on PET (Al-PET) substrates. These are getting more popular and have found wide use in RFID tags and single-layer circuits. However, both aluminum and PET have their own constraints and require special processing to make finished circuits. Aluminum is not easy to solder to at low temperatures and PET cannot withstand high temperatures. Thus conventional low temperature solder cannot be used to attach components to these circuits without additional processing or using conductive epoxies. These add costs which limit the use of Al-PET circuits. Averatek’s ‘Mina’, is an advanced surface treatment technology that addresses all these constraints and paves the way for large scale, low cost manufacturing of Al-PET circuits.

Conventional methods used to assemble RFIDs
Assembly of RFID tags and flexible circuits involves mounting of chips onto the pads of the circuits. Although use of solder is preferred, soldering to aluminum is difficult because of the presence of a thin layer of aluminum oxide. This layer forms when the bare metal is exposed to air. Since the manufacturing of Al-PET substrates is done under atmospheric conditions, all aluminum surfaces are covered with aluminum oxide. While the formation of oxide is self limiting, its presence prevents the bonding of solder to the base aluminum.

Special processing can be done on the pads to remove and prevent the formation of aluminum oxide. These include Electroless Nickel Immersion Gold plating (ENIG), nickel-palladium or nickel-silver plating. All these need a series of process steps and extensive wet chemistry, which add costs that make it prohibitive for mass adoption.

Anisotropic conductive paste (ACP) is a common solution to the above problems and is widely used for attaching components to aluminum based RFIDs. It is applied on the face of the chip, which is then attached to the antenna using heat and pressure. However, ACP has its own challenges. It is made of adhesive epoxy filled with conductive metal particles, usually silver. These are typically syringe applied, require longer cure times, have pot-life issues and electrically inferior to conventional solders. In addition, they have to be stored at low temperatures in special freezers, to control the polymerization of the epoxy. Overall, they are very expensive. (2)
Assembly of RFIDs using Mina

Averatek’s ‘Mina’ is an advanced surface treatment chemistry that can be printed directly on the aluminum pads where components need to be assembled. Any of the conventional printing techniques can be used including screen, stencil etc. The aluminum surface does not need any surface cleaning or preparation. Once printed, it has to be cured thermally and leaves the pad surface active and ready to accept solder. Cured Mina on the pad is non-conductive and hence makes room for easy print registration. To attach a component, it simply would need solder on it via plated bumps or printing, placed on the Mina activated pad, and then passed through a re-flow oven. Mina removes the aluminum oxide layer and allows the formation of a true metal to metal bond between the solder and the aluminum on the pads. Thus both the electrical properties and the bond strength are far superior to ACP. In addition, it can be stored at room temperature, and reused multiple times.

Key Features of Mina

- Creates solderable surface on aluminum
- Activates aluminum surface at thickness of 25um (Required thickness may vary depending on product application)
- Screen and stencil printable
- Simple process control
- Excellent stability
- Supports Roll to roll manufacturing

The advantages of using Mina in combination with low temperature solder over ACP are summarized below in Table 1

Table 1 – Comparison of Mina-solder process with ACP

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<tr>
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<th>ACP</th>
<th>Mina</th>
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<tr>
<td>1</td>
<td>Applied on entire face of chip.</td>
<td>Screen printed on pads leaving an active but non conductive surface.</td>
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<td>2</td>
<td>Expensive, as it is silver filled and used over entire face of chip.</td>
<td>Cost effective as allows the use of conventional solder and only on pads.</td>
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<td>3</td>
<td>Capacity limited as it requires special handling during a long curing cycle with regards to temperature and pressure.</td>
<td>Requires no special handling. Mina can be applied to the pads and cured in conventional low temperature ovens. Solder can be plated or printed on the chip using conventional methods and then reflowed onto the activated pads.</td>
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<td>4</td>
<td>Electrical performance is compromised due to presence of epoxy.</td>
<td>Enables solder to bond directly to aluminum metal, ensuring good electrical properties.</td>
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<td>5</td>
<td>Resultant bonds have good shear strength due to presence of epoxy.</td>
<td>Resultant bonds have great shear strength due to metal-to-metal bond.</td>
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<td>6</td>
<td>Has pot-life issues as epoxy polymerization begins immediately once brought to temperature of use.</td>
<td>Has no potlife issues. Mina can be printed, stored and re-used at room temperature.</td>
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<td>7</td>
<td>Requires special storage conditions, below 0°C.</td>
<td>Can be stored at room temperature.</td>
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**The Mina production process for RFID and flexible circuits**

The production process for Al-PET based flexible circuits is highly simplified due to Mina. Existing print and etch process can be used for patterning the aluminum. After that, the process is simple and described below in Figure 1.

![Production and assembly process using Mina](image)

**Figure 1** – Production and assembly process using Mina
Performance and summary
Mina enables mass scale production of Smart tags in a cost effective way. Some evaluations are shown below.

![Screen-printed Mina on RFID antenna pads](image)

Picture 1 – Mina printed on aluminum pads of antennas

Antennas shown in Picture 1 were printed with Mina using a conventional semi-automatic screen printer. A polyester screen of 150 mesh size was used, which printed a uniform layer of Mina over the aluminum pads. A chip was then soldered onto the pads and tested for shear strength. The failure point was observed to be within the solder, demonstrating superior bond between the aluminum pad and the solder.

Overall, Averatek’s Mina is a revolutionary product that will help the mass adoption and use of aluminum based RFIDs and flexible circuits.

References