

# **Aerosol Jet Bonds for Low loss, Low Noise Interconnects for mm-Wave IC Packaging**

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Since the late 1950s, wire bonds have been the most widely used method of connecting ICs to other packages and other components. However, it is a well-established fact that wire bonds (and ribbon bonds) suffer from high insertion loss as signal frequencies increase above 20 GHz due primarily to the high inductance of the bond wire. Designers have struggled to minimize the inherent impedance mismatch of traditional wire bonding by minimizing the length and height of the bond wire loop, by doubling the wire bonds in a V-shape, and by adding compensation capacitance to the flares and pads of the bond. Despite these efforts, wire bonding has continued to present a major obstacle in the efficient coupling of mm-wave signals. With the increased demand for 5G telecommunications equipment, automotive radar and mm-wave imaging devices, the deficiencies of wire bonding are becoming more prominent, necessitating viable technology alternatives for RF designers.

Over the last several years, however, researchers have shown that improved interconnects can be printed using a non-contact method of applying nanoparticle inks over a dielectric fill. The new method, called Aerosol Jet printing, is capable of jetting extremely fine conductive interconnects (as narrow as 10  $\mu\text{m}$ ) in arbitrary patterns, essentially printing a micro-strip from one component to another, or from a component to a packaging substrate. The Aerosol Jet bonds (AJ bonds) have the advantage of 1) producing little or no loop height, reducing inductive reactance, 2) having the ability to vary the width of the trace, thus tuning its characteristic impedance 3) being bonded directly to a dielectric material with controlled coupling to ground planes 4) the ability to be printed on a variety of lower-cost pad materials and 5) since it is a non-contact technology, it eliminates the scrap of fragile die caused by the thermal-sonic wire-bonding process, especially on GaAs/GaN die.

In this presentation, we will give a brief overview of the AJ process and show some examples of current applications in the mm-wave region. We will show results from RF simulations comparing AJ bonds to traditional wire bonds. We will also present test results from actual printed interconnects for mm-wave frequencies, using a test samples evaluated with a network analyzer. Finally, we will demonstrate results from reliability testing for the AJ interconnects that establish the technology's readiness for production applications. The presentation will conclude with a brief discussion of the next steps in the technology's high-volume implementation.