Indium Plating Challenges: Unlocked

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INDIUM IS THE GREAT APPEASER OF interconnect materials. However, it also tends to be a bit of an attention seeker. One day it's a hot topic and everyone's interested. The next, it's suddenly passé, and you get eye rolls when you mention it. Today, indium's time may finally be here.

As a solder or even a seal, indium presents an intriguing case as an enabling material. Pillar-based methods of packaging devices, which we're still calling advanced, have become commonplace as a means of stacking die for increased performance. But now, the industry is also experiencing a persistent, explosive expansion of device types and use cases. And the harsh truth is that if you make two perfect semiconductor devices with 100% yield each, and then you connect them through pillars that don't hold up, your amazing chips become useless.

Chip packages are showing up everywhere now, including the most extreme conditions into which we can inject, install or launch them. Take satellites. That expensive cargo, folded neatly inside the nose cone of a rocket, launches from the pad at a temperature of maybe 24°C. In orbit, it neatly and cleverly unfolds itself in an environment of around -270°C. As it zips from dark side to sunny side of the Earth, radiation from the sun raises its temperature back up by some 200+ degrees.

Common solders readily crack in these conditions, forcing aerospace engineers to burden an otherwise trim piece of technology with a lot of bulk and complexity (and mass!) for heat deflection and abatement.

Enter indium, the appeaser — it gets along with everyone in almost any situation. Indium, magically, joins the scene with a malleability that fits almost in the middle of what was historically the precious sweet spot of lead-based solders. Like a gluten-free bread that actually tastes ok, indium provides quite favorable mechanical characteristics like a conventional solder. Amazingly, it retains these at near-absolute zero and holds up over time through the kind of heat cycling that low-earth orbit imposes.

But… there has to be a downside, or everyone would be using indium. As I hinted at the start, there's been some drama.

In the mid 2010s, rumors arose of an impending shortage of indium. Indium is included on the U.S. government's list of Technology-Critical Elements (TCE), and in recent years, its refinement infrastructure has caught up fully to demand. While still somewhat rare, indium is more readily available than gold, platinum or iridium.

Deposition at small feature sizes becomes the next hurdle. Resistive thermal evaporation — historically, the leading method — bears a number of brutal shortcomings for volume manufacture, including overall cost and flexibility. These challenges worsen as features are scaled, even modestly. On the other hand, electroplating of indium is highly flexible and cost-manageable.

Indium plates beautifully. But here, too, there have been complications (spoiler alert: we've figured them out). The two key issues: very low plating efficiency, which leads to excessive gas evolution, thus void defects, etc.; and enormous as-deposited grains. Plating efficiency and gas evolution are related and, in large part, tied to chemistry formulation. However, even after formulation improvements by several chemical manufacturers, gas evolution was still not completely eliminated. Indium incurs a galvanic reaction in contact with a host of other metals when submerged. So, getting the reactor and anode design right is critical — not a straightforward task since indium wets certain other solids, and will fold itself around substructure.

Once all the design aspects are sorted (which we've done), you still have the grain-size issue. It is not uncommon to pursue a packaging scheme deployed around pillars 20µm in diameter or even smaller. Native grain size of electrodeposited indium tends to be on the order of 30-40µm! That means a single grain is, on average, larger than the width of what it fills. Not great.

In the end, for manufacturers interested in exploring indium's benefits, the key is to start with a technology partner that understands this material well and can serve as a center point for pulling it all together: chemistry, wafer and reactor technology. A partner used to the indium drama. ClassOne Technology sees ourselves as just that kind of partner. SD