SMI/Alloy Enterprises Hybrid Design Microchannel Cooler

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Introduction:

Spectra-Mat, Inc. (SMI) specializes in controlled expansion composites (CECs). Porous tungsten infiltrated with copper combines the outstanding high electrical and thermal conductivity of copper with the high hardness, strength, and low thermal expansion of tungsten. Composites of refractory metals and copper can be made to match coefficients of thermal expansion of semiconductors or ceramics for thermal management and high temperature needs.

Alloy Enterprises produces high-performance thermal components using their patented Stack Forging™ method, a novel fabrication process combining advancements in 3D geometry preparation, laser cutting of complex components and diffusion bonding of their proprietary feedstock to create a detailed layered finished product, single piece after bonding, with intricate interior geometries.

Combining the technologies enables a leap forward in micro-channel cooler (MCC) technology, an MCC uniting the robustness of the tungsten or molybdenum copper substrate while maintaining the thermal match to the GaAs or GaN mating part, and with the effective and expedient manufacturing and design methods provided by the Stack Forging™ technology.

Background:

SMI has designed and manufactured MCCs from tungsten copper. The resulting three-layer stack proved an effective device with superior life and excellent thermal resistance characteristics. Edge radii were 8 um or better, and worst corner radii routinely in the 8-16 um range.

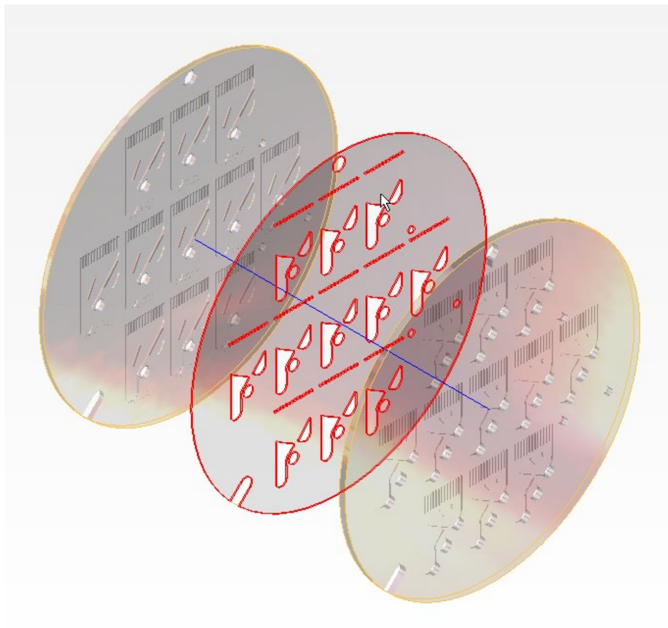

Figure 1: MCC layers at bonding prior to singulation

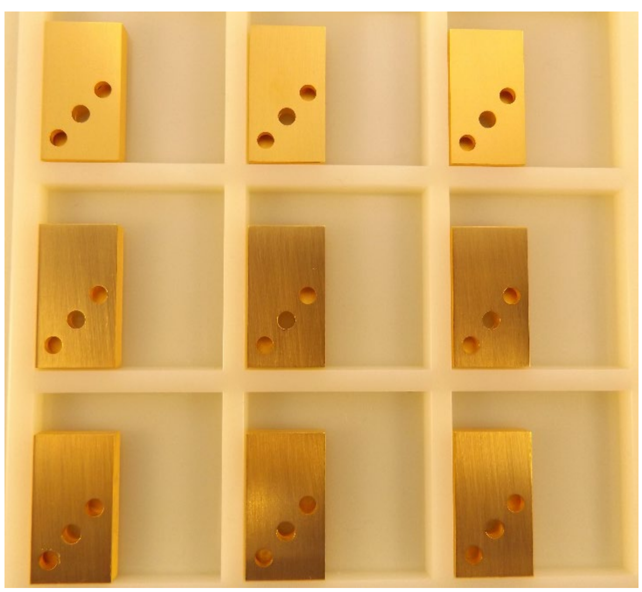

Figure 2: Singulated 3 layer W-Cu MCC

SMI's unparalleled controlled expansion composites are more than twice the hardness and stiffness of copper. They are thermally matched to laser bars. When turned into MCCs, thermal resistance of .46 was measured on a .12 cm^2 laser bar, within the specifications of all copper MCCs (typically R_{th} < .5°C/Watt at .4 lpm, or less). Pressure drop was < 15 psi @ .4 lpm.

Nonetheless, because of the complexities of forming and bonding the large tungsten copper composite material, limited use for a ‘better’ MCC was found. Excellent performance, but high cost. Delivery was restricted from the complex machining of the composites, as other techniques proved to not be capable of the fine features necessary for the MCC.

New Technology:

Enter the age of widespread 3D assembly methods. Whereas SMI’s original MCC had three layers, the latest generation built with Alloy Enterprise’s techniques has nine. The addition of more layers allows for much improved flow channels. We can improve the flow overall, optimizing the flow path for the thinner materials. SMI’s thin layer bond between the proprietary base MCC and the composite bonding shelf provides an identical expansion for the laser bar with an improved cooling path – lowered thermal resistance, identical pressure drop, increased thermal conductance.

Test Results

SMI MCC Parameter	Target	Stack Forged Hybrid
Flow rate	0.4 LPM	0.3 LPM
Pressure drop (psi)	15.0	<17
Thermal resistance °C/Watt	.5	<.25
Critical surface flatness	<10µm	<5 µm
He leak test	< 5 x 10^{-5} atm-cc/s	<5 x 10^{-8} atm-cc/s

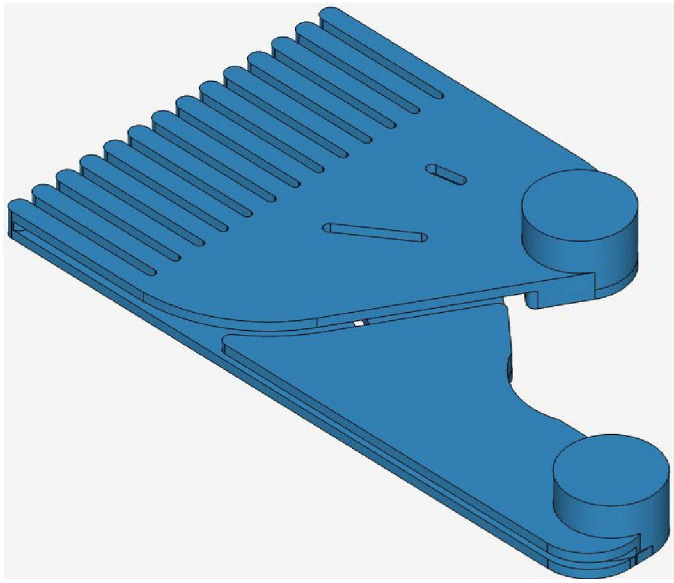

Figure 4: Original MCC channel configuration

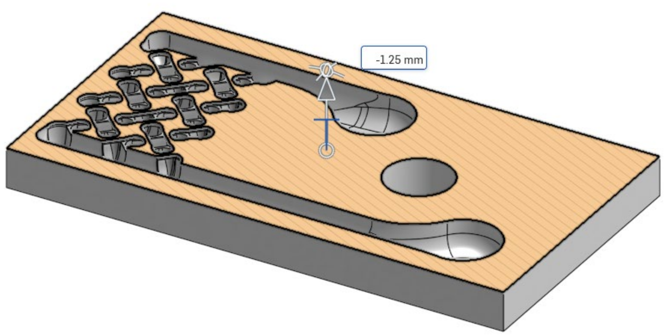

Figure 5: Advanced channel configuration in the Stack Forged Hybrid component

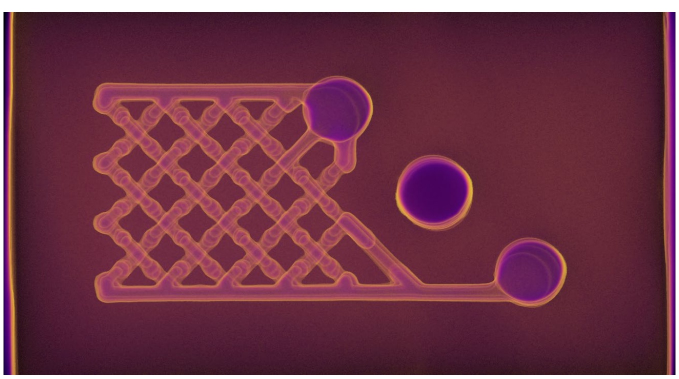

Figure 5: CT scan of Stack Forged Hybrid component

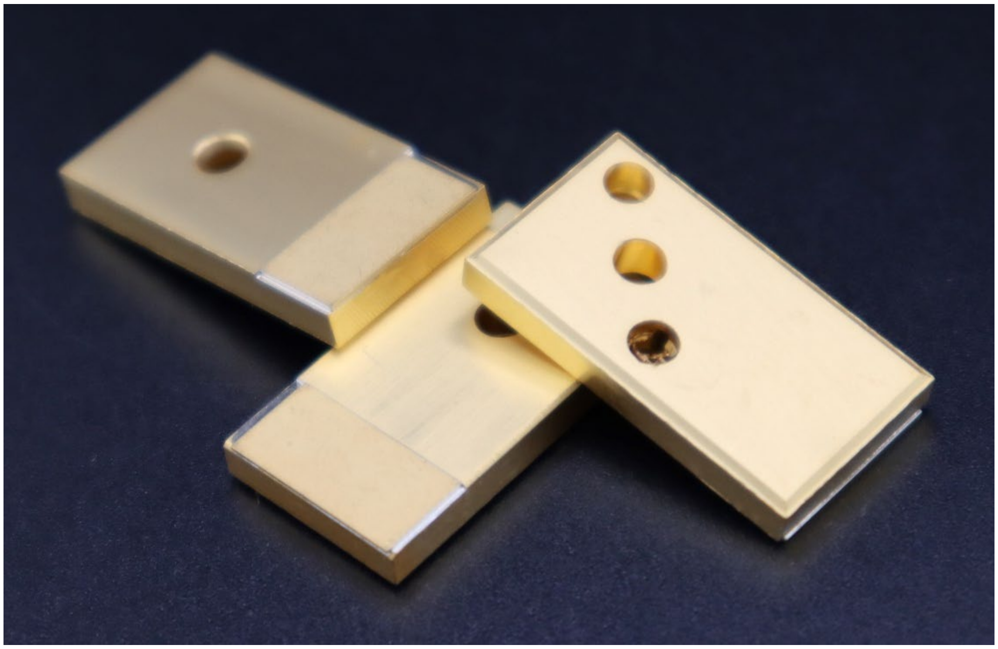

Figure 6: Stack Forged MCC "composite" with bonded W/Cu submount

The Stack Forging ™ technique shows significant advantage overall over prior methods. First, Alloy Enterprises current modeling and manufacturing can provide a base MCC in just a few weeks, as compared to eight or nine for a purely W-Cu MCC. This immediately lends itself to bespoke MCC's with a quick turn. As SMI and Alloy can prepare items in parallel, a first round iteration with modeling might take a total of nine weeks, and a second run six weeks, bonding, plating, engraving and leak testing included.

Technically, the MCC's flowpath can be optimized and further, placed into "OEM preferable spaces" simply because the design and build times can be minimized. Need one mm off the length of a design? The lead time to make that change is weeks, not months, including plating at SMI's plating facility, attachment of the W-Cu submount base and engraving. The new approach increases flexibility in design and throughput.

Finally, cost. The hybrid MCC built using these technologies represents a compromise between the expansion matching of W-Cu or MoCu composites to laser bars, but without the high price of a machined composite. The finished part is competitive in price and performance to an all-copper part but with the added reliability of hard solder bonding capability.

Interested: Contact

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