THERMAL PROPERTIES OF COPPER TUNGSTEN WITH COPPER VIA COMPOSITE

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Introduction

- CuW has been around for a long time
  - The 1st patent was issued to Paul Schwarzkopf in 1932 (Germany)
  - As product, CuW has been mature in production for the last 30+ years
- Can we improve CuW's thermal conductivity?
- Can we make a 'SUPER' CuW?

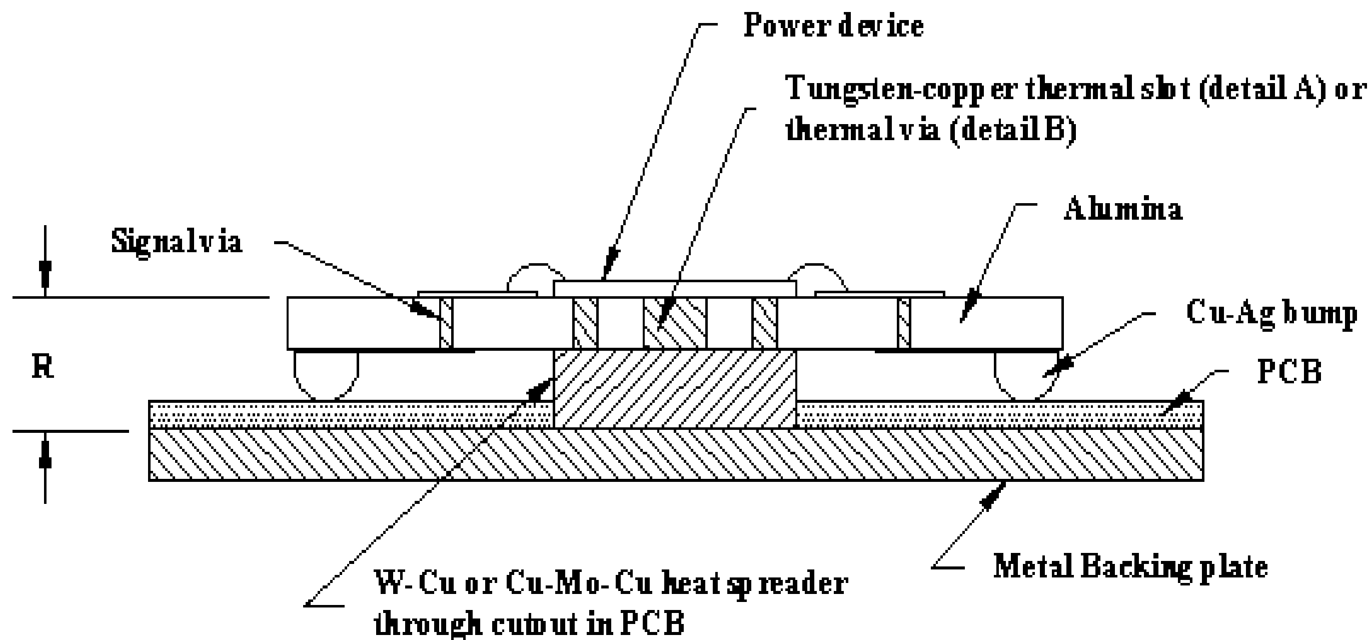
Goal

- To develop a CuW heat sink material that has higher thermal conductivity (TC)
- Control coefficient of thermal expansion (CTE)

Material	**CuW**	**Cu**
Thermal Conductivity	175[W/(m*K)]	400[W/(m*K)]
Coefficient of Thermal Expansion	7.57E-6[1/K]	17.0E-6[1/K]

Inspiration

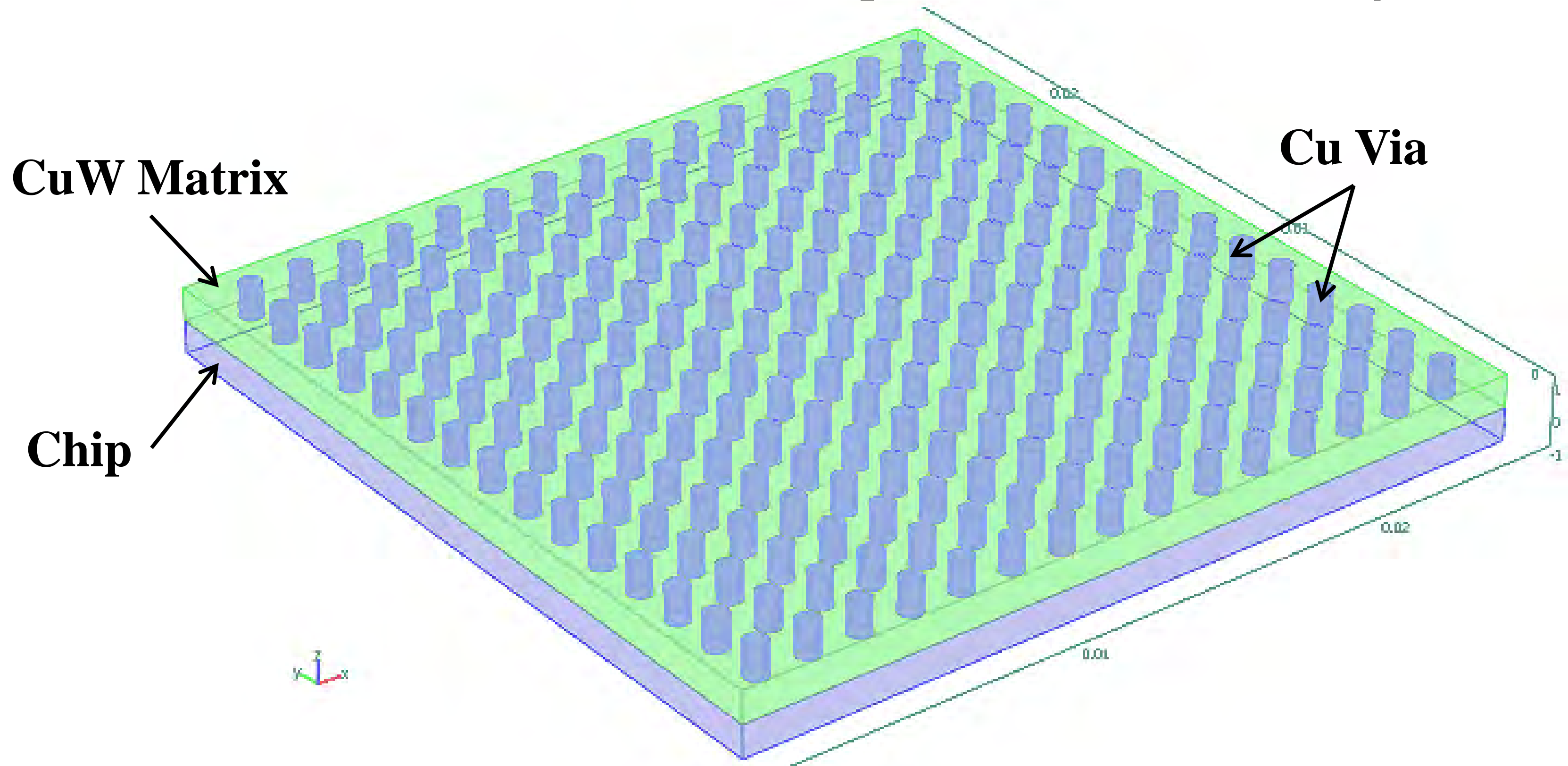
- Thermal Via



- http://nesl.ee.ucla.edu/courses/ee202a/2003f/submissions/hw2/SEYED_TABATABAEI/images/thermal%20VIABGA%202.gif

Our Approach

- CuW Matrix with an array of Cu Via composite

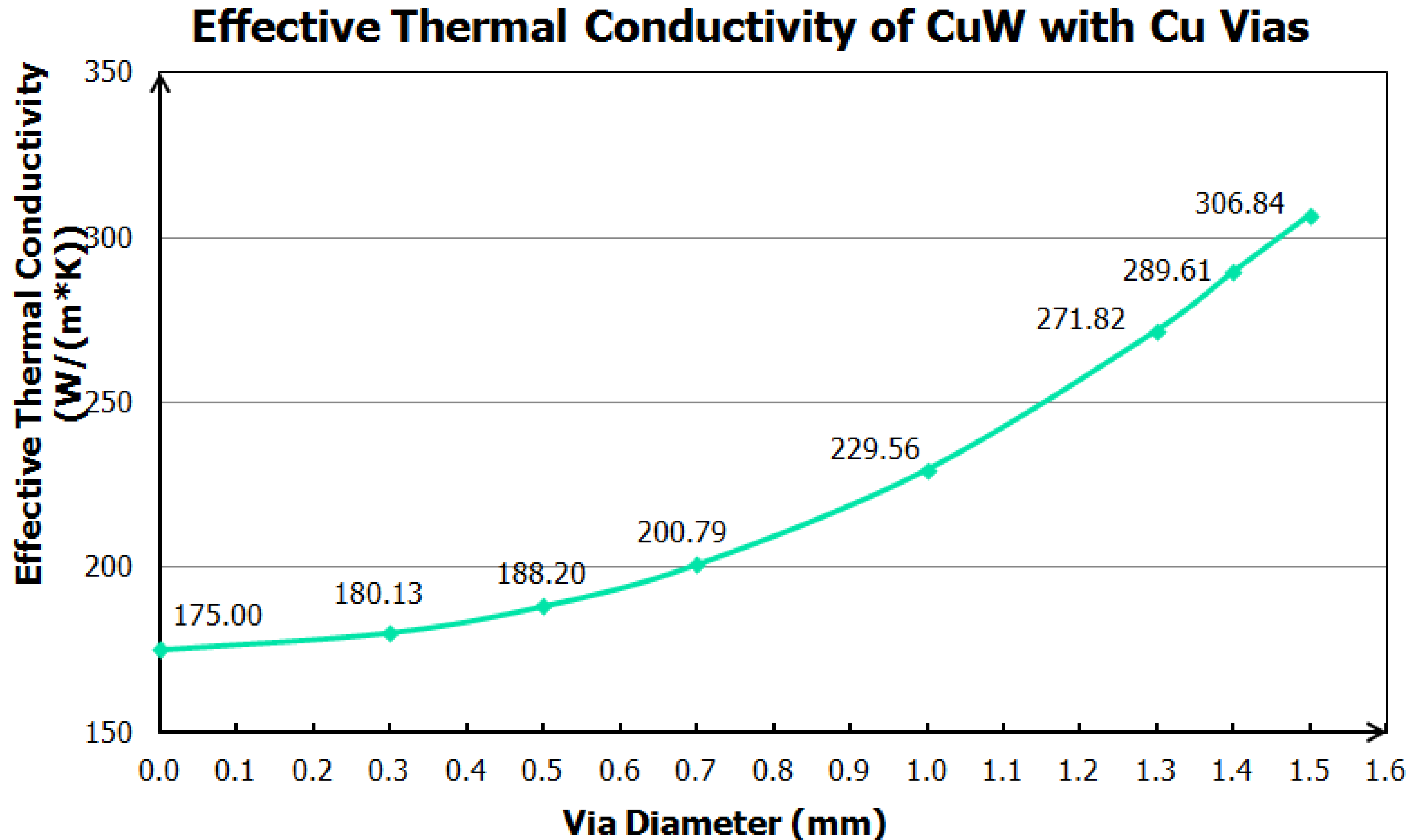


Due to Symmetry, the model can be reduced to a quarter with dimension of 25.0mm X 25.0mm X1.0mm with 25W power as shown below:

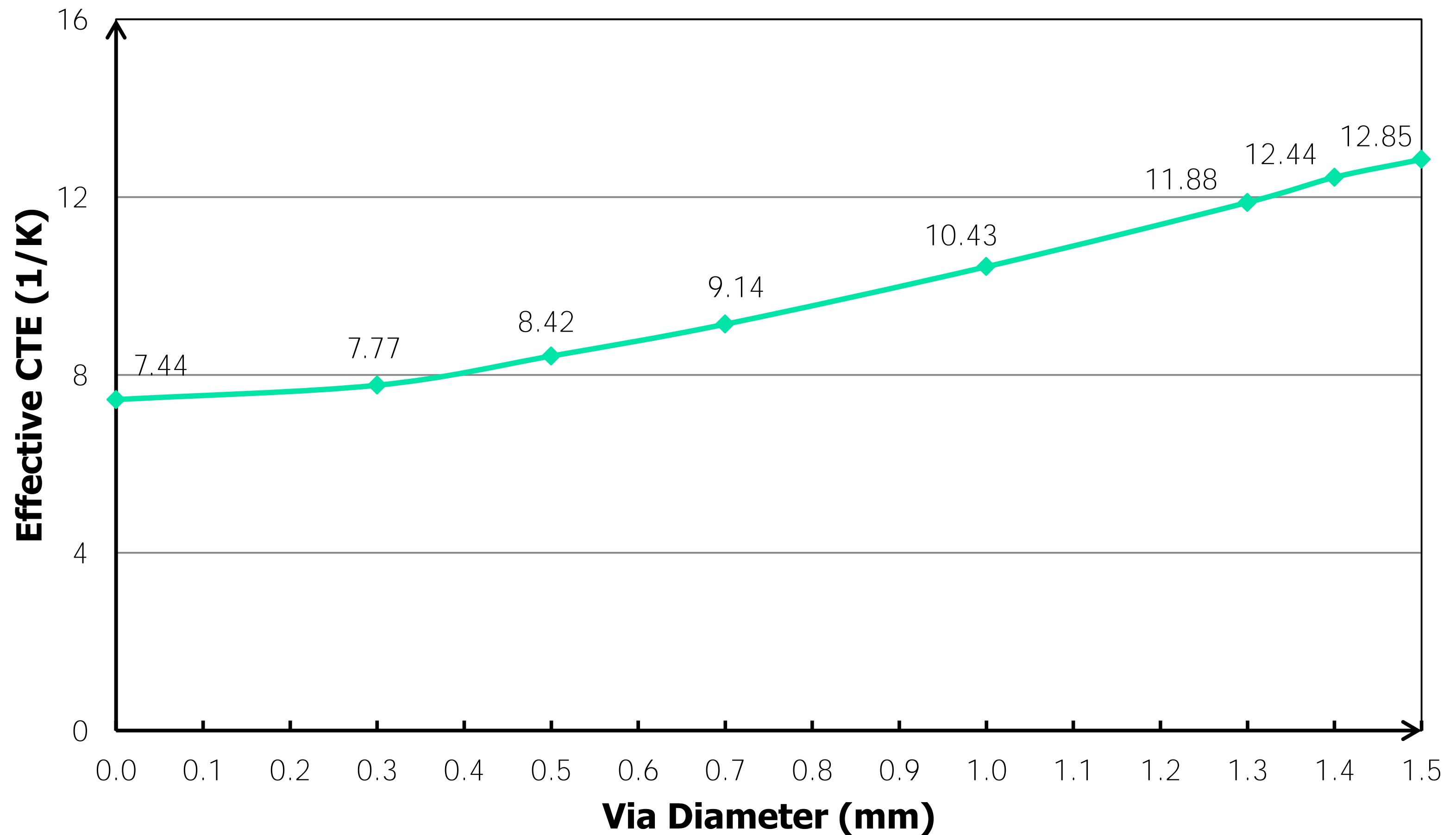
COMSOL® Model

Flange Material	CuW85	Cu
Thermal Conductivity	175 W/(m*K)	400 W/(m*K)
Simulation Environment	COMSOL 3.5a on Windows 7	
Chip Size & Power	Si (50.0mm X 50.0mm X 1.0mm) 100W	
Fixing Method	Bolt Down	
Heat Transfer Coefficient Between Flange & Heat Sink	3000 W/(m^2*K)	
Heat Sink Temperature	348.15 K (75 0C)	

Simulated Effective Thermal Conductivity



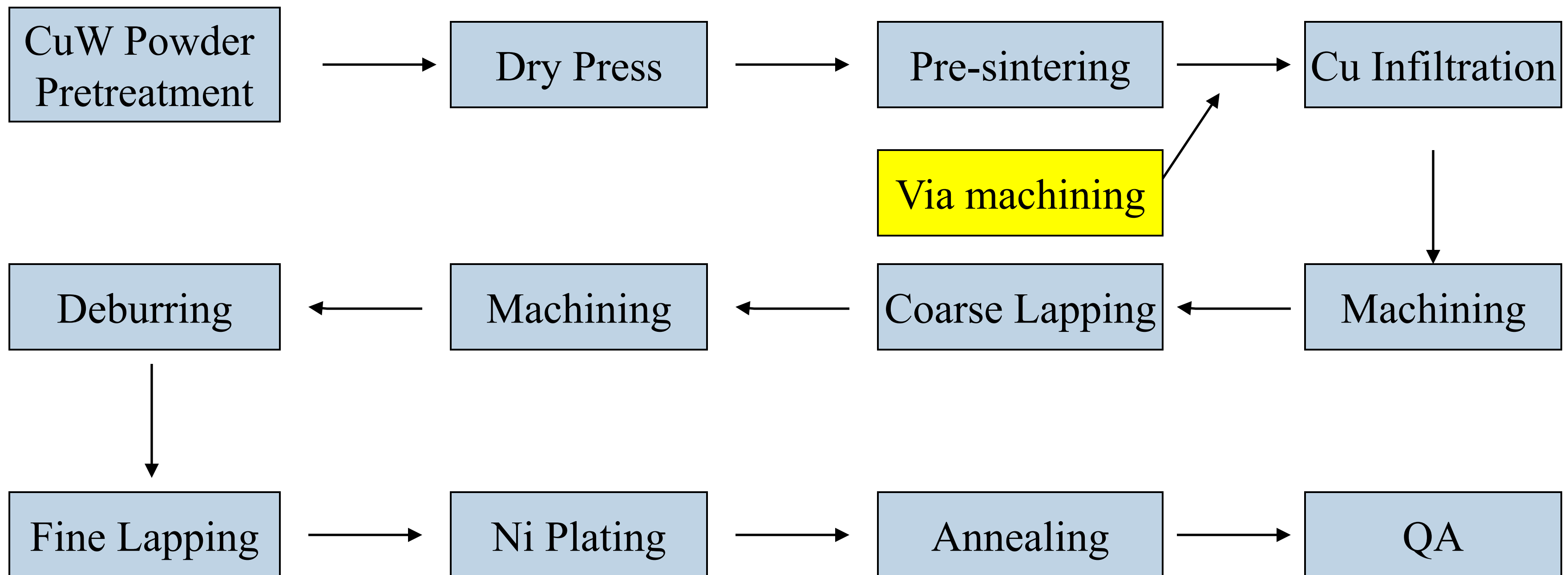
Simulated Effective CTE



Experiment

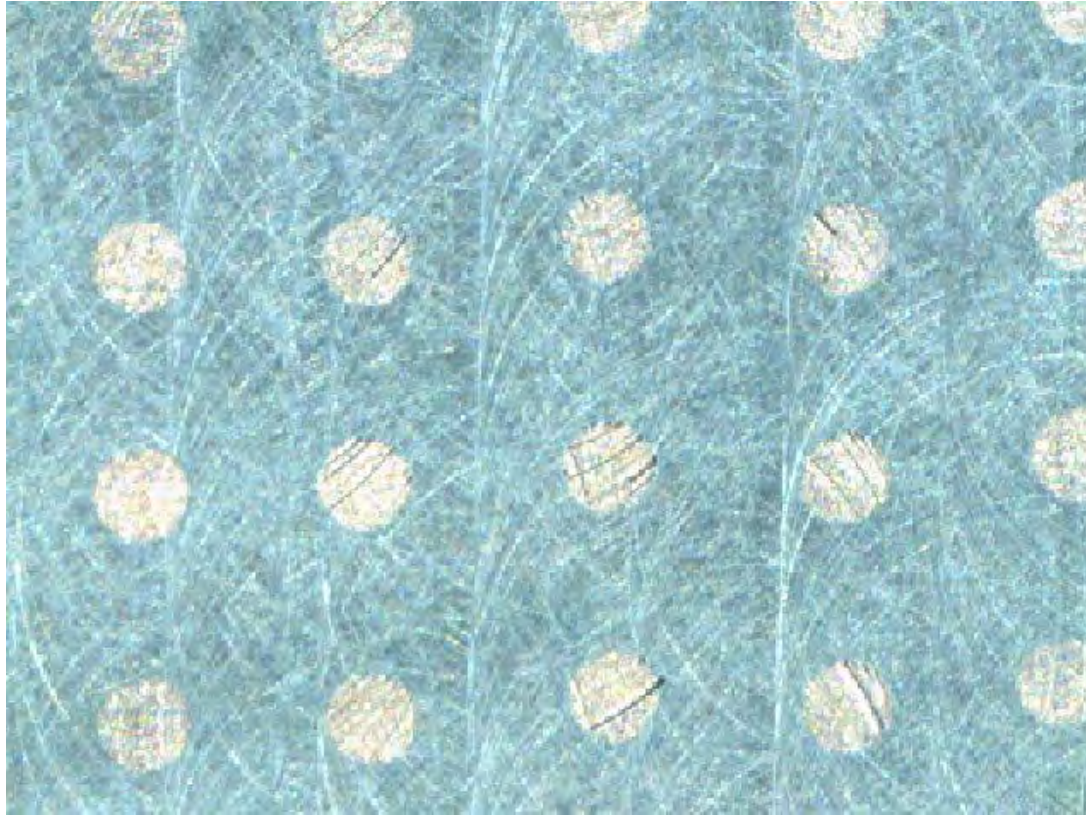
- Sample fabrication was done at the manufacturing facility located in Yixing, China of our industrial partner -Torrey Hill Tech., Inc.
- TC and CTE tests are done by Netzsch Shanghai

Experiment – Fabrication Process



Equipment for Fabrication

Specimen



CuW with 0.7mm Cu Vias

Results – TC of Pure CuW

热扩散系数 - NETZSCH LFA 分析

常规信息

数据库：	合金.mdb	**操作者：**	jll
仪器：	LFA 447	**备注(测量)：**	C0346
标识：	c0346_wcu合金-_2_257o0001 09.09	**比热表：**	WCu合金-2
日期/时间：	2009-9-14 14:16:52	**热膨胀系数表**	dL_const
材料：	WCu合金-2	**炉体：**	NanoFlash 300
密度 (25.0 ℃) /(g/cm^3	16.081	**样品支架：**	NanoFlash 12.7r
样品：	WCu合金-2	**激光：**	Xenon NanoFlas
类型：	单层	**炉体热电偶：**	K
厚度(室温下) /mm：	1.2090	**样品热电偶：**	K
直径 /mm：	12.730	**计算代码：**	C+p/l/0-0-0
检测器：	InSb		

结果

闪射点数	**温度** ℃	**模型**	**热扩散系数** mm^2/s	**导热系数** W/(m*K)	**Cp** J/g/K	**脉冲类型**
1	25.0	Cowan 模型 + 脉冲修正	68.244	181.240	0.165	1 (短)
2	25.0	Cowan 模型 + 脉冲修正	67.344	178.849	0.165	1 (短)
3	25.0	Cowan 模型 + 脉冲修正	63.765	169.343	0.165	1 (短)
4	25.0	Cowan 模型 + 脉冲修正	66.778	177.344	0.165	1 (短)
平均值:	**25.0**		**66.533**	**176.694**	**0.165**	
标准偏差:	**0.0**		**1.942**	**5.156**	**0.000**	

Results – TC of CuW with 0.7mm Vias

热扩散系数 - NETZSCH LFA 分析

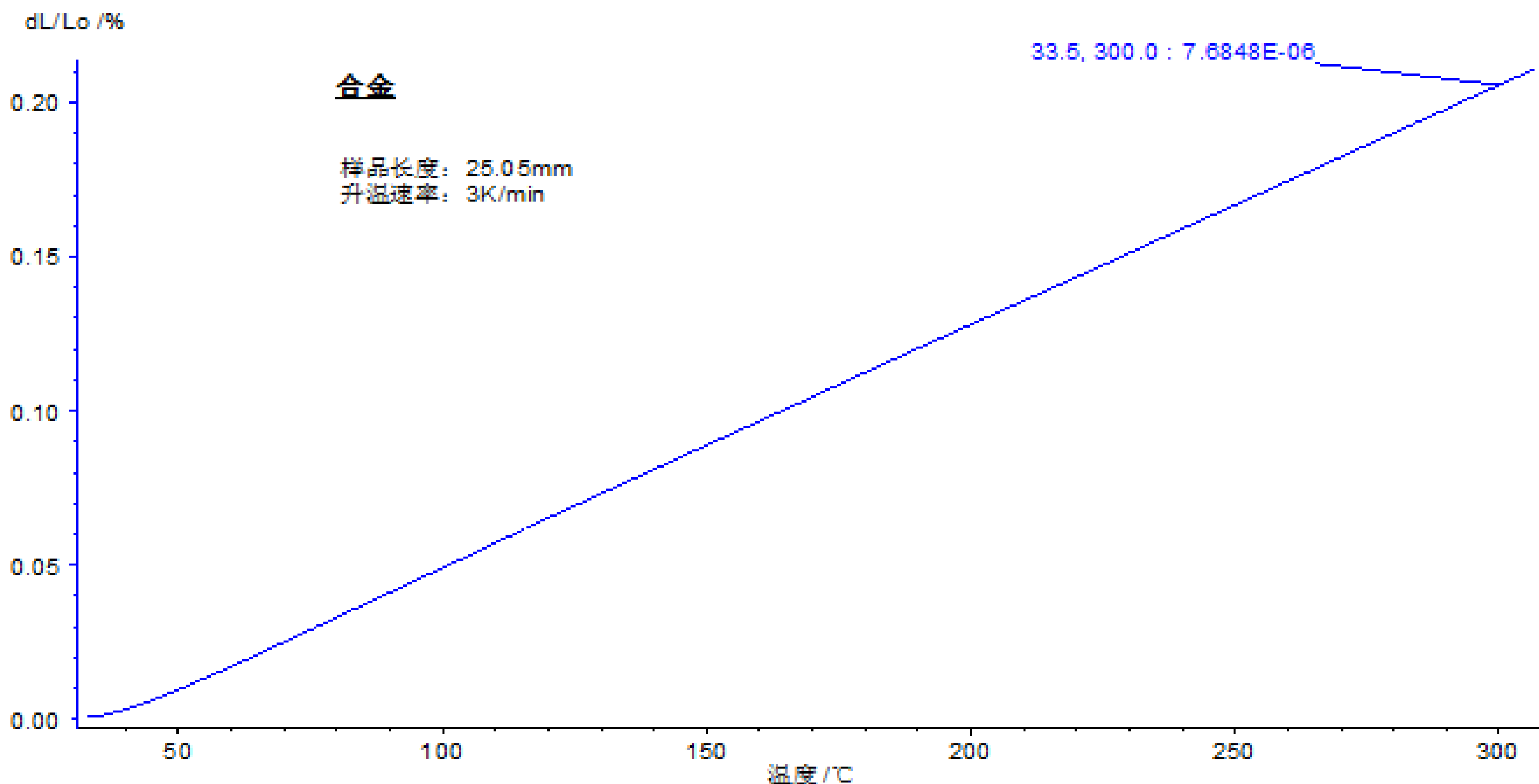
常规信息

数据库：	合金.mdb	**操作者：**	jll
仪器：	LFA 447	**备注(测量)：**	C0917
标识：	c0917_合金_3_219n4902 09.08.C	**比热表：**	合金
日期/时间：	2009-8-7 14:02:43	**热膨胀系数表**	dL_const
材料：	合金	**炉体：**	NanoFlash 300
密度 (25.0 ℃) /(g/cm^3)	14.899	**样品支架：**	NanoFlash 10.0s
样品：	合金	**激光：**	Xenon NanoFlash
类型：	单层	**炉体热电偶：**	K
厚度(室温下) /mm：	1.5490	**样品热电偶：**	K
直径 /mm：	10.000	**计算代码：**	C+p/l/0-0-0
检测器：	InSb		

结果

闪射点数	温度 ℃	模型	热扩散系数 mm^2/s	导热系数 W/(m*K)	Cp J/g/K	脉冲类型
1	25.0	Cowan 模型 + 脉冲修正	72.880	198.060	0.182	2 (中)
2	25.1	Cowan 模型 + 脉冲修正	73.274	199.131	0.182	2 (中)
3	25.1	Cowan 模型 + 脉冲修正	73.317	199.247	0.182	2 (中)
4	25.1	Cowan 模型 + 脉冲修正	73.981	201.054	0.182	2 (中)
平均值：	**25.1**		**73.363**	**199.373**	**0.182**	
标准偏差：	**0.1**		**0.457**	**1.241**	**0.000**	

Results – CTE of CuW with 0.7mm Vias



Conclusion

- For CuW with 0.7mm Cu Vias, TC is approximately 200 W/mK vs. 175 W/mK for pure CuW, which represents14% improvement on TC
- CTE of CuW with 0.7mm Cu Vias was measured to be 7.68ppm, which is similar to that of pure CuW 7.57ppm

Future

- CuW with non-uniformly distributed Cu Vias with different size
- CuW/Cu multilayer composite with Cu Vias
- CuW with graphite Vias

Acknowledgement

- Torrey Hills Technologies, LLC.
  - Equipment
    - Furnaces,
      - Electronics packaging
      - SMT
      - Solar cell
      - Other
    - Three roll mills
  - Components
    - CuW, CuMo, W, Mo etc. heat sinks
    - Various metal parts

Questions?