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Synthesis of W-AG Nanoalloys and Computer Aided Thermal Analysis of W-AG Nanoalloys Based Heat Sink

K. V Manikanta, D. Kondayya

***Abstract:** W-Ag finds applications in many frontier areas such as heat sinks and microwave absorbers for microelectronics devices, arcing tips, resistance welding electrodes, electrical contacts and heavy duty electronic contacts. These nanoalloys prepared by mechanical milling process result in highly dense product. Chemical approaches have significant advantages in terms of better stoichiometric control, purity and controllable particle size. The variation in chemical composition of these composites allows the match of thermal expansion coefficient with ceramic substrates used in semiconductor devices. In the present study, Ag nanoalloys with average sizes below 200 nm were prepared using tungsten powder and silver nitrate as precursors. Compositional characterization of W-Ag nanoalloys was carried out using portable XRF.The developed material i.e. W-Ag is used as heat sink application in which the heat sink is modeled and thermally analyzed for evaluation of heat flux. The heat flux obtained was compared with aluminum heat sink. It was perceived that W-Ag heat sink exhibited superiority in withstanding higher temperature. Whereas, heat sink designed from aluminum was limited with their parameter which is thermal conductivity.*

***Keywords:** Ansys, Silver (Ag), Spark Plasma Sintering (SPS), Tungsten(W), Three Dimension (3D), Two Dimension (2D)*

I. INTRODUCTION

Nanostructured W-Ag prepared by mechanical milling process result in highly dense product. The variation in chemical composition of these composites allows the match of thermal expansion coefficient with ceramic substrates used in semiconductor devices. Therefore, it finds applications in many frontier areas, e.g. heat sinks and microwave absorbers for microelectronics devices, arcing tips, resistance welding electrodes, electrical contacts and heavy duty electronic contacts. In addition, low melting/boiling point of Ag phase are utilized for removal of heat from engine components through sweating mechanism. Innovative work in heat sink has had a long history. However, it is as yet proceeding with endeavors to improve plan and execution by developments in displaying and expository procedures. Advancement of different heat sink plans alongside different fin geometries has altered the heat sink industry.

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* Correspondence Author
K. V Manikanta*, Department of Mechanical Engineering Sree nidhi Institute of Science and Technology, Hyderabad, Telangana India.
D. Kondayya, Department of Mechanical Engineering Sree nidhi Institute of Science and Technology, Hyderabad, Telangana India.

Mathematical formulas are used in Simulation software for modeling a real phenomenon.Simulation software is used widely to design equipments so that the end product relates to the design specification needed without any expense in process of modification. Ansys develops and markets finite element analysis software, used to simulate engineering problems.

In this work, the synthesized W-Ag nanoalloys were sintered at particular temperatures and hence, the temperature obtained was used for thermal analysis of heat sink prepared by these nanoalloys and was thereafter, compared with temperature distribution and heat flux of aluminum based heat sink.

II. EXPERIMENTAL PROCEDURE

A. Materials:

W-Ag nanocomposites of various compositions were prepared using commercially available reagents. Tungsten hexacarbonyl, silver nitrate,diphenyl ether,polyethylene glycol-400 (PEG 200, 98%) were purchased from SRL. Acetone and ethanol were used as received from SD Fine Chemicals, India.

B. Synthesis of W-Ag nanoalloys:

W-Ag nanoalloys were synthesized by mixing W powders with silver nitrate in varying ratios. The resulting powder was hydrogen reduced at 800 oC to achieve W-Ag alloys of various compositions. Table-1 represents the amount of tungsten powder and silver nitrate taken for W-Ag nanoalloys.

C. Elemental Analysis:

Determination of chemical composition remains one of the most important aspects in the synthesis of W-Ag alloys. XRF analysis shows that as-prepared composites mainly consist of W and Ag and found to beW-10 wt.% Ag, W-20 wt.% Ag and W-30wt.% Ag.

Table II.I: Initial amount of W powder and $AgNO_3$ taken for synthesis of W-Ag nanocomposites with varying compositions.

Expt. No.	Composition	Tungsten powder (gm)	Silver nitrate (gm)
1	W-10 wt.% Ag	5	0.9
2	W-20 wt.% Ag	4	1.8
3	W-30 wt.% Ag	3	2.5

D. Densification:

The sintering of W-10-30 wt. % Ag composites was carried out using spark plasma sintering (SPS). The sintering temperature variedbetween 900°C to 920 °C. However, sintering time was fixed for 60 minutes for all the experiments.

Details of sintering experiments are provided in Table 4.2. Densities of sintered compacts were measured using Archimedes principle.

Table II.II:Experimental details for spark plasma sintering

Composition	Temp, °C	Time, min
W-10 wt.% Ag	900-920	60
W-20 wt.% Ag	900-920	60
W-30 wt.% Ag	900-920	60

III. MODELING AND THERMAL ANALYSIS.

A. Modeling in Creo

Designs of a heat Sink with rectangular fins and inline arrangements are done in Creo parametric 2.0 in IGES format. Design parameters for both W-Ag and aluminum based heat sink were maintained homogeneously. A flat platform of 120 X 70 X 5 mm. Fin height for both the models is 40 mm. There are total number 20 fins in line arrangement on the base platform with a gap of 2 mm between them.

B. Geometry

Both the front view and top view of the 2D geometry and 3D model are shown in Figures-1 & 2 respectively. All the dimensions used for design is maintained in millimeter (mm).

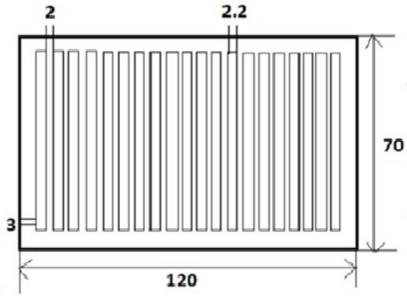

Fig.1:Top View of Heat Sink

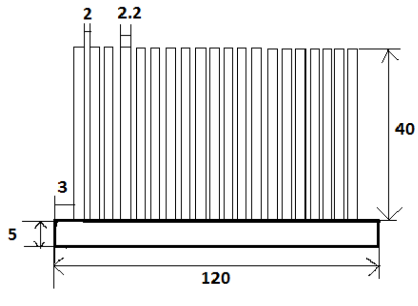

Fig. 2: Front View of Heat Sink

C. Thermal analysis of Heat sink

The steps followed in ANSYS workbench for thermal analysis are given below:

• Setup Analysis Environment

This involves:

1. Choosing type of Analysis
2. Defining Engineering data

• Build a model

This involves:

1. Importing files
2. Creating parts in Design Modeler

• Apply Boundary conditions

This involves:

1. Defining Connections
2. Applying Mesh Controls
3. Applying loads and supports

• Solve & Results review

D. Mesh Generation &Simulation

For work bench design modeler both the W-Ag and aluminum based heat sink model are imported into ANSYS and are meshed with a four node three dimensional tetrahedron element SOLID72 (Fine mesh) meshed model of W-Ag heat sink is shown in the figure-1. Mechanical APDL (ANSYS Parametric Design Language) solver is used to mesh the heat sinks.

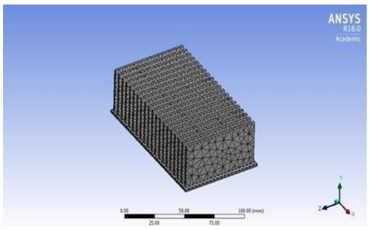

Fig 1: **Fine mesh**

Thermal conductivity value required for the as-sintered W-Ag sample prepared was insufficient in its parameters and out of scope for the experimental work accomplished. Therefore, thermal conductivity value of W-Ag heat sink was kept similar to aluminum heat sink for thermal analysis. Thermal analysis was conducted using ANSYS workbench based on finite volume methodology the effects of different important geometrical parameters on the steady state natural convective heat transfer rate was observed.

E. Results

A. *Temperature distribution in W-Ag and aluminum based heat sink*

In W-Ag the maximum temperature is 920 °C for proposed design. However, the Minimum temperature of heat sink is different for different types. Therefore, the minimum temperature for thermal analysis of W-Ag was kept at 784 °C in this design. Whereas, in case of aluminum heat sink designed for comparison, the parameters varied due to its limited properties i.e. in aluminum heat sink maximum temperature is 700°C and minimum temperature is 690 °C. The results are shown in Fig 1,2 & 3.

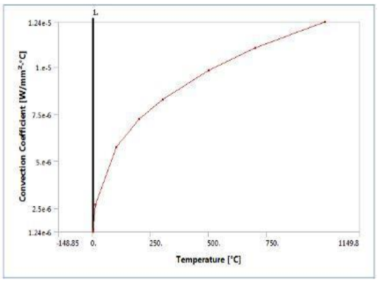

Fig 1: Convection Coefficient Vs. Temperature

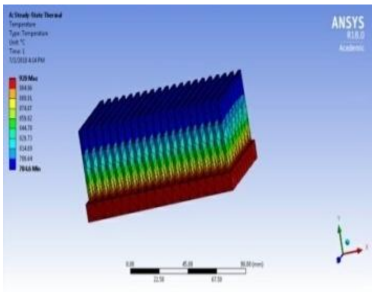

Fig 2: Temperature distribution of W-Ag based head sink.

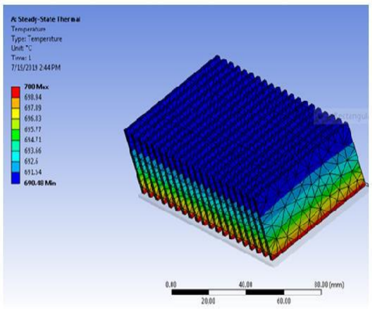

Fig 3: Temperature distribution of Aluminum based head sink.

B. *Heat flux distribution in W-Ag and aluminum based heat sink*

Total heat flux observed on the north bridge heat sink varied according to heat sink design. Therefore, the value of maximum heat flux generated for the proposed W-Ag heat sink design is 0.29731 W/mm^2 and minimum heat flux generated is 0.0018229 W/mm^2. Whereas, in case of aluminum results showed the maximum heat flux generated for the given design is 0.1283 W/mm^2 and minimum heat flux generated is generated automatically. The figures are shown in 1 & 2.

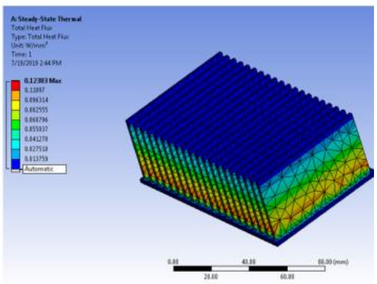

Fig 1:Total heat flux distribution in W-Ag based heat sink.

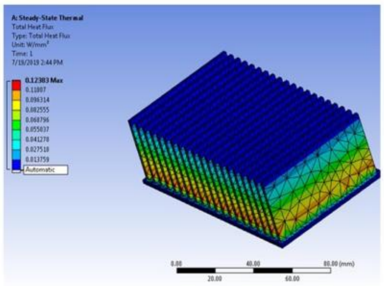

Fig 2: Total heat flux distribution in Aluminum based heat sink.

TABLE III.1: Temperature distribution and heat flux values of W-Ag and aluminum based heat sink

Temperature & Heat flux	W-Ag as-sintered Specimen	Aluminum
Maximum Temperature in (°C)	920	700
Minimum Temperature (°C)	784	690
Maximum Heat Flux in (W/MM^2)	0.29731	0.12383
Minimum Heat Flux (W/MM^2)	0.0018	Generated Automatically

It is evident from result that heat sink designed from W-Ag can withstand higher temperature and can dissipate heat soaring than aluminum based heat sink. As, heat sink designed from Al was limited with its parameters.

IV. CONCLUSION

W-10-30 wt.% Ag nanoalloys with average sizes below 200 nm are prepared by a chemical approach. Spark plasma sintering of W-Ag nanoalloy with composition W-10-30 wt.% Agshowed it can withstand temperature ranging from 900 °C to 920 °C. The heat sink designed from W-Ag nanoalloy can withstand higher temperature whereas heat sink designed from aluminum is limited with its thermal parameters which is heat dissipation.

REFERENCES

1. C. Wang, W. Ye, Chuanli Ma, W. Shang, Y. Chen, R. Wang. Effects of sodium dodecylsulfate on improving microstructural properties of electroplated silver-oxygen tungsten thin films, Surface Coating & Technology 201 (2007) 9456-9461.
2. F. Pan, S. P. Wen, R. L. Zong, F. Zeng, Y. Gao. Influence of plasticity mismatch and porosity on mechanical behavior of Nano scale Ag/W multilayers, Materials Science & Engineering 457 (2007) 38-43.
3. M. Madej. Silver- based infiltrated composites, Archives of Metallurgy and Materials 57 (2012) 605-612.
4. T. Mashimo, X. Huang. Nano equilibrium alloy powders and bulk alloys in W-Ag system prepared by mechanical alloying and shock compression, Journals of Alloys and Compounds 361 (2003) 118-124.
5. F. A. da Costa, A. G. Pereira da Silva, F. A. Filho, U. U. Gomes, F. A. Vieira. Synthesis of a Nano crystalline composite W-25 wt%.Ag powder by high energy milling, Powder Technology 188 (2008) 30-33.
6. J. Lezanski, M. Madej. The influence of production process parameters on the properties of W-Ag, Mo-Ag composites, Materials Science forums 534-536 (2007) 1513-1516.

7. A. Inberg, V. Bogush, E. Ginsburg, E. Rabinovich, N. Croitoru, Y. S. Diamand. The effect of surface activation on electroless Ag (W) deposition, Journals of Optoelectronics and Advanced Materials vol.8, no.6 (2006) 2035-2038
8. F. A. da Costa, A. G. P. da Silva, F. A. Filho, U. U. Gomes. Solid state sintering of W-25 % Ag powder prepared by high energy milling, International Journal of Refractory Metals & Hard Materials 26 (2008) 318-323.
9. V. Bogus, A. Inberg, N. Croitoru, V. Dubin, Y. S. Diamand. Electroless deposition of novel Ag-W thin films, Microelectronic Engineering 70 (2003) 489-494.
10. P. K. Sahoo, S. K. Srivastava, S. S. Kalyan Kamal, L. Durai. Microstructural and sintering behavior of W-Ag nanocomposites prepared by simultaneous thermal decomposition and polyolprocess', Advanced Science, Engineering and Medicine 6 (2014) 1-7.
11. K. A. M. Annuar, F. S. Ismail. Optimal Pin Fin Arrangement of Heat Sink Design And Thermal Analysis for Central Processing Unit, IEEE 2014.
12. S. Ravikumar. Experimental and Transient Thermal Analysis of Heat Sink for CPU processor for better performance, Materials Science and Engineering, (2017) 197 012085.
13. P. Chennakesavarao. A Thesis on Design Optimization of Heat Sink in Power Electronics, Int. Journal of Engineering Research and Applications, Vol. 4 ,October (2014) 83-94.

AUTHORS PROFILE

V. K. V Manikanta achieved his Bachelor's Degree (B. Tech) in Mechanical Engineering from GIET college of Engineering, Rajamahedravaram (Andhra Praddesh). Presently he is pursuing his Post graduation (M. Tech) in CAD/CAM from Sreenidhi Institute of Science and Technology, Hyderabad (Telangana). His project work includes "Fabrication of Intelligent Vehicle Sensor" (B. Tech). He did his M. Tech project work in collaboration with esteemed DMRL, Hyderabad. His area of interest includes Tool Designing &Mechanical Products Design.

Dr. D. Kondayya is a faculty of Mechanical Engineering with over 15 years of teaching experience. He did his Ph.D. in the area of Advanced Machining from Mechanical Engineering department of JNTUK, Kakinada in 2012, M.E.in Production Engineering from Faculty of Engineering & Technology, MSU Baroda in 1996. He received GATE scholarship from MHRD during his post-graduation study. Prior to teaching he served as Junior Engineer in Steel Melt shop division of ESSAR Steels Ltd, Surat for 3 years.

He is a member of Institution of Engineers, India. He has published research papers in several International Journals and Conferences. His research work has appeared in International journals like, International journal of advanced manufacturing technology, International journal of computer integrated manufacturing etc and international conferences like AIMTDR. His teaching areas are Manufacturing processes, Conventional and Advanced Machine tools, Operations Research, CAD/CAM. His research interests are Evolutionary algorithms, Advanced Machining Methods and Optimization.

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