Journal of Basic and Applied Engineering Research
Print ISSN: 2350-0077; Online ISSN: 2350-0255; Volume 2, Number 15; April-June, 2015 pp. 1249-1250

http://www.krishisanskriti.org/jbaer.html

# Comparative Study of Elastic Modulus of Bismuth-Cadmium (Bi-Cd) and Bismuth-Lead (Bi-Pb) Alloys Grown By Zone-Refining Technique

**Arti H Prajapati[1] and I.B. Patel[2]**

*[1,2]Department of Physics, Veer Narmad South Gujarat University, SURAT, GUJARAT-395007(INDIA)*
*E-mail: [1]arti.prajapati@gmail.com, [2]patelishverb@yahoo.com*

**Abstract—***Bismuth-Cadmium (Bi-Cd) and Bismuth-Lead (Bi-Pb) are alloys of high purity (99.99%) metals were grown in a vaccum atmosphere (~ 4 x 10 $^{-2}$ mbar) by Zone - Refining Technique. The Micro-hardness of these alloys obtained using indentation load of 5-20 gm for loading time of 10-30 sec at room temperature. The Young's Modulus of these alloys studied with the help of micro hardness. The comparison study of Young's Modulus reported in the present work.*

**Keywords:** *Zone-Refining Technique, Young's Modulus, Micro Hardness.*

## 1. INTRODUCTION

The Vicker's hardness test has been widely used to evaluate mechanical properties of metals and alloys because of its simple testing technique. In this test, there is very little damage done to specimen because the impression is very small. The importance of Hardness testing has to do with the relationship between Hardness and other mechanical properties like Young's Modulus, yield strength, ultimate tensile strength and stiffness. Young's Modulus is an indication of the Stiffness of a material.

## 2. EXPERIMENTAL PROCEDURE

Eutectic alloy Bismuth-Cadmium (Bi-Cd)and Bismuth-Lead (Bi-Pb) were grown from an appropriate amount of each metal of 3N purity. Alloys were prepared on the basis of percentage of molecular weight 9:1, 5:5 and 1:9 ratio. These samples were carefully melted in the oxidation furnace and shaken well in zone tube. These samples are successfully grown by Zone Refining Technique under a vaccum atmosphere (~ 4 x 10 -2 mbar). The Vicker's hardness test method consists of indenting the test material with a diamond indenter, in the form of a pyramid with a square base and an angle of 136 degrees between opposite faces subjected to a test force of between 5 gm and 20 gm. The full indentation load is normally applied for 10 to 15 seconds. The micro hardness values are the average of number of measurement on transverse and longitudinal section. The area of the sloping surfaces of the indentation is calculated. The hardness measured with pyramidal indenters depends on lead , especially for small load. The Vickers hardness [1,4] is the quotient obtained by dividing the load by the square mm area of indentation.

$$H_V = \frac{(1.854)P}{d^2}$$

Where, P = Load in kg,

d = Arithmetic mean of the two diagonals,

Hv = Vickers hardness.

We calculated Elastic modulus [2- 4] by the following formula,

$$\text{Elastic modulus, } E = (81.9635) \times Hv$$

## 3. RESULT AND DISCUSSION

Young's modulus is a measure of the stiffness of a material, depends upon strength of interatomic bonds and composition, and is not strongly depends upon microstructure. The value of elastic modulus decreases with increasing the indentation load but it changes with increasing the loading time at room temperature .Its value decreases with increasing indentation load and temperature at constant loading time t = 10 sec. The results of elastic modulus of Bi-Cd and Bi-Pb at room temperature are shown in the table 1.

**Table 1: Elastic modulus (E) (At Room Temperature)**

| Composition wt.% | Load in kg | Elastic modulus (E) Pa | | | | | |
|---|---|---|---|---|---|---|---|
| | | Bi-Cd | | | Bi-Pb | | |
| | | 10 sec | 20 sec | 30 sec | 10 sec | 20 sec | 30 sec |
| 9:1 | 0.005 | 1.6393 | 1.5737 | 1.4262 | 1.2213 | 1.2049 | 1.0327 |
| | 0.010 | 1.2540 | 1.1967 | 1.1393 | 1.7294 | 1.3934 | 1.3442 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0.015 | 1.1147 | 1.0819 | 1.0491 | 1.2540 | 1.2376 | 1.1967 |
| | 0.020 | 1.0327 | 1.0082 | 0.9590 | 1.0409 | 1.0082 | 0.9836 |
| 5:5 | 0.005 | 1.6966 | 1.3688 | 1.2295 | 2.1147 | 2.0901 | 1.8770 |
| | 0.010 | 1.8606 | 1.6147 | 1.4835 | 2.1638 | 1.9917 | 1.8032 |
| | 0.015 | 1.4180 | 1.2704 | 1.1229 | 1.4671 | 1.4426 | 1.4098 |
| | 0.020 | 1.0901 | 1.0573 | 1.0163 | 1.3606 | 1.2295 | 1.2213 |
| 1:9 | 0.005 | 1.5901 | 1.4753 | 1.3688 | -- | -- | -- |
| | 0.010 | 2.3442 | 2.2786 | 2.1966 | 1.3196 | 1.1147 | 1.0819 |
| | 0.015 | 1.6147 | 1.4671 | 1.2786 | 1.0819 | 1.0000 | 1.0082 |
| | 0.020 | 1.2458 | 1.1393 | 1.0082 | 0.9918 | 0.9918 | 0.9590 |

When the indenter is subjected to very small loads, only elastic deformation is observed, although the unit load greatly exceeds the hardness values usually measured. At a certain load, there is sudden break and ordinary plastic flow of the material under the indenter begins. This effect was attributes to the lack of dislocations under indenter at very small load. With increase in load, metal and alloys that already contains dislocations is drawn into the process, and plastic deformation begins [5]. The alloying of bismuth deposits by lead despite the reduction of the grains, somewhat lowers their micro hardness, because lead is less hard than bismuth. Young's modulus is directly proportional to hardness, so its lowers their young's modulus [6]. The presence of cadmium quantities in alloys can enhance their hardness, wear resistance and mechanical properties [7].

## 4. ACKNOWLEDGEMENTS

The authors thank to Dr. I. B. Patel for his guidance and his encouragement and Dr. K. C. Poria, Head of the Department of Physics, Veer Narmad South Gujarat University, for providing laboratory facilities.

## REFERENCES

[1] Kay Geels, Metallographic and Materialographic Specimen Preparation, Light Microscopy, Image Analysis and Hardness Testing, ASTM International, U.S.A, (2006).

[2] R. Awad, A. I. Abou-Aly, M. M. H. Abdel Gawad, I. G-Eldee,. *J Supercond Nov Magn* DOI 10.1007/s10948-011-1334-y, September (2011).

[3] Cetinkara,H.A.,Yilmazlar,M.,Ozturk,O.,Nursoy,M.,Terzioglu, C.*: J. Phys. Conf.* Ser. 153, 012038 (2009).

[4] Tabor, D.: *The Hardness of Metals*. Clarendon, Oxford (1951).

[5] A. P. Semenov, *Russian Engineering Research*; Vol. 28, No.12, pp.1177-1182, (2008).

[6] V.V. Povetkin and T.G. Shibleva, ISSN 0033-1732, Protection of Metals, Vol. 42, No.5, pp. 516-519. @ Pleiades Publishing, Inc., 2006.

[7] Cadmium (Materials Flow) by Thomas O. Liewellyn, Bureau of Mines, Washington, DC.