Anısotropy of Dıfferent Types of Alloys

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Abstract

The norm of elastic constant tensor and the norms of the irreducible parts of the elastic constants of the alloys Iron-Silicon at different percentages of Silicon, Lead-Indium at different percentages of Indium, Molybdenum-Rhenium at different percentages of Rhenium, Niobium-Hydrogen at different percentages of Hydrogen, Niobium-Molybdenum at different percentages of Molybdenum, Niobium-Oxygen at different percentages of Oxygen, Niobium-Zirconium at different percentages of Zirconium, Palladium-Rhodium at different percentages of Rhodium, Palladium-Rhodium at different percentages of Rhodium, and Palladium-Silver at different percentages of Silver are calculated. The relation of the scalar parts norm and the other parts norms and the anisotropy of the alloys are presented. The norm ratios are used as a criterion to present the anisotropy degree of the properties of the alloys.

Keywords: Norm, Anisotropy, Elastic Constant, Irreducible, and Alloys.

1 Introduction:

An alloy is a mixture of metals or a mixture of a metal and another element, the term alloy is used to describe a mixture of atoms in which the primary constituent is a metal. The primary metal is called the base, the matrix, or the solvent. The secondary constituents are often called solutes Alloys are used in a wide variety of applications. In some cases, a combination of metals may reduce the overall cost of the material while preserving important properties. In other cases, the combination of metals imparts synergistic properties to the constituent metal elements such as corrosion resistance or mechanical strength, the mechanical properties of alloys will often be quite different from those of its individual constituents. A metal that is normally very soft (malleable), such as aluminum, can be altered by alloying it with another soft metal, such as copper. Although both metals are very soft and ductile, the resulting aluminum alloy will have much greater strength, Alloying a metal is done by combining it with one or more other elements that often enhance its properties. For example, the combination of carbon with iron produces steel, which is stronger than iron, its primary element, The alloy constituents are usually measured by mass, Alloys are usually classified as substitutional or interstitial alloys, depending on the atomic arrangement that forms the alloy. They can be further classified as homogeneous (consisting of a single phase), or heterogeneous (consisting of two or more phases) or intermetallic. The decomposition of the elastic constant tensor to its irreducible parts and the norm concept and its relation to anisotropy are given in [1,2].

2 Alloys:

The elastic constants of Cubic systems Alloys are given in the following table, [3,4].

Table 1. Elastic constants in GPa

Alloy	C_{11}	C_{44}	C_{12}
Iron-Silicon, Fe-Si,			
at % Si			
8.59	216.4	124.6	134
11.68	215.5	126.7	137
12.91	217.0	127.9	137
25.1	238	136	138
Lead-Indium, Pb-In,			
at % In			
5.5	49.32	14.43	42.51
9.0	59.70	13.90	33.70
20.7	48.70	16.60	18.90
Molybdenum-rhenium, Mo-Re			
at % Re			
7.0	466.5	114.8	172.9
16.6	465.0	123.7	185.8
26.9	460.7	132.3	195.9
Niobium-Hydrogen, Nb-H			
at % H			
0.1	246.8	28.2	133.2
1.06	247.0	28.6	134.4
3.06	245.8	29.6	133.8
Niobium-Molybdenum, Nb-Mo			
at % Mo			
16.8	271.0	29.47	133.4
23.3	286.0	32.02	134.8
33.9	315.7	36.29	136.8
51.6	363.6	62.63	143.4
75.2	422.3	68.59	153.0
92.1	454.0	102.3	159.6
Niobium-Oxygen, Nb-O			
at % O			
0.59	247.2	28.2	133.4

9.60	249.4	30.0	134.0
Niobium-Zirconium, Nb-Zr			
at % Zr			
69.6	127.1	33.76	91.9
74.7	120.4	33.42	88.5
79.7	116.4	32.56	88.7
Palladium-Rhodium, Pd-Rh			
at % Rh			
1	222.7	72.1	172.0
5	227.2	76.0	172.4
20	249.0	90.25	173.8
Palladium-Silver, Pd-Ag			
at % Ag			
2	220.3	71.8	170.0
10	207.7	75.5	159.6

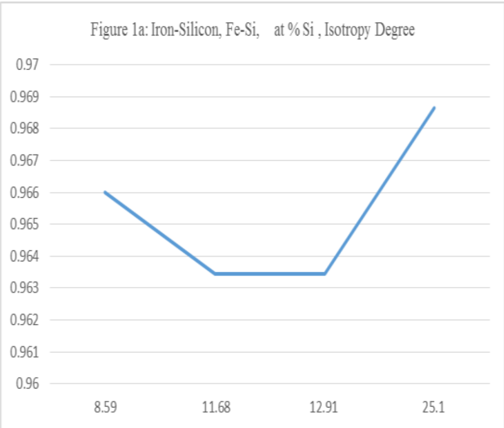
By using table 1, and the decomposition of the elastic constant tensor and the norm concept we can calculate the norms and the norm ratios of the given alloys as shown in the following table.

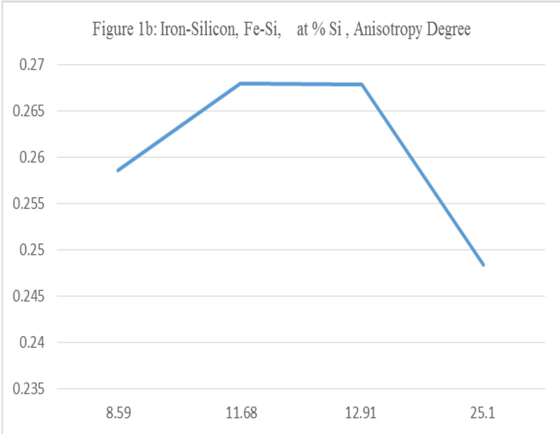
Table 2. The norms and norm ratios (the anisotropy degree).

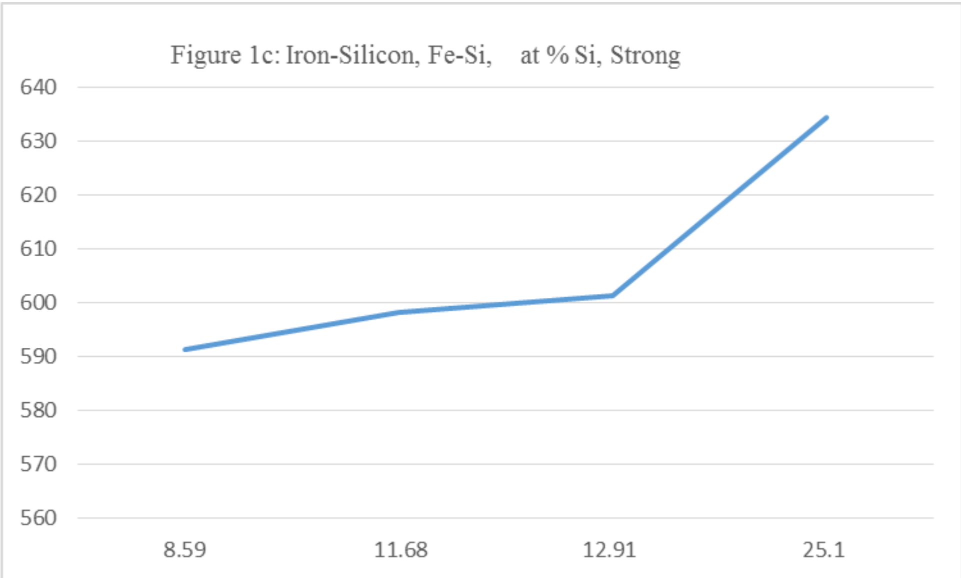
Alloy	N_s	N_d	N_n	N	N_s / N	N_d / N	N_n / N
Iron-Silicon, Fe-Si, at % Si							
8.59	571.1528	0	152.8747	591.2581	0.965996	0	0.258558
11.68	576.3232	0	160.2985	598.2006	0.963428	0	0.267968
12.91	579.3866	0	161.1234	601.373	0.96344	0	0.267926
25.1	614.6089	0	157.6406	634.5035	0.968645	0	0.248447
Lead-Indium, Pb-In, at % In							
5.5	1.383895	0	20.20916	139.8572	0.989505	0	0.144498
9	134.8001	0	1.649727	134.8102	0.999925	0	0.012237
20.7	101.3418	0	3.116151	101.3897	0.999528	0	0.030734
Molybdenum-rhenium, Mo-Re, at % Re							

7	915.9316	0	58.65697	917.8079	0.997956	0	0.06391
16.6	941.2604	0	29.14518	941.7115	0.99521	0	0.030949
26.9	958.8581	0	0.183303	958.8581	1	0	0.000191
Niobium-Hydrogen, Nb-H, at % H							
0.1	529.7725	0	52.42467	532.36	0.995139	0	0.098476
1.06	532.3243	0	50.77494	534.7404	0.995482	0	0.094953
3.06	530.3967	0	48.392	532.5997	0.995864	0	0.09086
Niobium-Molybdenum, Nb-Mo, at % Mo							
16.8	558.3048	0	72.09308	562.9402	0.991766	0	0.128065
23.3	579.3029	0	79.88346	584.7848	0.990626	0	0.136603
33.9	619.4446	0	97.44389	627.0621	0.987852	0	0.155398
51.6	704.4832	0	87.01395	709.8366	0.992458	0	0.122583
75.2	793.5522	0	121.09	802.7378	0.988557	0	0.150846
92	870.0146	0	82.30306	873.8988	0.995555	0	0.094179
Niobium-Oxygen, Nb-O, at % O							
0.59	530.5804	0	52.60797	533.1821	0.99512	0	0.098668
9.6	535.0383	0	50.77494	537.4422	0.995527	0	0.094475
Niobium-Zirconium, Nb-Zr, at % Zr							
69.6	323.8126	0	29.62177	325.1646	0.995842	0	0.091098
74.7	310.0515	0	32.02304	311.7008	0.994709	0	0.102736
79.7	305.3446	0	34.296	307.2646	0.993751	0	0.11617
Palladium-Rhodium, Pd-Rh, at % Rh							
1	593.7306	0	85.69417	599.8829	0.989744	0	0.142851

5	601.9746	0	89.08527	608.5307	0.989226	0	0.146394
20	639.2115	0	96.50904	646.456	0.988794	0	0.149289
Palladium-Silver, Pd-Ag, at % Ag							
2	587.3658	0	85.51086	593.5576	0.989568	0	0.144065
10	557.4961	0	94.30941	565.4168	0.985991	0	0.166796







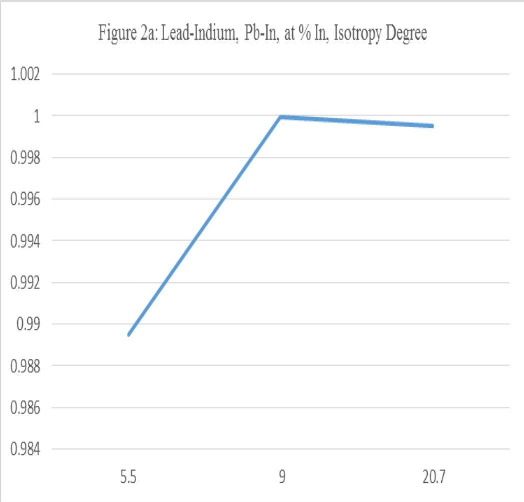


Figure 2a: Lead-Indium, Pb-In, at % In, Isotropy Degree

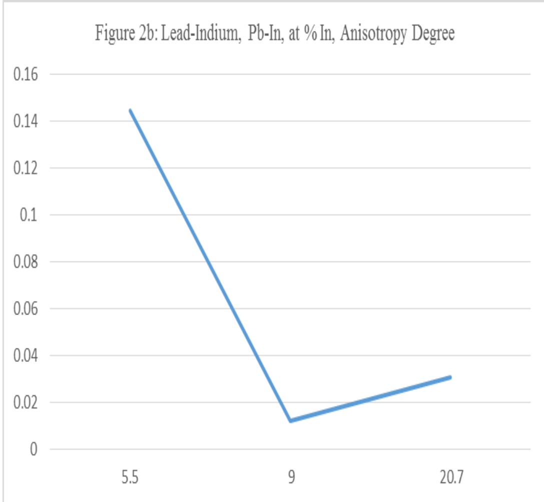


Figure 2b: Lead-Indium, Pb-In, at % In, Anisotropy Degree

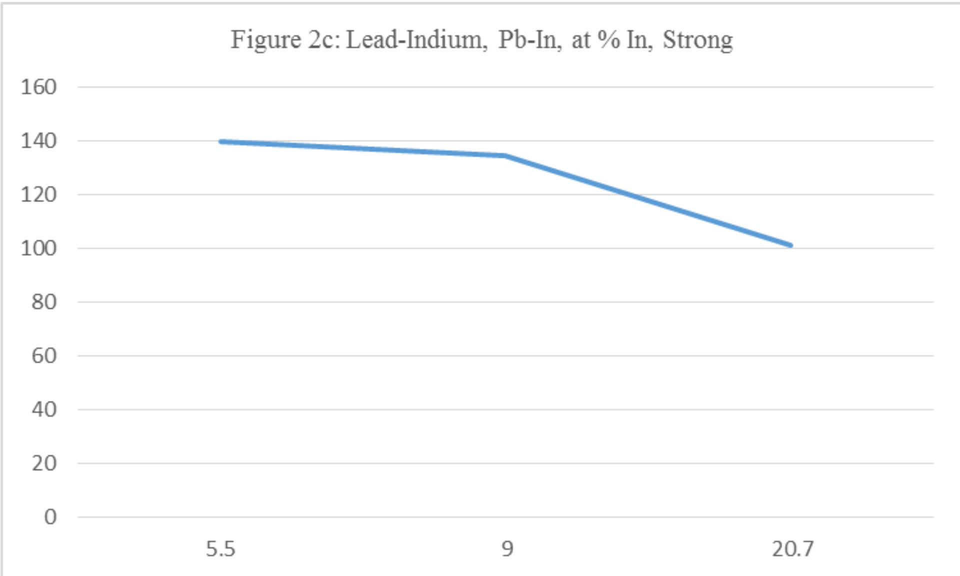


Figure 2c: Lead-Indium, Pb-In, at % In, Strong

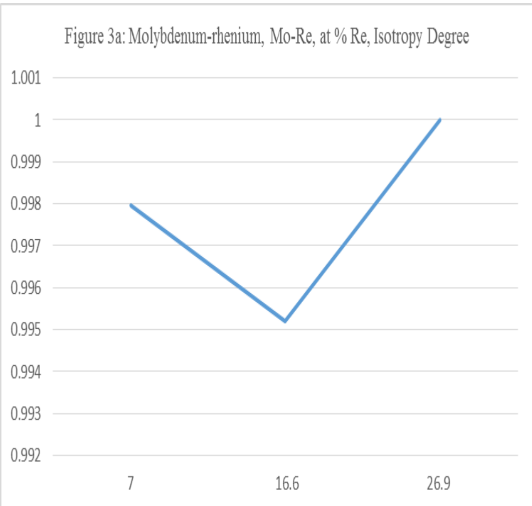


Figure 3a: Molybdenum-rhenium, Mo-Re, at % Re, Isotropy Degree

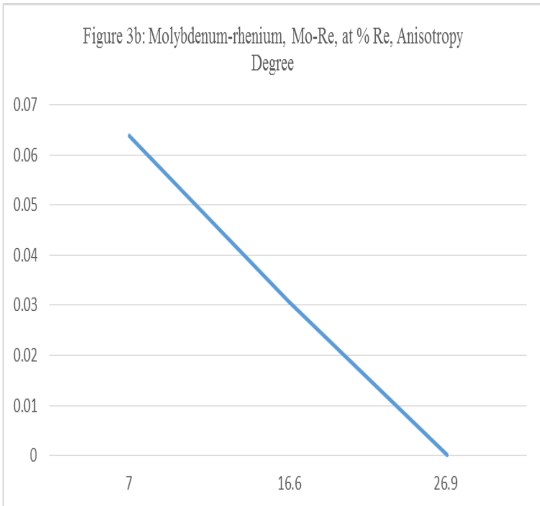


Figure 3b: Molybdenum-rhenium, Mo-Re, at % Re, Anisotropy Degree

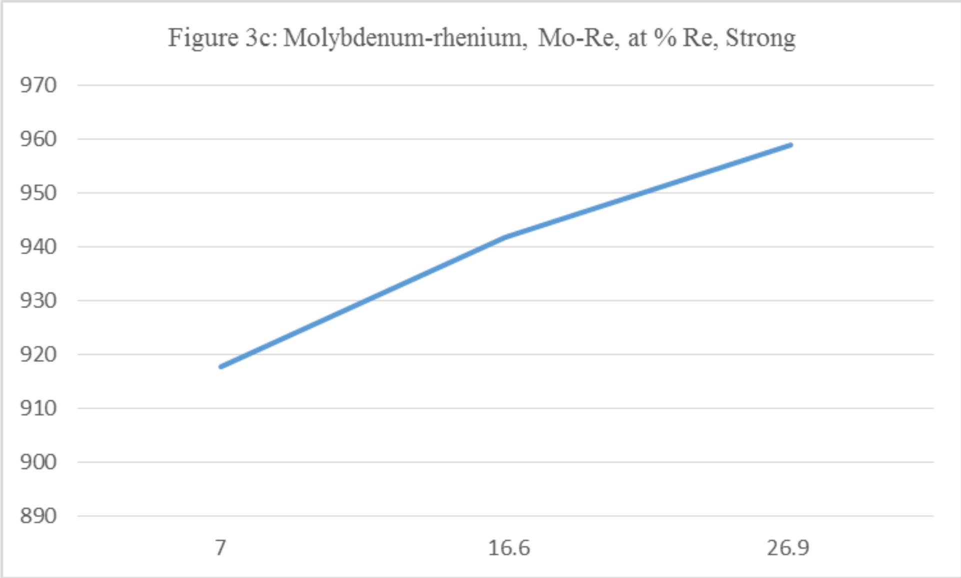


Figure 3c: Molybdenum-rhenium, Mo-Re, at % Re, Strong
970
960
950
940
930
920
910
900
890
7
16.6
26.9

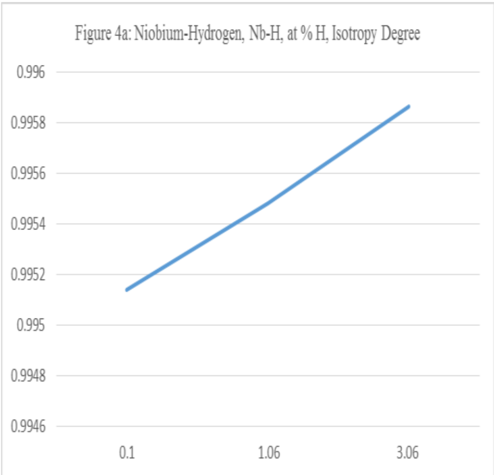


Figure 4a: Niobium-Hydrogen, Nb-H, at % H, Isotropy Degree
0.996
0.9958
0.9956
0.9954
0.9952
0.995
0.9948
0.9946
0.1
1.06
3.06

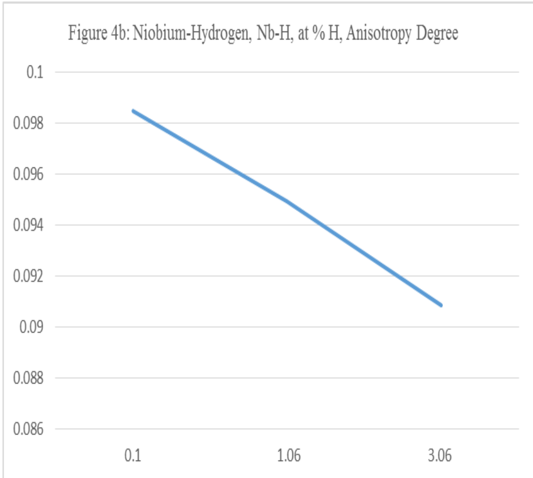


Figure 4b: Niobium-Hydrogen, Nb-H, at % H, Anisotropy Degree
0.1
0.098
0.096
0.094
0.092
0.09
0.088
0.086
0.1
1.06
3.06

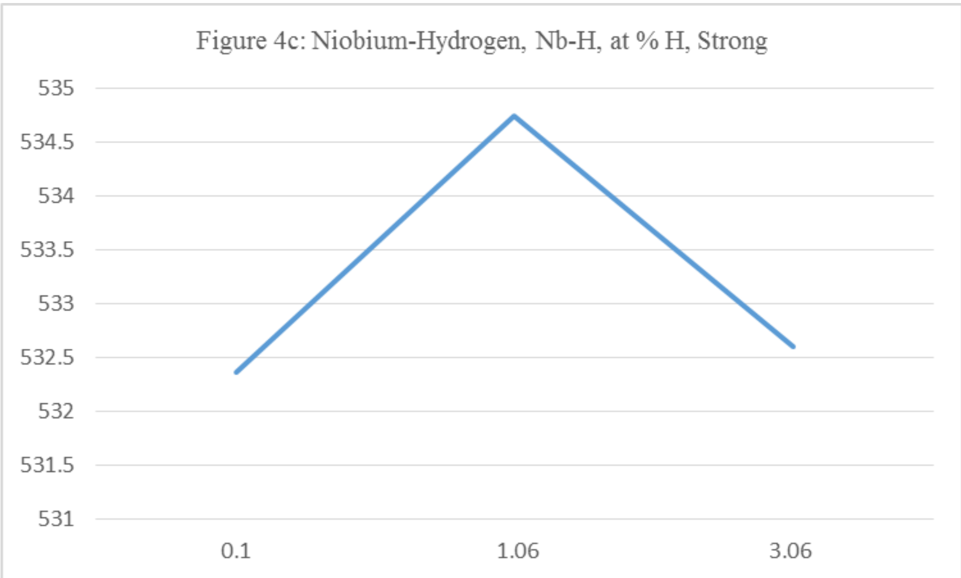


Figure 4c: Niobium-Hydrogen, Nb-H, at % H, Strong
535
534.5
534
533.5
533
532.5
532
531.5
531
0.1
1.06
3.06

Figure 5a: Niobium-Molybdenum, Nb-Mo, at % Mo, Isotropy Degree

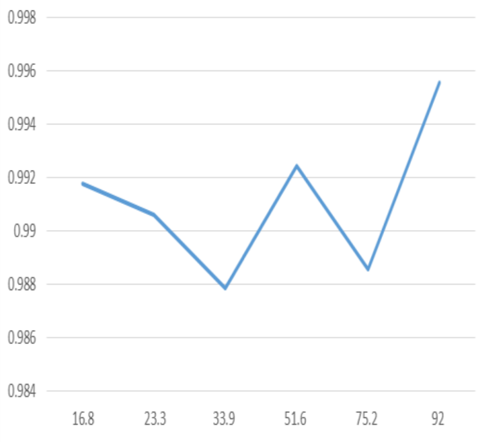


Figure 5b: Niobium-Molybdenum, Nb-Mo, at % Mo, Anisotropy Degree

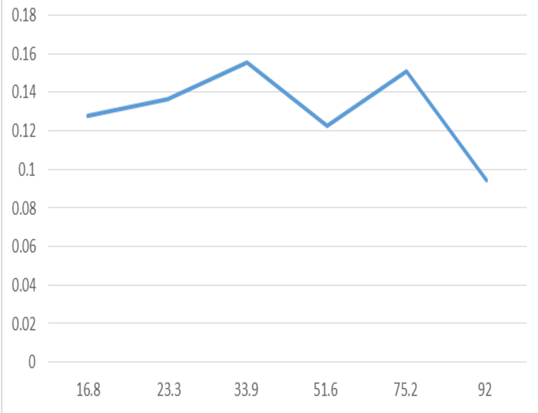


Figure 5c: Niobium-Molybdenum, Nb-Mo, at % Mo, Strong

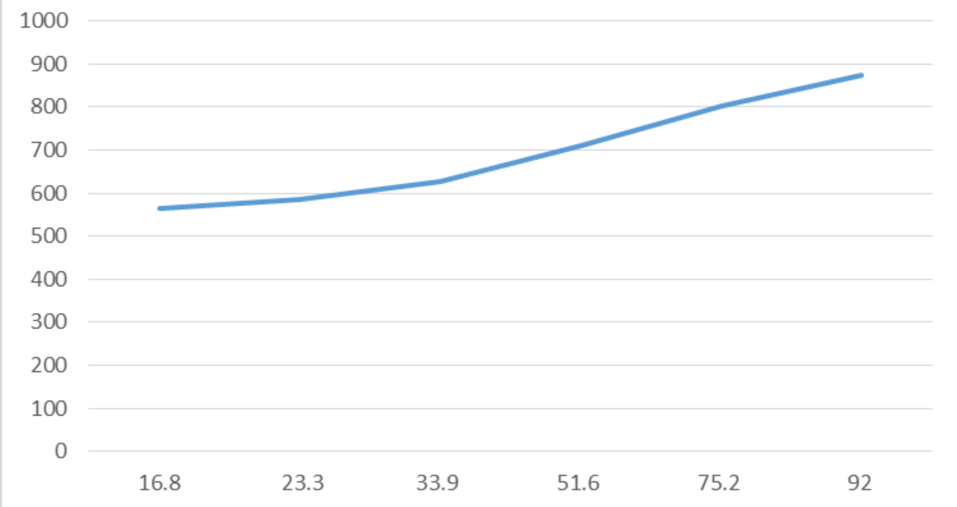


Figure 6a: Niobium-Oxygen, Nb-O, at % O, Isotropy Degree

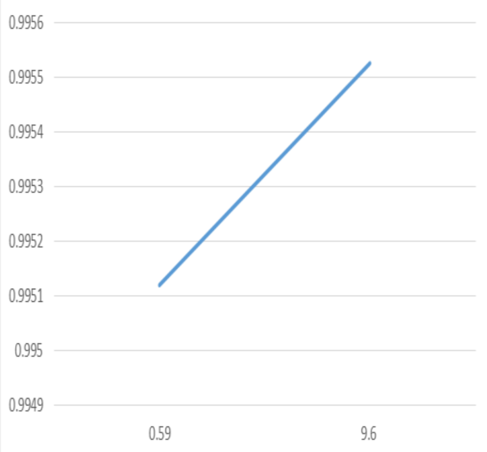
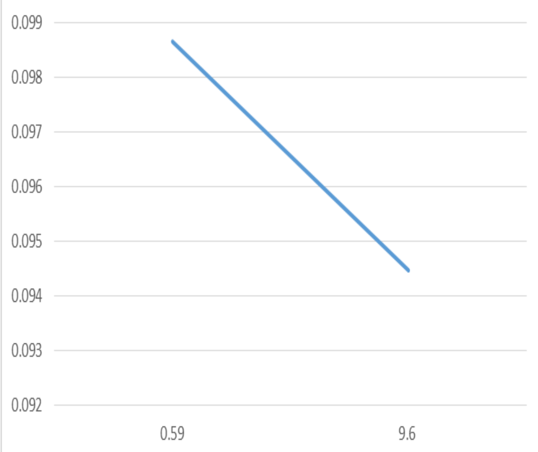


Figure 6b: Niobium-Oxygen, Nb-O, at % O, Anisotropy Degree



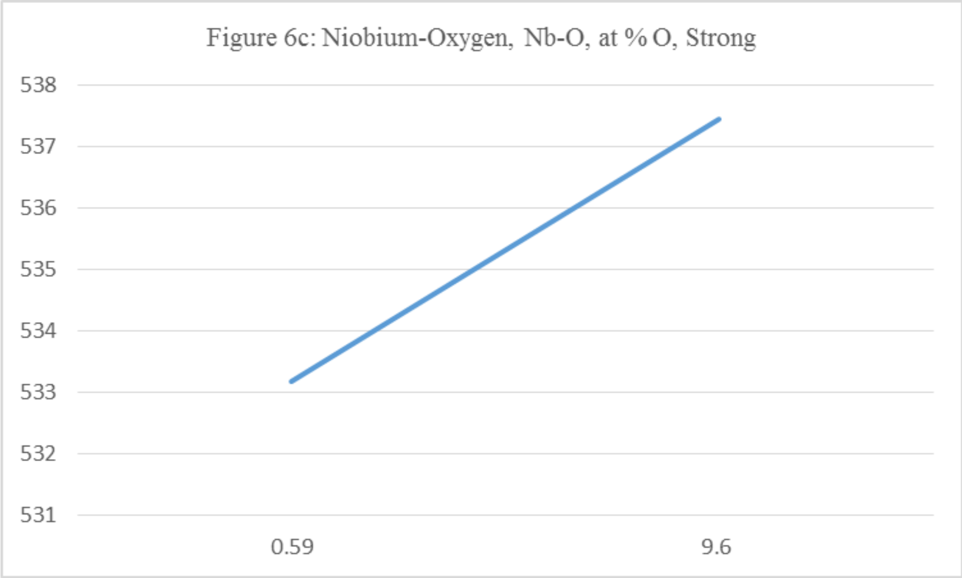


Figure 6c: Niobium-Oxygen, Nb-O, at % O, Strong
538
537
536
535
534
533
532
531
0.59
9.6

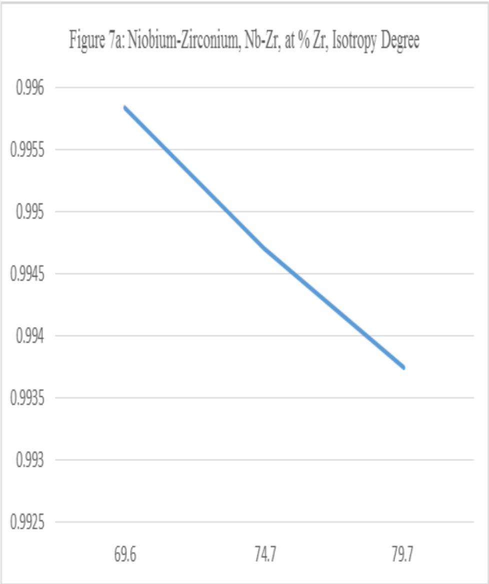


Figure 7a: Niobium-Zirconium, Nb-Zr, at % Zr, Isotropy Degree
0.996
0.9955
0.995
0.9945
0.994
0.9935
0.993
0.9925
69.6
74.7
79.7

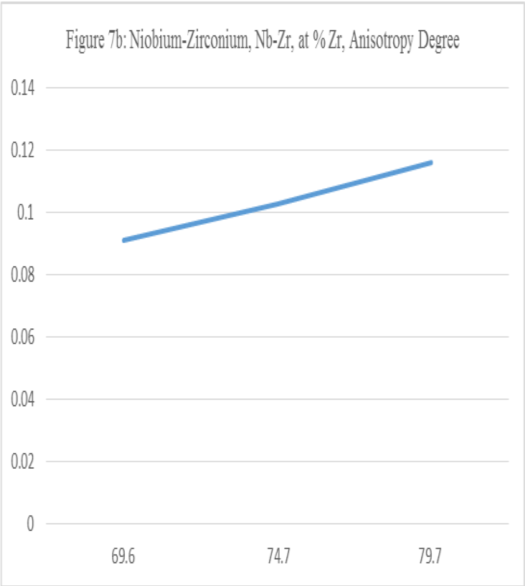


Figure 7b: Niobium-Zirconium, Nb-Zr, at % Zr, Anisotropy Degree
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
69.6
74.7
79.7

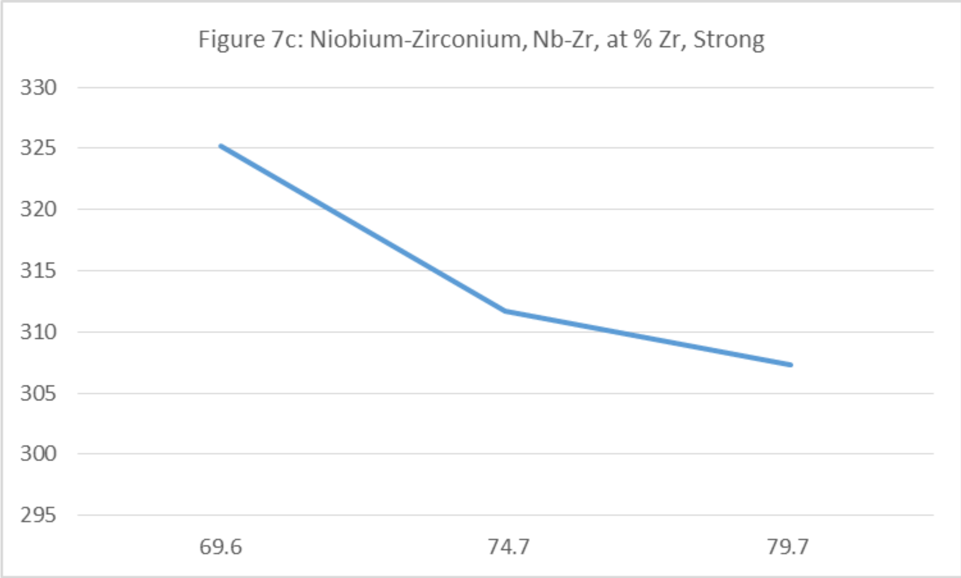


Figure 7c: Niobium-Zirconium, Nb-Zr, at % Zr, Strong
330
325
320
315
310
305
300
295
69.6
74.7
79.7

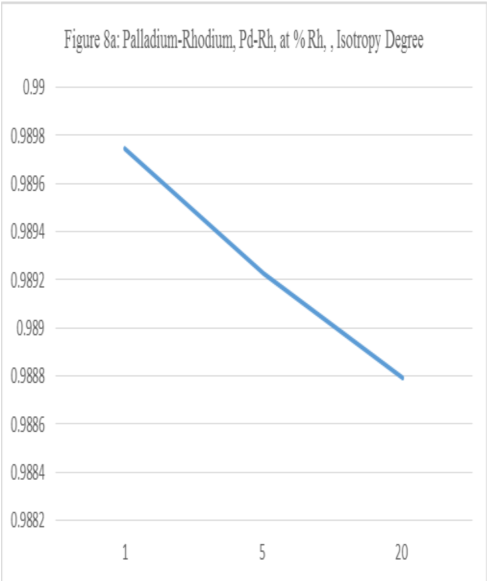


Figure 8a: Palladium-Rhodium, Pd-Rh, at % Rh, , Isotropy Degree
0.99
0.9898
0.9896
0.9894
0.9892
0.989
0.9888
0.9886
0.9884
0.9882
1
5
20

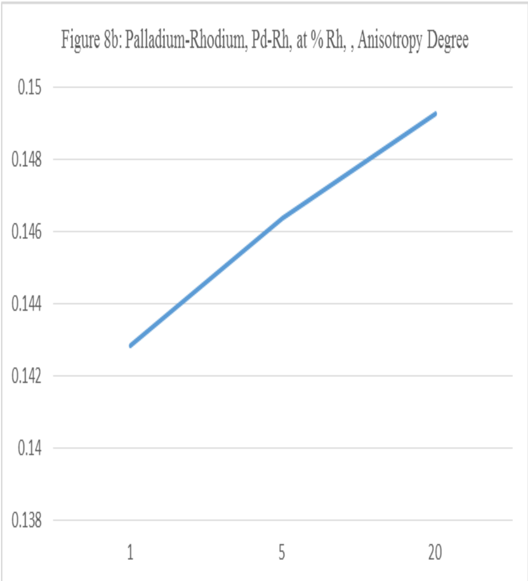


Figure 8b: Palladium-Rhodium, Pd-Rh, at % Rh, , Anisotropy Degree
0.15
0.148
0.146
0.144
0.142
0.14
0.138
1
5
20

Figure 8c: Palladium-Rhodium, Pd-Rh, at % Rh, Strong

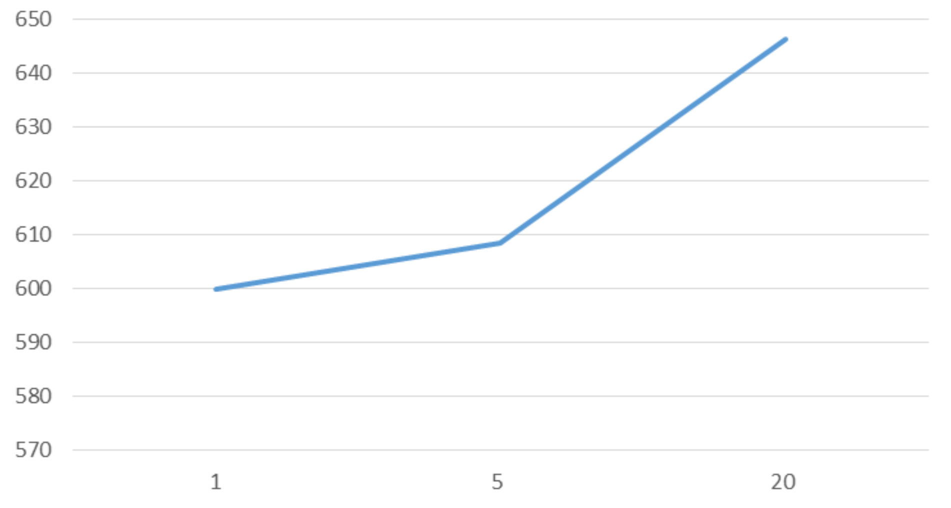


Figure 9a: Palladium-Silver, Pd-Ag, at % Ag, Isotropy Degree

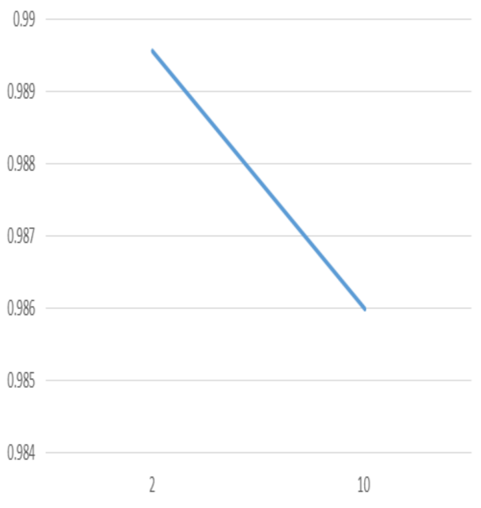
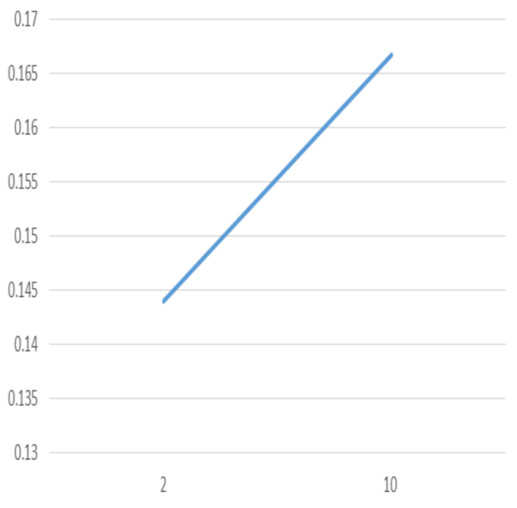
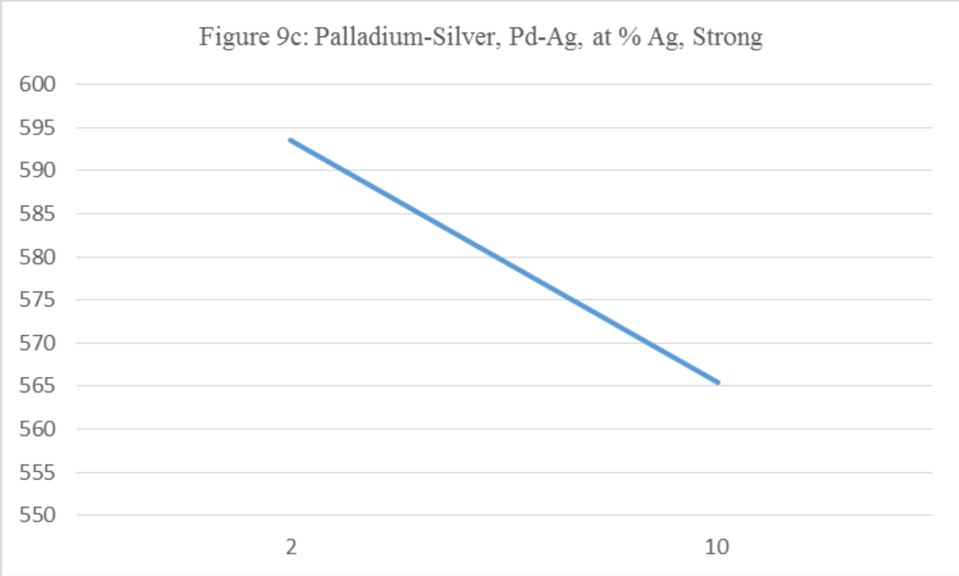


Figure 9b: Palladium-Silver, Pd-Ag, at % Ag, Anisotropy Degree





3 Conclusion:

From table (2) and the figures shown above we can conclude that Molybdenum-rhenium, Mo-Re, at 26.9 % Re is the most isotropic alloy with highest value of N_s / N and lowest value of N_n / N, and Iron-Silicon, Fe-Si, at 11.68 % Si is the most anisotropic alloy with highest value of N_n / N and with lowest value of N_s / N. From table (2) and the figures shown above we can conclude that as the isotropy increases the anisotropy decreases and vice versa. Which means that as N_n / N increases the anisotropy increases and isotropy decreases and as N_s / N increases isotropy increases and anisotropy decreases. And also, the strongest material is Molybdenum-rhenium, Mo-Re, at 26.9 % Re, which has the highest value of N. From table (2) and the figures shown above we can notice that the alloys have different isotropy behavior as the percentage of the associated materials increases.

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