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Anisotropy of Ferromagnetic Materials

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ABSTRACT

The decomposition of elastic constant tensor into its irreducible parts is given. The norm of elastic constant tensor and the norms of the irreducible parts of the elastic constants of ferromagnetic materials (the elements Fe, Ni and Co and some of their alloys) are calculated. The relation of the scalar parts norm and the other parts norms and the anisotropy of the ferromagnetic materials are presented. The norm ratios are used to study anisotropy of ferromagnetic materials and the relationship of their structural properties and other properties with their anisotropy are given.

Keywords: Ferromagnetic, Norm, Anisotropy, and Elastic constants.

1 INTRODUCTION

The decomposition procedure and the decomposition of elastic constant tensor is given in [1,2,3,4,5,6], also the definition of norm concept and the norm ratios and the relationship between the anisotropy and the norm ratios are given in [3,4,5,6]. As the ratio $\mathrm{N_s/N}$ becomes close to one the material becomes more isotropic, and as the ratio $\mathrm{N_n/N}$ becomes close to one the material becomes more anisotropic as explained in [3,4,5,6].

2 CALCULATIONS

Let us consider the irreducible decompositions of the elastic constant tensor in the following crystals

Table 1, Elastic Constant (GPa), [7]

Element, Cubic System	c_{11}	c_{44}	c_{12}
$\beta-Cobalt, Co^{a)}$ $\nu(n=3)$	260 35	110 36	160 1
Iron, Fe $\nu(n=10)$	230 2	117 1	135 3
Nickel, Ni, Zero field	247	122	153

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$\nu(n=4)$	2	2	3
Nickel, Ni, Saturation field $\nu(n=4)$	249 1	124 1	152 3

Table 2, Elastic Constants (GPa) [7]

Alloy	c_{11}	c_{44}	c_{12}
Cobalt – Iron, Co-Fe at % of Fe 6	234.0	125.9	158.9
8	232.7	124.8	159.8
12	228.7	122.9	160.0
14	226.5	121.3	160.4
Iron-Nickel, Fe-Ni at % Ni 27.2	160.8	116.0	95.8
29.0	152.6	113.1	91.6
33.3	133.3	105.9	85.7
30.4	140.4	112.1	84.0
32.1	136.2	108.6	85.2
34.2	135.6	104.2	91.0
36.5	150.7	102.0	107.7
38.8	159.2	102.4	116.2
41.3	171.3	102.9	126.1
50.2	205.3	107.5	145.9
73	230.4	119.2	144.4
At % Ni, 4.2 K 35	157.3	100.6	123.5
59.6	228.3	117.6	150.1
77.6	247.6	127.7	151.2
89.2	254.6	130.0	152.8
100	261.4	130.9	154.8

By using table 1and table 2, and the decomposition of the elastic constant tensor, we calculated the norms and the norm ratios as in table 3 and in table 4.

Table 3, the norms and norm ratios

Element	N_s	N_d	N_n	N	N_s / N	N_d / N	N_n / N
$\beta - Cobalt, Co^{a)}$ $\nu(n=3)$	646.3405	0	109.9818	655.631	0.98583	0	0.16775
Iron, Fe $\nu(n=10)$	580.9673	0	127.3956	594.7711	0.976791	0	0.214193
Nickel, Ni, Zero field $\nu(n=4)$	631.5956	0	137.4773	646.3846	0.97712	0	0.212687
Nickel, Ni, Saturation field $\nu(n=4)$	634.5013	0	138.3938	649.4187	0.97703	0	0.213104

Table 4, the norms and norm ratios

Alloy	N_s	N_d	N_n	N	N_s / N	N_d / N	N_n / N
Cobalt – Iron, Co-Fe at % of Fe 6	628.2480	0	161.9482	648.7856	0.968345	0	0.249617
8	626.9524	0	161.9482	647.5311	0.96822	0	0.250101
12	620.6867	0	162.3148	641.5591	0.967466	0	0.253001
14	617.0188	0	161.6733	637.8483	0.967344	0	0.253467
Iron-Nickel, Fe-Ni at % Ni 27.2	446.3587	0	153.0580	471.8717	0.945932	0	0.324364
29.0	428.0973	0	151.4083	454.0834	0.942772	0	0.333437
30.4	403.6885	0	153.7912	431.9909	0.934484	0	0.356006
32.1	395.5679	0	152.3248	423.883	0.933201	0	0.359356
33.3	389.3039	0	150.4918	417.379	0.932735	0	0.360564

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34.2	396.2451	0	150.1252	423.7307	0.935134	0	0.354294
36.5	433.1531	0	147.5589	457.5973	0.946582	0	0.322465
38.8	455.3155	0	148.2921	478.8557	0.950841	0	0.30968
41.3	484.2108	0	147.1923	506.0887	0.956771	0	0.290843
50.2	557.9259	0	142.6098	575.8636	0.968851	0	0.247645
73	596.7849	0	139.6769	612.9126	0.973687	0	0.227890
At % Ni, 4.2 K 35	461.5350	0	153.4246	486.3678	0.948942	0	0.31545
59.6	600.8719	0	143.8929	617.861	0.972503	0	0.232889
77.6	635.3463	0	145.7259	651.8443	0.97469	0	0.223559
89.2	648.2635	0	144.9927	664.2804	0.975888	0	0.21827
100	660.1009	0	142.2431	675.2528	0.977561	0	0.210652

3 CONCLUSION

- From table (3), considering the ratio $\frac{N_s}{N}$ we can say that Copper, (first ionization energy is 745KJ/mole) is more isotropic than Nickel, (first ionization energy is 577.9KJ/mole), and considering the value of N which is more high in the case of Nickel, so can say that Nickel elastically is stronger than Copper, and Nickel with saturation field is more anisotropic and elastically is stronger than Nickel with zero field.
- From table (4) considering the ratio $\frac{N_s}{N}$ we can say that in the Alloy Cu-Al as the percentage of Ni increases the anisotropy of the alloy increases, and considering the value of N which is increasing as the percentage of Ni increases, so can say that the alloy becomes elastically strongest.

REFERENCES

[1]. Jerphagnon, J., Chemla, D. S., and Bonnevile, R., (1978), "The Description of Condensed Matter Using Irreducible Tensors", Adv. Phys, 11, p1003-1017.

[2]. Radwan, Fae'q A. A. (1999), " Norm Ratios and Anisotropy Degree", The First International Conference in Mathematical Sciences, Applied Mathematics, ICM99, November 1999, United Arab Emirates University, Al Ain, United Arab Emirates. Pak. J. Appl. Sci..Vol. 1, (3): 301-304, 2001.

[3]. F. A. A. Radwan, 'Scalar Irreducible Parts of Sixth Rank Tensor', Arab Gulf Journal of Scientific Research, 19 (3), Pp163-166, (2001).

[4]. Fae`q A. A. Radwan, ' Some Properties of Copper - Gold and Silver - Gold Alloys at Different % of Gold', Journal: Lecture Notes in Engineering and Computer Science Year: 2011, Vol 2189, Issue: 1, pp1221-1224.

[5]. Fae`q A. A. Radwan, ' Isotropy of Some Types of Bones`, International Journal of Engineering Science and Technology (IJEST), Vol. 3 No. 4 April 2011: 3382-3386.

[6]. Fae’q A. A. Radwan, ‘Some properties of copper-nickel at different % of Ni’, Pelagia Research Library, Der Chemica Sinica, 2014, 5(1):34-38.

[7]. Landolt-Börnstein, Group III, "Crystal and Solid State Physics", Volume, 11, Springer-Verlag.