**Prediction of phase selection of amorphous alloys and high entropy alloys by artificial neural network**

Lin Wang a, Peiyou Li a\*, Wei Zhang a, Fangyi Wan b, Junxia Wu a, Longquan Yong c, Xiaodi Liud

a School of Materials Science and Engineering, Shaanxi University of Technology, Hanzhong 723001, People’s Republic of China

b School of Aeronautics, Northwestern Polytechnical University, Xi’an, 710071, People’s Republic of China

c School of mathematics and computer science, Shaanxi University of Technology, Hanzhong 723001, People’s Republic of China

d College of Mechatronics and Control Engineering, Shenzhen University, Shenzhen 518060, People’s

Republic of China

Corresponding author, Tel./fax: +86-0916-2641711; E-mail address: [lipeiyou112@163.com](mailto:lipeiyou112@163.com) (P. Li).

Table 1 The phase composition of 330 alloys reported and the values of four characteristic parameters.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Alloys | *δ* | Δ*χ* | Δ*H*m | *S*id | Phases |
| Cu0.5NiAlCoCrFeSi[1]  Zr17Ta16Ti19Nb22Si26[2]  Cu50Zr50[3]  Ni50Nb50[4]  PdPtCuNiP[5]  SrCaYbMgZn[6]  SrCaYbMgZnCu[7]  SrCaYb(Li0.55Mg0.45)Zn[7]  ErTbDyNiAl[7]  AlCrTaTiZr[8]  CuNbNiTiZr[9]  Pd75Si25[10]  Mg50Cu50[11]  Zr50Ni50[12]  Mg50Ni50[13]  ZrHfTiCuNi[14]  ZrHfTiCuFe[14]  ZrHfTiCuCo[14]  Cu0.5NiAlCoCrFeTi[15]  Cu0.5NiAlCoCrFe[16]  AlCrMoSiTi[17]  AlCrMoTaTiZr[18]  AlMoNbSiTaTiVZr[19]  Zr41.2Ti13.8Cu12.5Ni10Be22.5[10]  Pd40Cu30Ni10P20[20]  Fe41Co7Cr15Mo14C15B6Y2[20]  Mg54Cu26.5Ag8.5Gd11[20]  Cu46Zr42Al7Y5[20]  Y36Sc20Al24Co20[20]  Co48Cr15Mo14C15B6Er2[20]  Ti40Zr25Cu12Ni3Be20[22]  Pt42.5Cu27Ni9.5P21[20]  Ca65Mg15Zn20[20]  Ca40Mg30Cu30[23]  Ca45Cu36Mg19[23]  Ca47Cu27Mg19Zn7[24]  Ca50Cu25Mg15Zn10[24]  Ca50Cu25Zn15Mg10[24]  Ca50Cu30Mg20[23]  Ca50Mg25Zn15Cu10[24]  Ca53Cu24Mg23[23]  Ca55Cu25Mg20[23]  Ca55Cu35Mg10[23]  Ca55Mg25Zn20[24]  Ca55Zn27Mg18[24]  Ca58Cu24Mg18[23]  Ca60Mg20Cu20[23]  Ca60Mg25Cu15[23]  Ca60Zn22.5Mg17.5[24]  Ca60Zn30Mg10[24]  Ca63Al32Cu5[24]  Ca65Cu25Mg10[23]  Ca65Mg20Cu15[23]  Ca65Mg25Cu10[23]  Mg65Cu25Dy10[24]  Mg65Cu25Gd10[24]  Mg65Cu25Ho10[24]  Mg65Cu25Pr10[24]  Mg68Ni15Gd10Ag7[25]  Mg69Ni15Gd10Ag6[25]  Mg70La17Ni13[25]  Mg70Ni15Nd15[23]  Mg71Ni18La11[25]  Mg73Ni15Gd10Ag2[25]  Mg75Ni15Gd10[25]  Mg80Ni10Nd10[19]  Ni42Zr25Ti20Al8Cu5[24]  Ni59Zr20Ti16Si5[24]  Ni60Nb25Zr15[24]  Ni60Nb30Zr10[24]  Ni60Zr20Ti5Nb10Al5[26]  Ni61Zr22Nb7Al4Ta6[26]  Pd77Si17Cu6[27]  Pr68Cu25Al7[27]  Pd40Ni40P20[23]  Ti40Cu32Pd18Zr10[23]  Ti40Cu36Pd14Zr10[23]  Ti40Cu40Pd10Zr10[23]  Ti50Be18Zr15Cu9Ni8[28]  Ti50Cu32Ni30Sn3[28]  Ti50Ni24Cu20Sn3Si2B1[24]  Zr42Cu36Al8Ag8Au6[25]  Zr42Cu36Al8Ag8Hf6[25]  Zr42Cu36Al8Ag8Ni6[25]  Zr42Cu36Al8Ag8Ti6[25]  Zr44Cu36Al8Ag8Fe4[25]  Zr44Cu36Al8Ag8Nb4[25]  Zr44Cu36Al8Ag8Pd4[25]  Zr44Cu40Ag8Al8[25]  La55Al25Cu15Ag5[26]  La55Al25Ni10Cu10[26]  La55Al25Ni5Cu10Co5[25]  La62Al14Cu12Ni12[24]  La62Cu17Al14Ag7[24]  La62Cu19Al14Ag5[24]  La62Cu22Al14Ag2[24]  Fe66B22W6Y6[25]  Fe67B22Y6Mo5[29]  Fe67B22Y6W5[25]  Fe68B22Y6Co4[26]  Fe68B22Y6Ni4[26]  Fe71B22Y6Mo1[29]  Fe71B22Y6W1[29]  Fe62B22Co10Y6[26]  Fe64B22Co8Y6[26]  Fe66B22Co6Y6[26]  Fe68B22Y6Mo4[29]  Fe68B22Y6W4[25]  Fe69B22Y6Mo3[29]  Mg65Ni20La15[25]  6FeNiCoSiCrAlTi[30]  WNbMoTa[31]  WNbMoTaV[31]  FeCoNiCrCu[32]  CoCr2FeNi[33]  FeCoNiCrCuAl0.5[32]  FeCoNiCrCuAl0.8[32]  FeCoNiCrCuAl1.0[32]  FeCoNiCrCuAl1.5[32]  FeCoNiCrCuAl2.0[32]  FeCoNiCrCuAl2.3[32]  FeCoNiCrCuAl2.8[32]  FeCoNiCrCuAl3[32]  CuNiCoFe[34]  FeNi2CrCuAl0.4[35]  FeNi2CrCuAl0.6[35]  FeNi2CrCuAl0.8[35]  FeNi2CrCuAl1.0[35]  FeNi2CrCuAl1.2[35]  AlCo0.5CrCuFeNi[36]  AlCoCr0.5CuFeNi[36]  AlCoCrCu0.5FeNi[36]  AlCoCrCuFe0.5Ni[36]  AlCoCrCuFeNi0.5[36]  CoCrMnNi[37]  Al0.5CoCrCu0.5FeNi[38]  CuFeReRu[39]  Al1.5CoCrCu0.5FeNi[36]  Al2CoCrCu0.5FeNi[36]  AlCrCu0.5FeNi[36]  AlCo0.5CrCu0.5FeNi[36]  AlCoCuNi[40]  AlCo1.5CrCu0.5FeNi[36]  AlCo2CrCu0.5FeNi[36]  AlCo3CrCu0.5FeNi[36]  AlCo3.5CrCu0.5FeNi[36]  AlCoCu0.5FeNi[38]  AlCoCr0.5Cu0.5FeNi[36]  NbTaTiV[41]  AlCoCr1.5Cu0.5FeNi[36]  AlCoCr2Cu0.5FeNi[36]  AlCoCrCu0.5Ni[36]  AlCoCrCu0.5Fe0.5Ni[38]  AlNbTaV[42]  AlCoCrCu0.5Fe1.5Ni[36]  AlCoCrCu0.5Fe2Ni[38]  AlCoCrCu0.5Fe[38]  AlCoCrCu0.5FeNi0.5[36]  NbTiVZr[43]  AlCoCrCu0.5FeNi1.5[38]  AlCoCrCu0.5FeNi2[38]  AlCoCrCu0.5FeNi2.5[36]  AlCoCrCu0.5FeNi3[38]  CrCuFeMnNi[44]  CoCrFeMnNi[45]  TiZrNbMo[44]  Al0.5CrCuFeMnNi[46]  Al0.8CrCuFeMnNi[46]  AlCrCuFeMnNi[44]  Al0.8CrCu1.5FeMnNi[44]  Al0.8CrCuFe1.5MnNi[44]  Al0.8CrCuFeMn1.5Ni[44]  HfNbTIZr[47]  Al0.4Hf0.6TaNbZrTi[48]  Al0.5CoCrCuFeNi[32]  Al0.7CoCrFeNi[49]  Al0.8CoCrCuFeNi[32]  AlCoCrCuFeNi[32]  Al2CoCrCuFeNi[32]  AlCoCrFeNi[50]  AlCoCrCuNi[40]  Al2.5CoCrCuFeNi[45]  Al2.8CoCrCuFeNi[32]  AlCoCrFeNiCu0.25[51]  Al0.75CoCrFeNiCu0.25[51]  NbTiV2Zr[43]  TaMoNbW[30]  TaNbHfZrTi[52]  CuNi[53]  CoCrFeNi[54]  CoCrCuFeNi[32]  CoCrFeCuMn[54]  CoFeNi2V0.5Nb0.4[55]  CoFeNi2V0.5Nb0.75[55]  CoFeNi2V0.5Nb[56]  CuTiVFeNiZrCo[57]  AlTiVFeNiZr[57]  AlCrCuFeNi[58]  AlCrCuFeNiMo0.1[57]  AlCrCuFeNiMo0.2[57]  AlCrCuFeNiMo0.3[57]  AlCrCuFeNiMo0.4[57]  AlCrCuFeNiMo0.5[57]  HfNbTaTiZr[52]  AlMoNbTi[59]  AlMoTaTi[60]  CoCrNi[53]  CoCrFeNiN[61]  MoNbTaVW[31]  NiCoFeCr[54]  CrTaMoNi[57]  CrCo1.5Ni1.5[62]  Al10Co17Fe34Mn5Ni34[63]  Al35Cr35Mn8Mo5Ti17[64]  FeCoCrNiMn[45]  FeCoCrNiAlTi[65]  FeCoCrNiAlSi[66]  FeCoCrAlCu[67]  FeCoCrNiTiAl0.6[68]  FeCoCrNiMo0.2[57]  CoCrFeNiTi[69]  NbCrFeMnCoNi[70]  TiCrFeMnCoNi[70]  TiVCrCuFeMnCoNi[71]  Ti2CrCuFeCoNi[72]  AlTiVYZr[72]  ZrTiVCuNiBe[72]  CoCrCuFeNiTi0.8[73]  CoCrCuFeNiTi1.0[73]  Al0.5CoCrCuFeNiTi0.8[74]  Al0.5CoCrCuFeNiTi1.0[74]  Al0.5CoCrCuFeNiTi1.2[74]  Al0.5CoCrCuFeNiTi1.4[74]  Al0.5CoCrCuFeNiTi1.6[74]  Al0.5CoCrCuFeNiTi1.8[74]  Al0.5CoCrCuFeNiTi2.0[74]  Al0.5CoCrCuFeNiV0.6[75]  Al0.5CoCrCuFeNiV0.8[75]  Al0.5CoCrCuFeNiV1.0[75]  ZrHfTiAlCuNi[76]  AlCoCrFeNiTi1.5[65]  AlNbTiZr[57]  Al40Mg40Li10Zn10[77]  Al35Mg35Li15Zn15[77]  Al15Li35Mg35Ca10 Si5[78]  Al15Li35Mg48Ca1 Si1[78]  Al15Li38Mg45Ca0.5 Si1.5[78]  Al15Li39Mg45Ca0.5Si0.5[78]  Al58.5Mg31.5Zn4.5Cu4.5Si1[79]  Al63Mg27Zn4.5Cu4.5 Si1[79]  Al66.7Mg23.3Zn4.5Cu4.5Si1[79]  Al80Mg14Zn2.7Cu2.7Si0.6[79]  FeSiBAlNiCo0.2[80]  FeSiBAlNiCo0.8[80]  AlNbTiVZr0.1[81]  AlNbTiVZr0.25[81]  AlNbTiVZr0.5[81]  AlNbTiVZr[81]  AlNbTiVZr1.5[81]  Ti28Cu14Ni34.8Nb23.2[82]  Ti30Cu15Ni33Nb22[82]  Ti32Cu16Ni31.2Nb20.8[82]  Hf0.5Mo0.5NbTiZrB0.1[83]  Hf0.5Mo0.5NbTiZrB0.3[83]  Hf0.5Mo0.5NbTiZrB0.7[83]  Hf0.5Mo0.5NbTiZrB0.9[83]  CoNiFeAlTi[84]  CrNbTiZrAl0.25[85]  Al20Cr10Nb15Ti20V25Zr10[86]  Cr0.3Hf0.5Mo0.5NbTiZr[87]  CoCrMoNbTi0.4[88]  AlFeMgTiZn[89]  AlLiMgZnSn[77]  AlLi0.5MgZn0.5Cu0.5[77]  Al80Li5Mg2Zn5Cu5[77]  Al80Li5Mg2Zn5Sn5[77]  Al1.0CrFeMnTi0.25[90]  Al2.0CrFeMnTi0.25[90]  Al1.5CrFeMnTi[91]  Al2.0CrFeMnTi[91]  B4Co[92]  AlNbTiZr0.1[93]  AlNbTiZr0.25[93]  AlNbTiZr0.5[93]  AlNbTiZr1.5[93]  AlNbTiCr[93]  AlNbTiVCr0.25[94]  CoCrMoNb[95]  CoCrMoNbTi[95]  CoCrMoNbTi0.2[95]  CoCrMoNbTi0.5[95]  CrHfNbTiZr[96]  CrNbTiVZr[43]  CrTaTi0.17VW[97]  CrTaTi0.3VW[97]  CrTaVW[97]  BNi3[92]  NbCrZrTi[43]  NbCrVZrTi[43]  MoNbCrCo[95]  MoNbCrTiCo[95]  MoNbCrTi0.2Co[95]  MoNbCrTi0.4Co[88]  MoNbCrTi0.5Co[95]  Mo0.5NbVCrTi[98]  Mo0.5NbVCr1.5Ti[98]  Mo0.5NbVCr2.0Ti[98]  WTaMoNbVCr[99]  MoNbCrTi0.4[88]  NbHfCrZrTi[96]  NbTiZrVMo[100]  NbTiZrVCr[43]  NbTiZrVAl0.24[100]  Al4CrFeMnTi0.25[101]  Al3CrFeMnTi0.25[101]  NbMoTaWVCr[99]  Al1.5NbTiVZr[102]  CrFe[103]  AlCr1.5NbTiV[104]  AlCrNbTiV[31]  MoNbCrTi[105]  CrMoNbTiVWZr[106]  Cr0.3MoNbTiZr0.3[106]  Cr0.3MoNbTiV0.6Zr0.3[106]  Al12.5Cr25Nb25Ti25Zr12.5[107]  Al12Cr24Mo4Nb24Ti24Zr12[107]  Al11.5Cr23Mo8Nb23Ti23Zr11.5[107]  CrNbTiZr[43]  CrMo0.5NbTa0.5TiZr[108]  TiZrHfNbCr[96] | 6.35  11.08  11.27  6.85  9.29  15.25  18.14  15.71  13.74  7.84  9.25  7.29  11.22  12.52  12.47  10.33  10.43  10.23  6.97  5.5  8.67  7.46  8.65  13.98  9.08  18.56  11.02  11.85  13.55  18.41  12.16  9.64  13.45  17.6  18.94  18.07  18.1  18.57  18.07  15.52  16.92  17.15  19.14  13.71  14.68  16.94  16.01  14.76  13.99  15.05  15.54  17.09  14.61  13.19  10.29  10.55  10.22  9.4  9.67  9.64  10.72  8.36  11.06  9.49  9.42  6.91  10.58  11.27  9.86  9.03  10.64  10.86  6.3  10.5  9.17  7.32  7.53  7.73  11.27  7.91  9.1  9.86  10.03  10.5  9.86  10.41  9.96  10.02  10.27  15.23  16.19  16.17  16.42  15.08  15.36  15.77  19.93  19.89  19.9  19.73  19.73  19.76  19.77  19.74  19.74  19.74  19.86  19.86  19.83  12.06  6.56  2.31  3.15  1.03  0.28  4.17  4.92  5.28  5.89  6.26  6.4  6.57  6.61  1.14  3.86  4.49  4.96  5.32  5.6  5.45  5.44  5.51  5.4  5.43  3.45  4.37  3.97  6.11  6.46  5.92  5.71  5.85  5.33  5.17  4.88  4.75  5.9  5.7  3.93  5.34  5.18  5.81  5.66  3.53  5.37  5.23  5.87  5.68  7.04  5.35  5.2  5.06  4.93  3.2  3.27  5.98  4.66  5.15  5.39  4.96  5.08  5.05  4.87  4.91  4.17  5.18  4.92  5.28  6.26  5.78  5.52  6.48  6.57  5.64  5.17  7.47  2.31  4.99  1.27  0.3  1.03  3.15  4.14  5.06  5.48  9.54  9.34  5.63  5.62  5.62  5.61  5.6  5.58  4.99  2.54  2.55  0.16  17.32  3.15  0.3  5.91  0.17  4.65  6.52  3.27  7.22  6.61  5.58  7.09  2  6.68  5.49  6.29  5.5  7.24  10.95  11.49  5.7  6.12  6.26  6.53  6.76  6.94  7.09  7.21  7.31  4.09  4.06  4.04  9.43  7.5  4.8  5.58  5.54  10.94  5.43  5.35  4.71  6.49  6.27  6.04  4.81  16.72  15.84  4.42  4.96  5.6  6.34  6.71  7.18  7.17  7.16  9.05  13.14  18.08  19.81  7.46  8.51  6.81  6.97  6.24  8.13  5.89  7.38  3.33  3.54  6.29  6.37  6.65  6.53  19.02  2.22  3.12  3.97  5.16  6.04  4.71  5.79  6.53  6.05  6.31  8.62  8.67  5.16  5.28  4.96  16.19  8.77  8.67  5.79  6.53  6.05  6.24  6.31  5.92  6.21  6.36  4.65  5.81  8.62  6.84  8.67  6.85  6.01  6.22  4.65  6.06  0.32  6.29  5.9  5.92  7.55  5.74  5.95  7.72  7.61  7.49  8.77  8.03  8.62 | 0.12  0.2  0.29  0.16  0.16  0.26  0.35  0.26  0.3  0.11  0.22  0.13  0.3  0.29  0.3  0.27  0.25  0.26  0.14  0.12  0.23  0.26  0.24  0.22  0.14  0.3  0.3  0.28  0.25  0.29  0.18  0.17  0.26  0.37  0.4  0.38  0.38  0.39  0.39  0.31  0.37  0.37  0.42  0.26  0.28  0.37  0.35  0.32  0.27  0.29  0.32  0.38  0.32  0.28  0.26  0.26  0.26  0.27  0.26  0.25  0.23  0.23  0.25  0.23  0.22  0.19  0.24  0.24  0.22  0.2  0.24  0.24  0.13  0.34  0.14  0.28  0.27  0.25  0.17  0.18  0.19  0.34  0.28  0.28  0.27  0.27  0.27  0.29  0.28  0.33  0.33  0.33  0.35  0.35  0.35  0.35  0.22  0.19  0.21  0.18  0.18  0.18  0.19  0.18  0.18  0.18  0.19  0.21  0.19  0.27  0.11  0.36  0.34  0.09  0.11  0.11  0.12  0.12  0.12  0.13  0.13  0.13  0.13  0.03  0.11  0.12  0.12  0.12  0.13  0.12  0.12  0.12  0.12  0.12  0.15  0.11  0.14  0.13  0.13  0.12  0.12  0.12  0.12  0.12  0.11  0.11  0.11  0.12  0.05  0.12  0.12  0.13  0.13  0.05  0.12  0.11  0.12  0.12  0.12  0.12  0.12  0.12  0.12  0.14  0.14  0.31  0.14  0.14  0.14  0.14  0.14  0.15  0.13  0.12  0.11  0.12  0.12  0.12  0.13  0.12  0.13  0.13  0.13  0.12  0.12  0.11  0.36  0.12  0.01  0.1  0.09  0.14  0.11  0.12  0.12  0.21  0.19  0.12  0.13  0.14  0.15  0.16  0.16  0.12  0.25  0.27  0.11  0.5  0.34  0.1  0.25  0.1  0.11  0.13  0.14  0.14  0.12  0.12  0.14  0.12  0.14  0.14  0.15  0.15  0.15  0.16  0.2  0.13  0.14  0.14  0.14  0.14  0.15  0.15  0.15  0.15  0.12  0.12  0.12  0.24  0.15  0.11  0.21  0.23  0.27  0.23  0.24  0.23  0.16  0.16  0.15  0.12  0.14  0.13  0.05  0.07  0.09  0.11  0.12  0.17  0.17  0.17  0.27  0.28  0.3  0.3  0.15  0.12  0.09  0.25  0.22  0.17  0.33  0.28  0.16  0.17  0.11  0.1  0.1  0.1  0.06  0.05  0.07  0.09  0.12  0.04  0.04  0.22  0.23  0.22  0.23  0.14  0.12  0.33  0.33  0.34  0.06  0.12  0.12  0.22  0.23  0.22  0.22  0.23  0.18  0.17  0.16  0.32  0.25  0.14  0.27  0.12  0.12  0.08  0.09  0.32  0.11  0.09  0.04  0.04  0.25  0.34  0.28  0.26  0.1  0.15  0.19  0.12  0.22  0.14 | -22.58  -48.64  -23  -30  -23.68  -13.12  -13.11  -12.15  -37.6  -20  -21.28  -41.25  -3  -49  -4  -27.36  -15.2  -23.52  -17.18  -7.93  -34.08  -16.11  -32.19  -35.2  -24.88  -33.35  -8.45  -24.88  -34.92  -33.36  -25.88  -24.94  -14.26  -10.2  -11.3  -12.39  -13.29  -14.69  -10.92  -13.04  -10.2  -10.39  -11.75  -13.78  -16.22  -10.26  -9.6  -8.73  -15.03  -17.76  -17.83  -10.31  -8.55  -7.58  -5.71  -5.71  -5.71  -5.71  -7.21  -6.98  -7.17  -6.9  -6.37  -6  -5.46  -4.4  -41.93  -46.54  -35.04  -32.88  -39.62  -39.35  -32.16  -22.27  -22.72  -36.05  -30.97  -25.72  -26.37  -19.93  -25.96  -31.27  -24.97  -27.23  -23.89  -24.36  -23.14  -31.46  -25.18  -31.42  -33.6  -32.31  -28.79  -27.41  -26.95  -26.27  -19.19  -19.61  -19.21  -19.53  -19.72  -19.35  -19.27  -19.86  -19.75  -19.64  -19.55  -19.22  -19.48  -8.05  -21.22  -6.5  -4.64  3.2  -4.32  -1.52  -3.61  -4.78  -7.05  -8.65  -9.38  -10.28  -10.56  5  -1.7  -3.27  -4.61  -5.78  -6.78  -4.5  -5.02  -7.93  -5.55  -3.9  -5.5  -4.6  8  -10.14  -11.6  -7.7  -7.92  -8  -7.83  -7.67  -7.25  -7.03  -8.69  -8.32  -0.25  -7.56  -7.2  -10.17  -8.92  -13.75  -7.14  -6.49  -6.12  -7.28  -0.25  -8.28  -8.43  -8.45  -8.39  2.72  -4.16  -2.5  -1.92  -3.97  -5.11  -1.74  -3.31  -4.23  2.5  -6.33  -1.52  -10.57  -3.61  -4.78  -8.65  -12.32  -6.56  -9.78  -10.28  -9.94  -8.47  -1.28  -6.5  2.72  4  -3.75  3.2  4.16  -12.34  -15.91  -17.85  -20.16  -31.33  -4  -3.77  -3.55  -3.35  -3.16  -2.98  2.72  -15.25  -15.5  -4.89  -56.48  -4.64  -3.75  -13.75  -4.13  -8.03  -16.45  -4.16  -21.56  -27.33  -2.56  -20.05  -4.04  -16.32  -12  -13.44  -8.13  -14.04  -14.88  -24.89  -6.75  -8.44  -10.11  -11.6  -12.89  -14.02  -15  -15.86  -16.6  -4.07  -4.71  -5.25  -34.11  -23.91  -21.5  -2.68  -3.08  -8.95  -2.72  -3.15  -2.13  -2.7  -2.52  -2.34  -1.48  -30.98  -30.75  -16.51  -16.83  -17.19  -17.44  -17.32  -23.05  -22.48  -21.88  -5.78  -15.34  -29.71  -35.1  -26.4  -10.08  -16.61  -2.2  -12.77  -6.4  -6.08  -3.35  -0.96  -0.28  -12.07  -14.8  -17.98  -19  -15.36  -20.81  -21.21  -21.55  -20.94  -17.5  -15.83  -11.75  -13.44  -12.34  -12.94  -4  -4.64  -4.46  -4.59  -4.25  -18  -5  -4.64  -11.75  -13.44  -12.34  -12.77  -12.94  -4.35  -4.8  -5.02  -4.89  -5.74  -4  -2.72  -4.64  -5.99  -14.99  -15.31  -4.89  -21.55  -1  -13.75  -14.56  -5.5  -5.55  -4.28  -3.8  -14  -13.5  -12.99  -5  -4.92  -4 | 16.01  13.25  5.76  5.76  13.38  13.38  14.9  14.53  13.38  13.38  13.38  4.68  5.76  5.76  5.76  13.38  13.38  13.38  16.01  14.7  13.38  14.9  17.29  12.18  10.64  13.66  9.45  8.79  11.26  12  11.6  10.55  7.37  9.05  8.67  10.06  10.04  10.04  8.56  10.04  8.46  8.29  7.7  8.29  8.24  8.04  7.9  7.8  7.87  7.47  6.7  7.12  7.37  7.12  7.12  7.12  7.12  7.12  8.01  7.81  6.79  6.81  6.61  6.84  6.07  5.31  11.51  8.95  7.8  7.47  9.63  9.3  5.58  6.61  8.77  10.56  10.31  9.92  11.3  9.77  10.31  10.85  10.85  10.85  10.85  10.49  10.49  10.49  9.41  9.23  9.44  10.02  8.98  8.81  8.62  8.17  7.86  7.65  7.65  7.42  7.42  6.58  6.58  8.55  8.23  7.86  7.42  7.42  7.18  7.37  13.21  11.53  13.38  13.38  11.08  14.7  14.87  14.9  14.79  14.53  14.35  14.01  13.86  11.53  12.45  12.72  12.88  12.98  13.02  14.7  14.7  14.7  14.7  14.7  11.53  14.53  11.53  14.53  14.23  13.15  14.53  11.53  14.53  14.23  13.48  13.09  13.15  14.53  11.53  14.53  14.23  13.15  14.53  11.53  14.53  14.23  13.15  14.53  11.53  14.53  14.23  13.87  13.48  13.38  13.38  11.53  14.7  14.87  14.9  14.74  14.74  14.74  11.53  14.5  14.7  13.31  14.87  14.9  14.53  13.38  13.38  14.21  14.01  14.34  14.32  11.08  11.53  13.38  5.76  11.53  13.38  13.38  12.07  12.48  12.6  16.18  14.9  13.38  13.92  14.22  14.43  14.59  14.7  13.38  11.53  11.53  9.13  13.38  13.38  11.53  11.53  9  11.76  11.54  13.38  14.9  14.9  13.38  14.78  12.57  13.38  14.9  14.9  17.29  14.53  13.38  14.9  14.87  14.9  16  16.01  15.97  15.91  15.82  15.72  15.6  15.93  16  16.01  14.9  14.79  11.53  9.92  10.84  11.64  9.12  9.15  8.85  8.34  8.06  7.77  5.65  14.22  14.87  12.2  12.71  13.15  13.38  13.25  11.12  11.18  11.21  13.6  14.17  14.54  14.55  13.38  12.71  14.43  14.17  13.01  13.38  13.38  12.89  5.8  5.8  12.71  12.14  13.25  12.98  4.16  10.02  10.69  11.24  11.38  11.53  12.71  11.53  13.38  12.57  13.15  13.38  13.38  12.47  12.83  11.53  4.68  11.53  13.38  11.53  13.38  12.57  13.01  13.15  13.15  12.95  12.6  14.9  11.07  13.38  13.38  13.38  12.68  10.51  11.31  14.9  13.25  5.76  13.25  13.38  11.53  16.18  12.32  13.97  12.97  13.84  14.25  11.53  14.53  13.38 | AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  AM  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  SS  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM  IM |

Table 2 The MSE values of of characteristic parameters or parameter combinations in AM, SS and IM alloys.

|  |  |  |  |
| --- | --- | --- | --- |
| Parameters | *MSE*(AM) | *MSE*(SS) | *MSE*(IM) |
| *δ*  Δ*χ*  Δ*H*m  *S*id  *δ*+Δ*χ*  *δ*+Δ*H*m  *δ*+*S*id  Δ*χ*+Δ*H*m  Δ*χ*+*S*id  Δ*H*m+*S*id  *δ*+Δ*χ*+Δ*H*m  *δ*+Δ*χ*+*S*id  *δ*+Δ*H*m+*S*id  Δ*χ*+Δ*H*m+*S*id  *δ*+Δ*χ*+Δ*H*m+*S*id | 0.100  0.131  0.159  0.128  0.093  0.098  0.085  0.129  0.106  0.093  0.076  0.055  0.055  0.064  0.061 | 0.147  0.157  0.169  0.152  0.124  0.134  0.113  0.115  0.138  0.144  0.111  0.115  0.106  0.120  0.102 | 0.181  0.186  0.194  0.202  0.163  0.175  0.160  0.186  0.189  0.182  0.167  0.145  0.157  0.180  0.153 |

Table 3 The *R* values of of characteristic parameters or parameter combinations in AM, SS and IM alloys.

|  |  |  |  |
| --- | --- | --- | --- |
| Parameters | *R*(AM) | *R*(SS) | *R*(IM) |
| *δ*  Δ*χ*  Δ*H*m  *S*id  *δ*+Δ*χ*  *δ*+Δ*H*m  *δ*+*S*id  Δ*χ*+Δ*H*m  Δ*χ*+*S*id  Δ*H*m+*S*id  *δ*+Δ*χ*+Δ*H*m  *δ*+Δ*χ*+*S*id  *δ*+Δ*H*m+*S*id  Δ*χ*+Δ*H*m+*S*id  *δ*+Δ*χ*+Δ*H*m+*S*id | 0.7338  0.6247  0.5182  0.6830  0.7744  0.7578  0.8072  0.6714  0.7311  0.7562  0.8042  0.8631  0.8720  0.8486  0.8612 | 0.6000  0.5598  0.4312  0.5377  0.6880  0.6227  0.7147  0.7109  0.6015  0.5890  0.6968  0.7170  0.7262  0.6968  0.7576 | 0.3987  0.3000  0.3904  0.3222  0.5439  0.4321  0.5494  0.4339  0.4300  0.4173  0.5241  0.6182  0.5515  0.4898  0.5898 |

Table 4 Average prediction accuracy of 15 test sets of characteristic parameters or parameter combinations in AM, SS and IM alloys.

|  |  |  |  |
| --- | --- | --- | --- |
| Parameters | *P*AM  (%) | *P*SS  (%) | *P*IM  (%) |
| *δ*  Δ*χ*  Δ*H*m  *S*id  *δ*+Δ*χ*  *δ*+Δ*H*m  *δ*+*S*id  Δ*χ*+Δ*H*m  Δ*χ*+*S*id  Δ*H*m+*S*id  *δ*+Δ*χ*+Δ*H*m  *δ*+Δ*χ*+*S*id  *δ*+Δ*H*m+*S*id  Δ*χ*+Δ*H*m+*S*id  *δ*+Δ*χ*+Δ*H*m+*S*id | 89.9  86.9  84.1  87.2  90.7  90.2  91.5  87.1  89.4  90.7  92.4  94.5  94.5  93.6  93.9 | 85.3  84.32  83.1  84.8  87.6  86.6  88.7  88.5  86.2  85.6  88.8  88.5  89.4  88.0  89.8 | 81.85  81.43  80.6  79.8  83.7  82.5  84.0  81.4  81.1  81.8  83.3  85.5  84.3  82.0  84.7 |

Tabel 5 Cross-entropy loss values of AM, IM and SS phases for three and four parameter combinations.

|  |  |  |  |
| --- | --- | --- | --- |
| Parameters | AM | SS | IM |
| *δ*+Δ*χ*+Δ*H*m  *δ*+Δ*χ*+*S*id  *δ*+Δ*H*m+*S*id  Δ*χ*+Δ*H*m+*S*id  *δ*+Δ*χ*+Δ*H*m+*S*id | 0.0525  0.0402  0.0388  0.0460  0.0402 | 0.0868  0.0907  0.0687  0.0933  0.0627 | 0.1568  0.0910  0.1539  0.1571  0.1448 |

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