**Nanostructured High-Entropy Materials**

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**S1. Summary of Nanocrystalline HEAs**

A summary of the classification, mechanical properties, grain size, and structure of all nanocrystalline HEAs covered in **Sections 2-5** of the manuscript can be found in Table SI. Abbreviations in the table correspond to: Yield Strength (YS), Ultimate Tensile Strength (UTS), Percent Elongation (% Elong), Young’s Modulus (E), Average Grain Size (Avg. G.S), 3d Transition Metals (3D), Interstitial (Int), Refractory (Ref), Light Metal (LM), Precious Metal (PM), Composite (Comp), Precipitate (PCT), High-entropy Oxide (HEO), Mechanical Alloying (MA), DC Magnetron Sputtering (DMSC), RF Magnetron Sputtering (RMFS), High-pressure Torsion (HPT), Equal Channel Angular Pressing (ECAP), Annealing (Ann.), Flame Spray Pyrolysis (FSP), Nebulized Spray Pyrolysis (NSP), Reverse Co-precipitation Process (RCP), Cryo-rolling (CR), Vacuum Arc Deposition (VAD), Cryo-milling (CM), Rapid Solidification Process (RSP). The notation (c) in mechanical properties indicates that the value was obtained via a compression test. Hardness is presented in units of GPa, unless otherwise noted. In many cases of MA-processed HEAs, the mechanical properties reported are for consolidated powders, and as such have larger grain sizes than those reported in Table SI.

Table SI: Summary of NC-HEA methods, mechanical properties, average grain size, and structure.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Material** | **Type** | **Method** | **YS (MPa)** | **UTS (MPa)** | **% Elong** | **E (GPa)** | **Hardness (GPa)** | **Avg G.S (nm)** | **Structure** | **Ref.** |
| Al0.1CoCrFeNi | 3D | HPT |  |  |  |  | 482 HV | 80 | FCC | 1 |
| Al0.25CoCrFeNi | 3D | Cold Rolling | 1280 | 1479 | 2.3 |  |  |  | FCC | 2 |
| Al0.3CoCrFeMnNi | 3D | MA |  | 1800 (c) |  |  | 480 HV | 5 | FCC | 3 |
| Al0.3CoCrFeNi | 3D | HPT |  |  |  |  | 530 HV |  | FCC+BCC | 4 |
| Al0.3CoCrFeNi | 3D | HPT |  |  |  |  |  | 30 | FCC | 5 |
| Al0.3CoCrFeNi | 3D | DCMS |  |  |  | 191-197 | 10.4-12.3 | 10 | BCC+FCC | 6 |
| Al0.4CoFeNiSi0.4 | 3D | MA |  |  |  |  |  |  | FCC+BCC | 7 |
| Al0.5CoCrFeNi | 3D | Ann | 834 | 1220 |  |  |  | 18 | BCC+FCC | 8 |
| Al0.6CoFeNiTi0.4 | 3D | MA | 2732 | 3172 | 10.1 |  | 712 HV | 8.7 | BCC+FCC | 9 |
| Al7.5Co25Cu17.5Fe25Ni25 | 3D | MA | 1795 | 1936 | 10.6 |  | 454 HV | 24 | FCC | 10 |
| AlCoCrCuFe | 3D | MA |  |  |  |  | 770 HV | 10 | BCC | 11 |
| AlCoCrCuFeNi | 3D | MA | 2379 |  |  | 172 | 8.13 | 10 |  | 12 |
| AlCoCrCuFeNi | 3D | DCMS |  |  |  |  |  | 10 |  | 13 |
| AlCoCrCuFeNi | 3D | MA |  |  |  |  |  |  | FCC+BCC | 14,15 |
| AlCoCrCuFeNi | 3D | Ann |  | 1630 | 34 |  | 369.8 HV | 70 | FCC | 16 |
| AlCoCrCuFeZnx | 3D | MA |  |  |  |  |  |  | FCC, sometimes FCC+BCC) | 17 |
| AlCoCrCuNi | 3D | Sol-Gel |  |  |  |  |  | 14 | BCC+FCC | 18 |
| AlCoCrCuNiFeZn | 3D | MA |  |  |  | 152.4 | 7.773 | 20 | BCC | 19 |
| AlCoCrFeMnNi | 3D | MA |  | 2142 (c) |  |  | 662 HV |  | FCC | 20 |
| AlCoCrFeNi | 3D | MA |  |  |  |  | 8 | 30-40 | FCC+BCC | 21 |
| AlCoCrFeNi | 3D | MA |  |  |  |  |  |  | FCC+BCC | 22 |
| AlCoCrFeNi | 3D | MA | 1907 (c) |  |  |  | 625 HV |  | BCC | 23 |
| AlCoCrFeNi | 3D | MA |  |  |  |  |  | 27 | BCC+FCC | 24 |
| AlCoCrFeNi | 3D | Ann |  | 2639 (c) | 40.6 (c) |  |  | as low as 20 | BCCx2 | 25 |
| AlCoCrFeNiSix | 3D | MA |  |  |  |  | 1010 HV | 32 | BCC | 26 |
| AlCoCrFeNiTi | 3D | MA |  |  |  |  |  |  | FCC | 27 |
| AlCoCrFeNiTi + TiB2 | 3D | MA |  |  |  |  | 23.56 | 10 | BCC | 28 |
| AlCoCuZnNi | 3D | MA |  |  |  |  | 649 HVN | 15 | FCC+BCC | 29 |
| AlCoFe Ni(Cr, Cu, Mo, Ti) | 3D | MA |  |  |  |  | 766 HV |  | FCC+BCC | 30 |
| AlCoFeMoNiTi | 3D | (RSP) |  |  |  |  | 896 HV | 11.6-15.4 | BCC | 31 |
| AlCrCrFeMgNi4.75 | 3D | MA |  |  |  |  | 424 HVN |  | FCC+BCC | 32 |
| AlCrCuFeMgx | 3D | MA |  |  |  |  | 853 HV |  | BCC + IM | 33 |
| AlCrCuFeMnW | 3D | MA |  |  |  |  |  | ~25 | FCC+BCC+IM | 34 |
| AlCrCuFeMnWx (x=0,0.05,0.1,0.5) | 3D | MA |  |  |  |  |  | 20 | FCC+BCC | 35 |
| AlCrCuFeNiZn | 3D | MA |  |  |  |  | 700 HV |  | BCC+FCC | 36 |
| AlCrCuFeNiZn | 3D | MA |  |  |  | 148 | 870 HV | 20 | BCC+FCC | 37 |
| AlCrFeMnV | 3D | CM |  |  |  |  |  | 6 | BCC | 38 |
| AlCrFeNiZn | 3D | MA |  |  |  | 153.03 | 7.427 | 62 | Mix FCC BCC | 39 |
| AlCrFeTi | 3D | MA |  |  |  |  |  |  | BCC | 40 |
| AlCrFeTiZn | 3D | MA |  |  |  |  |  |  | BCC | 40 |
| AlCrFeTiZnCu | 3D | MA |  | 2830 (c) |  |  | 10 |  | BCC+FCC | 41 |
| AlCrFeTiZnCu | 3D | MA |  |  |  |  |  |  | BCC | 40 |
| AlCrMoNbZr | 3D | DCMS |  |  |  | 146 | 11.8 |  | BCC | 42 |
| AlFeTi | 3D | MA |  |  |  |  |  |  | BCC | 40 |
| Alx(FeNiCoCu)1-xTix | 3D | HPT |  | 1849 |  |  |  | 50 | FCC+IM | 43 |
| AlxCoCrCuFeNi | 3D | MA |  |  |  |  |  |  | BCC+FCC | 44 |
| AlxCoCrCuFeNi | 3D | Ann |  |  |  |  | 527 HV |  | FCC+BCC | 45 |
| AlxCoCrCuFeNi (x=0.5,1,2) | 3D | DCMS |  |  |  | 156.5 (reduced) | 15.1 |  | FCC(x=0.5), FCC+BCC (x=2) | 46 |
| AlxCoCrFeNiMn | 3D | MA | 2230 | 2552 | 1.69 |  | 622 HV |  | FCC+BCC+ IM | 47 |
| AlxCoCu1-xFeNi1.5V0.5 | 3D | MA | 1720 | 1930 | 9 |  | 541 HV | 7 | FCC+BCC | 48 |
| **Assortment of HEAs/MEAs** | 3D | HPT |  |  |  |  |  | Varies |  | 49 |
| Co0.5CrFeNiTi0.5 | 3D | MA | 2650 | 2690 (c) | 10 |  | 8.46 |  | BCC+FCC | 50 |
| CoCr2-xCuFeNix (x=1,1.2,1.5,1.8) | 3D | MA | 869 | 1856 | 32.2 |  | 321HV | 9-15 | BCC+FCC | 51 |
| CoCrCuFeNi | 3D | MA |  |  |  |  | 494 HV | 100 | FCC | 52 |
| CoCrCuFeNi | 3D | MA |  |  |  |  | 400 HV | 7 | BCC+FCC | 11 |
| CoCrCuFeNi | 3D | DCMS |  |  |  |  |  |  | BCC+FCC | 53 |
| CoCrCuFeNiAlTiXVMo (X=Zn,Mn) | 3D | MA | 2.53 |  |  |  | 7.6 |  | FCC+BCC | 54 |
| CoCrCuFeNiMox | 3D | MA | 1228 (c) | 1448 (c) |  |  | 530 HV |  | FCC+BCT+Rhom | 55 |
| CoCrCuFeNiNbx | 3D | DCMS |  |  |  |  |  |  | FCC | 56 |
| CoCrFeMn0.5NiTi0.5 | 3D | MA |  |  |  |  |  | 14 | BCC | 57 |
| CoCrFeMnNi | 3D | HPT |  |  |  |  | 5.38 | 30 | FCC | 58 |
| CoCrFeMnNi | 3D | MA | 1574 |  |  |  |  | 11.2 | FCC+Cr-carbide | 59 |
| CoCrFeMnNi | 3D | HPT |  |  |  |  | 6.2 | 38 | FCC | 60 |
| CoCrFeMnNi | 3D | HPT |  |  |  |  | 7.5 | 40 | FCC+BCC | 61 |
| CoCrFeMnNi | 3D | HPT |  |  |  |  | 5.2 | 33 | FCC | 62 |
| CoCrFeMnNi | 3D | MA | 1180 (c) | 2660 (c) |  | 184 | 688 HV |  | FCC+IM | 63 |
| CoCrFeMnNi | 3D | HPT |  | ~2000 |  |  | 910 HV | 50 | FCC+IM | 64 |
| CoCrFeMnNi | 3D | MA |  |  |  |  | 587 HV | 100 | FCC | 52 |
| CoCrFeMnNi | 3D | HPT + MA |  |  |  |  | 6.7 | 50 | FCC | 65 |
| CoCrFeMnNi | 3D | MA | 1987 (c) |  |  |  | 646 HV |  | BCC+FCC | 66 |
| CoCrFeMnNi | 3D | HPT |  |  |  |  | 6.5 GPa500 HV | 40 | FCC | 67 |
| CoCrFeMnNi | 3D | HPT |  | 1750 | 4 |  | 4.41 | 10 | FCC | 68 |
| CoCrFeMnNi | 3D | HPT |  |  |  |  |  | 10 | FCC | 69 |
| CoCrFeMnNi | 3D | ECAP | 980 | 990 | 35 |  | 315 HV | 100 | FCC | 70 |
| CoCrFeMnNi | 3D | CR |  |  |  |  |  | 230-420 | FCC+BCC+IM | 71 |
| CoCrFeMnNi | 3D | MA | 1314 | 2026 | 20.3 |  | 415 HV | 100 | FCC | 72 |
| CoCrFeMnNi | 3D | RFMS |  |  |  | 177 | 6.8 | 10 | FCC+BCC | 73 |
| CoCrFeMnNi | 3D | HPT |  |  |  |  |  | 55 | FCC | 74 |
| CoCrFeMnNi | 3D | HPT |  |  |  | 200 | 7.64 | 50 | FCC | 75 |
| CoCrFeMnNi | 3D | HPT |  |  |  | 214 | 5.8 | 50 | FCC | 76 |
| CoCrFeMnNi | 3D | DCMS |  |  |  |  |  | 10 | FCC+oxides | 77 |
| CoCrFeMnNi | 3D | CM |  |  |  |  |  | 4 | FCC | 38 |
| CoCrFeMnNi/polymer hybrid | 3D | RFMS |  |  |  |  |  | 5 |  | 78 |
| CoCrFeMnNiTi0.1 | 3D | HPT | 1950 | 2220 | 3 |  | 460 HV | 40 | FCC | 79 |
| CoCrFeMnNiTi0.1 | 3D | HPT |  |  |  |  | 450 HV | 10 | FCC | 79 |
| CoCrFeNi | 3D | DCMS |  |  |  | 205 | 9.5 | 7.8 | FCC | 80 |
| CoCrFeNi | 3D | MA |  |  |  |  |  |  | BCC+FCC+IM | 81 |
| CoCrFeNi | 3D | HPT |  |  |  |  |  | 68 |  | 82 |
| CoCrFeNi | 3D | MA |  |  |  |  |  | 30 | FCC+BCC+IM | 83 |
| CoCrFeNi(W1-xMox) | 3D | MA |  |  |  |  | 600 HV |  | BCC+FCC | 84 |
| CoCrFeNiMoNbZr | 3D | MA |  |  |  |  |  | 12.5 |  | 85 |
| CoCrFeNiZr | 3D | MA |  |  |  |  |  | 19 |  | 85 |
| CoCrNi | 3D | HPT |  | 993 |  |  |  | 199 | FCC | 86 |
| CoCrNi | 3D | HPT | 1880 | 2170 | 9 |  |  | 50 | FCC | 87 |
| CoCuNi | 3D | MA |  |  |  |  |  |  | BCC | 88 |
| CoCuNiZn | 3D | MA |  |  |  |  |  |  | FCC | 88 |
| CoCuNiZnAl | 3D | MA |  |  |  |  |  |  | FCC | 88 |
| CoCuNiZnAlTi | 3D | MA |  | 2360 (c) |  |  | 7.55 |  | BCC | 89 |
| CoCuNiZnAlTi | 3D | MA |  | 2760 (c) |  |  | 8.79 |  | FCC | 88 |
| CoFeNi - Mn,Cu,Cr | 3D | MA |  |  |  |  | 570 HV | 8 | BCC+FCC | 90 |
| CoFeNiTi | 3D | HPT | ~2300 | 2700 | 8-10 | ~150 |  | 20-50 | FCC+BCC | 91 |
| CrCoFeMnNi | 3D | MA |  |  |  |  | 7.8 | 9.4 | FCC | 92 |
| CrCoFeNi | 3D | MA |  |  |  |  |  | 43 |  | 85 |
| CrCoFeNi | 3D | MA |  |  |  |  | 6.3 | 22 | FCC | 92 |
| CrCuFeTiZn | 3D | MA |  |  |  |  | 6 | 45 | BCC+FCC | 93 |
| CrFeMnNiVC | 3D | HPT |  |  |  |  | 555 HV | 30 | FCC+Cr-carbide | 94 |
| CrFeNi-M-X (M=Co, Mn, Nb, Ti, Zr; X=B, Si) | 3D | MA |  |  |  |  |  | <10 | assorted, typically single phase | 95 |
| CrNbTiVZn | 3D | MA |  |  |  |  |  | 7 | FCC | 96 |
| CrNiTiZrV | 3D | RSP |  |  |  |  | 8.92 | 15 | Hexagonal Laves | 97 |
| Family of AlCoCrCuFeNiMoTi | 3D | MA |  |  |  |  |  | ~5 | Some FCC, Some BCC, some mixed, some amorphous | 98 |
| Ni45-x(FeCoCr)40(AlTi)15Hfx | 3D | Ann | 1110 |  |  |  |  | 90 | FCC+BCC+IM | 99 |
| NiMoTiNbTa | 3D | MA |  |  |  |  |  | 16 |  | 85 |
| AlTiVNb | Ref | HPT |  |  |  |  | 7.9 | 50 | BCC | 100 |
| HfNbTaTiZr | Ref | Ann |  |  |  |  |  | 25 | HCP+BCC | 101 |
| NbMoTaW | Ref | DCMS |  |  |  | 196.6 | 16 |  | BCC | 102 |
| NbMoTaW | Ref | DCMS |  |  |  |  | 12 | 15.8 | BCC | 103 |
| NbMoTaWVTi | Ref | MA | 2709 (c) | 3115 (c) | 11.4 (c) |  |  |  | BCCx2+FCC precipitates | 104 |
| NbTaMoW | Ref | DCMS | 2000 |  |  |  |  | 70-100 |  | 105 |
| TiVZrNbHf | Ref | VAD |  |  |  | 575 | 64 | 30-50 | FCC | 106 |
| TiVZrNbHf | Ref | VAD |  |  |  |  | 70 | 57 | FCC | 107 |
| TiZrNbHfTa | Ref | HPT |  | 1900 | 7.9 |  | 430 HV | 50 | BCC | 108 |
| Al0.5Co0.3CrFeNiC0.2 | Int (C) | MA | 2131 (c) |  | 3 |  | 617 HV | 12 | BCC+FCC | 109 |
| CoCrFeNi | Int (C) | MA |  |  |  |  | 575 HV | 5 | FCC+BCC+C,O | 110 |
| (Co,Cu,Mg,Ni,Zn)O | Int (O) | FSP, NSP, RCP |  |  |  |  |  |  | FCC | 111 |
| (Co,Mg,Ni,Zn)O | Int (O) | FSP, NSP, RCP |  |  |  |  |  |  | FCC+Oxides | 111 |
| CoCrFeMnNi | Int (O) | MA | 1269 | 1318 | 0.74 | 204.5 |  | 400 | FCC | 112 |
| Al0.5CoCrCuFeNi | Int (N) | DCMS |  |  |  |  | 4.4-10.4 | ~50 | BCC+FCC | 113 |
| AlCoCrCuFeMnNi | Int (N) | DCMS |  |  |  |  | 4.2-11.8 | ~50 | BCC+FCC | 113 |
| CoNiFeAl0.4Ti0.6Cr0.5 + SiC/7075 Al Composites | Comp | MA |  | 712 | 0.82 | 171 |  | 7 | FCC+BCC | 114 |
| CoCrFeMnNi + Al2O3 nanocomposite | Comp | MA | 1600 |  |  |  | 545 HV |  | FCC+oxides+ carbides | 115 |
| NiMgZnCuCo - Oxides | HEO | MA |  |  |  |  |  |  | Single phase - probably Rock Salt structure | 116 |
| Al20Li20Mg10Sc20Ti30 | LM | MA |  |  |  |  | 5.8 (4.9 annealed) | 12 (26 annealed) | FCC (powder) HCP (annealed) | 117 |
| CoCrFeMnNi+SiC | PCT | MA | 1900 (c) | 2000 (c) |  | 214 | 699 HV |  | FCC+IM | 63 |
| CuAgAuPtPd | PM | CM |  |  |  |  |  | 9 | FCC | 38 |

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