表1.1 原子掺杂反钙钛矿锰氮化合物的负热膨胀性能

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **分子式** | **负热膨胀系数** | **起始温度(K)** | **终止温度(K)** | **温度区间(K)** | **参考文献** |
| Mn3Cu0.53Ge0.47N | -16 | 267 | 342 | 75 | [1] |
| Mn3Cu0.5Ge0.5N | -12 | 280 | 365 | 85 | [1] |
| Mn3Ga0.7Ge0.3N0.88C0.12 | -18 | 197 | 319 | 122 | [1] |
| Mn3Ga0.5Ge0.4Mn0.1N | -3 | 327.9 | 392.65 | 65.5 | [1] |
| (Mn0.96Fe0.04)3Zn0.5Ge0.5N | -25 | 316 | 386 | 70 | [1] |
| Mn3Cu0.9Ge0.1N | -22.82 | 85.6 | 104.8 | 19.2 | [2] |
| Mn3Cu0.85Ge0.15N | -124.30 | 90.73 | 117.57 | 26.83 | [2] |
| Mn3Cu0.7Ge0.3N | -42.79 | 152.07 | 209.58 | 57.5 | [2] |
| Mn3Cu0.6Ge0.4N | -18 | 218.53 | 292.65 | 74.12 | [2] |
| Mn3Cu0.5Ge0.5N | -8.15 | 281.15 | 361.66 | 80.51 | [2] |
| Mn3Cu0.45Ge0.55N | -5.13 | 315.65 | 379.55 | 63.90 | [2] |
| Mn3Cu0.3Ge0.7N | —— | —— | —— | —— | [2] |
| Mn3Zn0.9Ge0.1N | -228 | 202 | 222 | 20 | [3] |
| Mn3Zn0.7Ge0.3N | -31 | 299 | 373 | 74 | [3] |
| Mn3Zn0.5Ge0.5N | -7.15 | 348 | 448 | 100 | [3] |
| Mn3Cu0.95Sn0.05N | -25.47 | 105.56 | 113.33 | 7.78 | [4] |
| Mn3Cu0.9Sn0.1N | -343.92 | 93.33 | 101.11 | 7.78 | [4] |
| Mn3Cu0.85Sn0.15N | -373.375 | 95.56 | 104.44 | 8.89 | [4] |
| Mn3Cu0.7Sn0.3N | -56.81 | 157.78 | 192.22 | 34.44 | [4] |
| Mn3Cu0.6Sn0.4N | -46.97 | 242.22 | 273.33 | 31.11 | [4] |
| Mn3Cu0.5Sn0.5N | -28 | 296 | 332 | 36 | [4] |
| Mn3Cu0.3Sn0.7N | —— | —— | —— | —— | [4] |
| Mn3Cu0.8Ga0.2N | -2.72 | 33.11 | 69.80 | 36.69 | [4] |
| Mn3Cu0.7Ga0.3N | -66.46 | 34.00 | 73.37 | 39.37 | [4] |
| Mn3Cu0.5Ga0.5N | -42.01 | 75.17 | 155.70 | 80.54 | [4] |
| Mn3Cu0.3Ga0.7N | -74.27 | 188.81 | 234.45 | 45.64 | [4] |
| Mn3Zn0.4Sn0.6N | -38 | 410 | 440 | 30 | [4] |
| Mn3Zn0.4Sn0.6N0.85C0.15 | -23 | 270 | 336 | 66 | [4] |
| Mn3Zn0.4Sn0.6N0.77C0.23 | -1.91 | 198.53 | 226.83 | 28.30 | [4] |
| Mn3Zn0.4Sn0.6N0.75C0.25 | —— | —— | —— | —— | [4] |
| Mn3Cu0.6Nb0.05Ge0.35N | -5.08 | 219 | 281 | 62 | [5]，[20] |
| Mn3Cu0.6Nb0.1Ge0.4N | -19.93 | 199 | 256 | 57 | [5]，[20] |
| Mn3Cu0.6Nb0.15Ge0.25N | -11.3 | 128 | 221 | 93 | [5]，[20] |
| Mn3Cu0.6Nb0.2Ge0.2N | -5.71 | 77 | 172 | 95 | [5]，[20] |
| Mn3Cu0.6Si0.05Ge0.35N | -26.63 | 210 | 270 | 60 | [6]，[21] |
| Mn3Cu0.6Si0.1Ge0.3N | -29.4 | 170 | 238 | 68 | [6]，[21] |
| Mn3Cu0.6Si0.15Ge0.25N | -11.55 | 90 | 190 | 100 | [6]，[21] |
| Mn3Cu0.6Si0.2Ge0.2N | —— | —— | —— | —— | [6]，[21] |
| Mn3Cu0.5Si0.05Ge0.45N | -6.57 | 260 | 340 | 80 | [21] |
| Mn3Cu0.5Si0.1Ge0.4N | -3.2 | 185 | 257 | 72 | [21] |
| Mn3Cu0.5Si0.15Ge0.35N | -2.6 | 143 | 231 | 88 | [21] |
| Mn3Cu0.5Si0.2Ge0.3N | —— | —— | —— | —— | [21] |
| Mn3Cu0.6Si0.11Ge0.29N | -21.1 | 152 | 228 | 76 | [21] |
| Mn3Cu0.6Si0.12Ge0.28N | -18.2 | 140 | 223 | 83 | [21] |
| Mn3Cu0.6Si0.13Ge0.27N | -15.6 | 128 | 214 | 86 | [21] |
| Mn3Cu0.6Si0.14Ge0.26N | -12.4 | 115 | 206 | 91 | [21] |
| Mn3Cu0.6Si0.15Ge0.25N | -11.6 | 95 | 195 | 100 | [21] |
| Mn3Cu1-*x*Ag*x*N | —— | —— | —— | —— | [7] |
| Mn3Ga0.5Ge0.4Mn0.1N | -3 | 334 |  |  | [8] |
| Mn3Ga0.5Ge0.4Mn0.1N0.95C0.05 | -2.32 | 253.26 | 337.21 | 83.95 | [8] |
| Mn3Ga0.5Ge0.4Mn0.1N0.9C0.1 | -0.5—0.5 | 190 | 272 | 82 | [8] |
| Mn3Ga0.5Ge0.4Mn0.1N0.8C0.2 | -0.39 | 197.53 | 281.48 | 83.95 | [8] |
| Mn3Ga0.5Ge0.4Mn0.1N0.75C0.25 | 0 | 138.97 | 161.55 | 22.58 | [8] |
| Mn3Zn0.4Sn0.6N0.8C0.2（800℃） | -20 | 205 | 270 | 65 | [8] |
| Mn3Zn0.4Sn0.6N0.8C0.2（900℃） | -5.30 | 205.76 | 310.37 | 104.61 | [8] |
| Mn3Zn0.4Sn0.6N0.8C0.2（945℃） | -1~1 | 235 | 292 | 57 | [8] |
| Mn3Zn0.4Sn0.6N0.8C0.2（980℃） | —— | —— | —— | —— | [8] |
| Mn3Cu0.55Sn0.45N （920 °C） | -0.5~0.5 | 255 | 323 | 68 | [8] |
| Mn3Cu0.4Sn0.5Mn0.1N0.9C0.1 （910 °C） | 0.18 | 231.83 | 284.04 | 52.20 | [8] |
| Mn3(Cu0.5Ni0.1Ge0.4)N | -15.35 | 209.98 | 280.04 | 70.06 | [9] |
| Mn3(Cu0.45Ni0.15Ge0.4)N | -9.76 | 184.93 | 265.16 | 80.23 | [9] |
| Mn3(Cu0.4Ni0.2Ge0.4)N | -12.11 | 181.80 | 251.86 | 70.06 | [9] |
| Mn3(Cu0.35Ni0.25Ge0.4)N | -8.74 | 164.97 | 244.81 | 79.84 | [9] |
| Mn3(Cu0.3Nix0.3Ge0.4)N | -10.02 | 155.18 | 224.85 | 69.66 | [9] |
| Mn3(Cu0.25Nix0.35Ge0.4)N | -7.69 | 145.40 | 210.37 | 64.97 | [9] |
| Mn3(Cu0.3Nix0.4Ge0.4)N | -3.31 | 125.05 | 164.97 | 39.92 | [9] |
| Mn3Zn0.9Sn0.1N | —— | —— | —— | —— | [10] |
| Mn3Zn0.8Sn0.2N |  |  |  |  | [10] |
| Mn3Zn0.7Sn0.3N |  |  |  |  | [10] |
| Mn3Zn0.5Sn0.5N |  |  |  |  | [10] |
| Mn3Zn0.2Sn0.8N |  |  |  |  | [10] |
| Mn3SnN | —— | —— | —— | —— | [10] |
| Mn3Ga0.75Si0.25N | -14 | 272 | 420 | 138 | [11] |
| Mn3Ga0.5Si0.5N | —— | —— | —— | —— | [11] |
| Mn3NiN | -123 | 250 | 330 | 80 | [12] |
| Mn3(Zn0.55Sn0.45)(N0.85C0.15) | -19.31 | 210.58 | 288.73 | 78.15 | [13] |
| Mn3(Zn0.4Sn0.6)(N0.85C0.15) | -23 | 270 | 336 | 66 | [13] |
| Mn3(Zn0.35Sn0.65)(N0.85C0.15) | -21 | 284 | 353 | 68 | [13] |
| Mn3(Zn0.6Sn0.4)(N0.85C0.1B0.05) | -34.9 | 243.35 | 295.56 | 52.21 | [13] |
| Mn3(Zn0.55Sn0.45)(N0.85C0.1B0.05) | -37 | 270 | 325 | 55 | [13] |
| Mn3(Zn0.5Sn0.5)(N0.85C0.1B0.05) | -30 | 280 | 340 | 60 | [13] |
| Mn3(Cu0.4Sn0.6)N | -- | -- | -- | -- | [14] |
| Mn3(Cu0.5Sn0.5)N | -1.42 | 293.62 | 343.97 | 50.34 | [14] |
| Mn3(Cu0.6Sn0.4)N | -18.67 | 238.23 | 274.18 | 35.95 | [14] |
| Mn3(Cu0.7Sn0.3)N | -31.75 | 193.34 | 218.71 | 25.36 | [14] |
| Mn3(Cu0.4Sb0.6)N | -34.78 | 86.99 | 102.14 | 15.15 | [14] |
| Mn3(Cu0.5Sb0.5)N | -71.57 | 102.14 | 117.29 | 15.15 | [14] |
| Mn3(Cu0.6Sb0.4)N | -192.44 | 117.29 | 123.08 | 5.79 | [14] |
| Mn3(Cu0.7Sb0.3)N | -68.23 | 116.85 | 135.12 | 18.27 | [14] |
| Mn3(Cu0.5Sb0.1Sn0.4)N | -7.24 | 293.69 | 323.5 | 29.80 | [14] |
| Mn3(Cu0.5Sb0.2Sn0.3)N | -18.13 | 248.42 | 294.03 | 45.60 | [14] |
| Mn3(Cu0.5Sb0.3Sn0.2)N | -46.60 | 208.24 | 233.32 | 25.07 | [14] |
| Mn3(Cu0.5Sb0.4Sn0.1)N | -92.92 | 143.37 | 158.16 | 14.80 | [14] |
| Mn3(Cu0.5Sb0.5)N | -83.75 | 113.61 | 128.42 | 14.81 | [14] |
| Mn3Cu0.9Si0.1N | -6.3 | 122 | 132 | 10 | [15] |
| Mn3Cu0.8Si0.2N | -2.8 | 127 | 137 | 10 | [15] |
| Mn3Cu0.7Si0.3N | -1.7 | 58 | 97 | 39 | [15] |
| Mn3Cu0.6Si0.4N | -0.8 | 83 | 96 | 13 | [15] |
| Mn3Cu0.5Si0.5N | —— | —— | —— | —— | [15] |
| Mn3AgN | -44.5 | 260.88 | 275.98 | 8 | [16] |
| Mn3Ag0.7Mn0.3N | -57 | 213 | 233 | 20 | [16] |
| Mn3Ag0.6Mn0.4N | -16.7 | 175 | 212 | 37 | [16] |
| Mn3Ag0.5Mn0.5N | -5.14 | 135 | 185 | 50 | [16] |
| Mn3Ag0.4Mn0.6N | -0.48 | 5 | 87 | 82 | [16] |
| Mn2.85Cr0.15Cu0.6Ge0.4N | -32.27 | 191 | 239 | 48 | [20] |
| Mn2.7Cr0.3Cu0.6Ge0.4N | -29.15 | 135 | 190 | 55 | [20] |
| Mn2.65Cr0.45Cu0.6Ge0.4N | -19.14 | 80 | 150 | 70 | [20] |
| Mn2.4Cr0.6Cu0.6Ge0.4N | —— | —— | —— | —— | [20] |
| Mn3Cu0.55Re0.05Ge0.4N | -13.8 | 241 | 305 | 64 | [20] |
| Mn3Cu0.5Re0.1Ge0.4N | -12.60 | 251 | 315 | 64 | [20] |
| Mn3Cu0.4Re0.2Ge0.4N | -1.07 | 238 | 295 | 57 | [20] |
| Mn3Cu0.3Re0.3Ge0.4N | —— | —— | —— | —— | [20] |
| Mn3Cu0.6Ge0.4N0.95C0.05 | -23.13 | 173 | 226 | 53 | [21] |
| Mn3Cu0.6Ge0.4N0.9C0.1 | -23.875 | 135 | 191 | 56 | [21] |
| Mn3Cu0.6Ge0.4N0.85C0.15 | -22.34 | 85 | 137 | 52 | [21] |
| Mn3Cu0.8Ge0.2N | -60.27 | 119.68 | 164.68 | 45 | [21] |
| Mn3Cu0.7Ag0.1Ge0.2N | -66.50 | 159.50 | 189.50 | 30 | [21] |
| Mn3Cu0.6Ag0.2Ge0.2N | -64.49 | 174.74 | 205.06 | 30.32 | [21] |
| Mn3Cu0.5Ag0.3Ge0.2N | -45.024 | 184.68 | 225.25 | 40.58 | [21] |
| Mn3Cu0.6Si0.05Ge0.35N | -30.0 | 216.01 | 267.97 | 51.96 | [21] |
| Mn3Cu0.6Si0.1Ge0.3N | -29.35 | 176.14 | 240.20 | 64.05 | [21] |
| Mn3Cu0.6Si0.15Ge0.25N | -9.88 | 79.41 | 199.67 | 120.26 | [21] |
| Mn3Cu0.6Si0.2Ge0.4N | —— | —— | —— | —— | [21] |
| Mn3AgN | -22.43 | 270.1 | 288.7 | 18.6 | [22] |
| Mn3Ag0.98Nb0.02N | -14.1 | 267.6 | 287.3 | 19.7 | [22] |
| Mn3Ag0.96Nb0.04N | -20 | 266.4 | 287.5 | 20.9 | [22] |
| Mn3Ag0.94Nb0.06N | -24 | 266.3 | 284.9 | 18.6 | [22] |
| Mn3Ag0.92Nb0.08N | -21.5 | 266.3 | 287.3 | 21 | [22] |
| Mn3Ag0.9Nb0.1N | -18.2 | 260.1 | 284.8 | 24.7 | [22] |
| Mn3GaN | -60.5 | 282 | 325 | 43 | [23] |
| Mn3Ga0.9Ge0.1N | -22.1 | 276 | 334 | 58 | [23] |
| Mn3Ga0.8Ge0.2N | -20.0 | 351 | 411 | 60 | [23] |
| Mn3Ga0.7Ge0.3N | -18.0 | 370 | 438 | 68 | [23] |
| Mn3Ga0.6Ge0.4N | -12.6 | 421 | 473 | 53 | [23] |
| Mn3Ga0.5Ge0.5N | -0.1 | 423 | 475 | 52 | [23] |
| Mn3Ga0.9Sn0.1N | -145 | 265 | 332 | 67 | [23] |
| Mn3Ga0.8Sn0.2N | -38.4 | 314 | 373 | 59 | [23] |
| Mn3Ga0.7Sn0.3N | -24 | 335 | 396 | 61 | [23] |
| Mn3Ga0.6Sn0.4N | -15.6 | 355 | 422 | 67 | [23] |
| Mn3Ga0.5Sn0.5N | -12 | 407 | 458 | 51 | [23] |
| Mn3Ga0.4Sn0.6N | -6.5 | 451 | 489 | 38 | [23] |
| Mn3Ga0.3Sn0.7N | -0.45 | 480 | 513 | 33 | [23] |
| Mn2.95Cu0.1Zn0.4N | -34 | 330 | 365 | 35 | [17] |
| Mn3.1Zn0.5Sn0.4N | -36.4/-15.80 | 335 | 375 | 40 | [18] |
| Mn3.25Zn0.5Sn0.25N | -31.13 | 299.02 | 344.12 | 45.10 | [18] |
| Mn3Ga0.6Sn0.4N | -31.33 | 372.55 | 418.63 | 46.08 | [18] |
| Mn3Cu0.5Sn0.4N | -18.40 | 298.04 | 337.25 | 39.21 | [18] |
| Mn3.27Zn0.45Sn0.28N | -30.3 | 265 | 325 | 60 | [19] |
| 实验数据 | | | | | |
| Mn3.1Zn0.4Sn0.5N | -7.93 | 391 | 439 | 48 |  |
| Mn3.1Zn0.5Sn0.3N | -25.3 | 313 | 371 | 58 |  |
| Mn3.1Zn0.6Sn0.3N | -29.7 | 330 | 381 | 51 |  |
| Mn3.2Zn0.4Sn0.4N | -9.91 | 357 | 413 | 56 |  |
| Mn3.2Zn0.5Sn0.3N | -33.8 | 250 | 197 | 53 |  |
| Mn3.2Zn0.6Sn0.2N | -19.6 | 238 | 309 | 71 |  |
| Mn3.3Zn0.4Sn0.3N | -30.7 | 261 | 306 | 45 |  |
| Mn3.3Zn0.5Sn0.2N | -22.6 | 266 | 273 | 67 |  |
| Mn3.3Zn0.6Sn0.1N | -29.0 | 175 | 217 | 42 |  |
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