CSU-Ros. Conf.

MAGNETIC PROPERTIES OF NICKEL-MANGANESE ALLOYS

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Various states of atomic order, achieved by different heat treatments, determine the magnetic behavior of nickel-manganese alloys. This is due to the different possible atomic spin interactions: parallel Ni-Ni and Ni-Mn, and antiparallel Mn-Mn. The balance between these interactions is affected by the composition and the degree of atomic order. The disordered state is achieved by rapid cooling from 1000°C, while prolonged annealing gives the equilibrium, or ordered, state. Between the disordered and ordered states are intermediate configurations, the nature of which is not known. However, we have developed a magnetic cluster model and have related their size and density to the atomic order and magnetic properties.

The compositions of greatest interest are near 25% manganese. The magnetization of Ni_3Mn increases by a factor of ten as it goes from the disordered to the ordered state. If nickel-manganese is cooled to 4°K in the presence of an external magnetic field, a preferred direction (anisotropy) of magnetization is induced. We have measured the strength of this unidirectional anisotropy and found that the effect is greatest for disordered, 25% Mn, for which the net atomic spin interaction is almost zero.

In addition to their fundamental scientific appeal, there are technical applications for nickel-manganese. Permanent magnets with unidirectional anisotropy would be more stable than ordinary ferromagnets with axial anisotropy. This could be useful in computer memories, for example. In the ordered state, Ni_3Mn is highly permeable, making it a good choice for power transformers. The suitability for each application is determined by the magnetic qualities, and consequently by the composition and ordering state of the alloys. By controling these, the desired magnetic performance can be obtained.