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Temperature dependence of tunnel magnetoresistance of ultrathin Fe films

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The studies of the dependence of the tunnel magnetoresistance magnitude on the temperature of the annealed and unannealed films at different temperatures of ultrathin Fe films have been conducted. There is a slight increase of the magnetoresistance magnitude in the range of the effective thickness of 20-25 nm with decrease of measurement temperature to 150 K. While the effective thickness reduces to 15-20 nm, the tunnel magnetoresistance magnitude is reduced 1,3-1,5 times. The tunnel magnetoresistance magnitude is reduced 5-10 times when the temperature drops to 150 K with the effective thickness of 10-15 nm. For the films annealed at the temperature of 520 K in the range of thickness of 5-10 nm, the magnetoresistance increases in 2-5 times when the temperature drops.

There are various types of the temperature dependence of the magnetoresistance due to the formation of the percolation cluster and the change in the films' magnetic state. Analyzing the temperature dependence of the magnetoresistance for the freshly condensed films with the effective thickness of 15-20 nm, it is necessary to consider competing impacts from a percolation cluster and the separate superparamagnetic particles in the presence of the dipole-dipole interaction. The film will have a large number of tunnel barriers of small width with high conductivity. Temperature dependence of the magnetoresistance will be determined by the competition of two processes – the magnetic blocking of the separate clusters and the formation of a magnetically ordered system of clusters. With the temperature decreasing due to the process of blocking, a bigger amount of noninteracting clusters will contribute to the tunnel magnetoresistance. This process leads to the increase of the magnetoresistance magnitude. With further temperature decrease processes of the magnetic ordering will induce ordering the moments of the individual clusters, i.e. the formation of a magnetically ordered system within the entire sample and the decrease of the magnetoresistance. As a result of this competition the maximum will form on the temperature dependence of the magnetoresistance.