Spontaneous magnetization of a metal-insulator interface

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Properties of a metal-insulator interface have essential importance for modern electronics. Some recent results point to an existence of metal-induced states in the energy gap of the insulator predicted in [1]. At an ideal interface these states are extended in the metal and damped in the insulator. Potential disorder results in their localization at the insulator surface and in the appearing of the local magnetic moments [2]. In this way the magnetic flux noise in superconducting quantum interference devices (SQUIDs) was explained [3]. An areal density of the localized electrons required to account for the observed noise magnitude is about $5 \cdot 10^{17}$ m^{-2}.

In the present investigation we directly observed spontaneous magnetization of an eutectic $In_{0.15}Ga_{0.85}$ - sapphire interface.

Excellent wetting of ceramics, glass and other insulators by an eutectic $In_{0.15}Ga_{0.85}$ (melting point 16.5 ^{o}C) is well known. According to [1] high metal-insulator adhesion results from the electron states localized at the insulator surface. As an insulator EPI polished sapphire substrate with orientation $(3\bar{1}3)$, thickness 0.17 mm and area 0.28 cm^2 was used. Small amount ($\sim$ 1 mg) of eutectic was distributed over substrate with a toothpick.

Measurements with a home-built SQUID-magnetometer were done at several temperatures from $T = 4.5$ K up to $T = 309$ K, that is 20 K above the melting point of an eutectic $In_{0.15}Ga_{0.85}$. Magnetic moment of spontaneous magnetization was directed from an insulator to a metal, its density at low temperature corresponds to $1.8 \cdot 10^{18}$ m^{-2} localized spin-1/2 states. Diminishing of the magnetic moment at highest temperature did not exceed 10%.

Influence of a strong magnetic field on the direction of spontaneous magnetization was investigated with a capacitance cantilever (torque magnetometer). These measurements have confirmed the existence of the spontaneous magnetization of a metal-insulator interface, its sign and an order of value. Phase diagram of the spontaneous magnetization on $H - T$ plane spreads above room temperature along the $T-$axis and is restricted to $2 - 2.5$ T along the $H-$axis at $T \leq 100$ K.

Results of these investigations are published in [4, 5].

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