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3D-2D crossover in melting transition on superconducting Mo/Si multilayers

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Two-dimensional and three-dimensional vortex-lattice melting is observed on superconducting Mo/Si multilayers. Quasi-2D melting takes place in the range of high magnetic fields. The position of the melting transition on H-T phase diagram is in a reasonable quantitative accordance with the existing theories. Above melting line another phase transition is found connected with the decoupling in the liquid phase or with transition from hexatic to ordinary liquid. TAFF regime of the vortex motion is observed in the fluid phase governed by the plastic barrier charateristic for viscous liquid. TAFF regime with different activation energy takes place also in a vortex solid phase above the depinning line.

New concepts that have appeared in the context of studies of high-T_c superconductivity can be applied for many conventional superconductors, especially for the artificial superlattices (SL) having the layered structure like their high-T_c counterparts. In particular, thermally activated vortex creep processes were observed on MoGe/Ge [1] and PbTe/PbS [2] SLs, while the vortex lattice melting was observed on NbGe/Ge SLs [3].

We have been studied the different regimes of the thermally activated dissipation at the vortex motion in the magnetic fields orthogonal to the layers on Mo/Si SLs. SLs with 30 - 40 bilayers were prepared by magnetron sputtering. The thickness of Mo layers have been varied in the range 22 - 35 Å, of Si layers - in the range 34 - 66 Å. For all samples investigated two clearly defined temperature ranges may be singled out on Arrhenius plots (Fig.1) where lnR is linear with T^{-1}, but with different slope.

The measurements with different transport currents j showed that in the two orders of j variation the activation energy is independent of current and, respectively, thermally activated flux flow (TAFF) takes place. This statement is valid for the both ranges of the resistive transitions mentioned above.

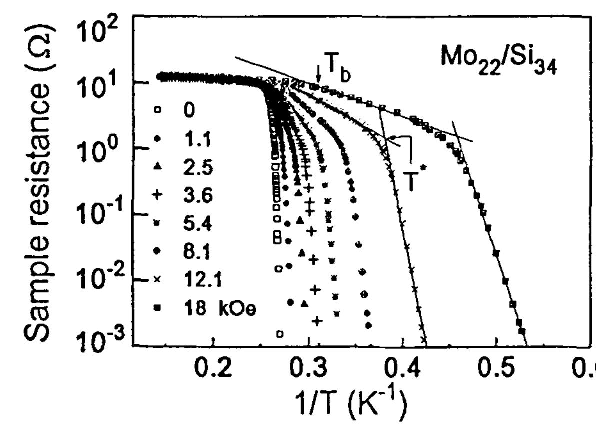

Fig.1

There are two characteristic temperatures on all Ahrrenius plots, T^* and T_b. One of them, T^*, separates two regimes of thermally activated resistance behavior. Another one, T_b, corresponds to the transition from TAFF to slower R change with T, characteristic for a viscous flux flow regime. These temperatures as a function of H are shown for two SLs in Fig.2. The both lines, $T^*(H)$ and $T_b(H)$ terminate at the strong field range by about vertical portions. Such behavior implies that these

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