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Fabrication and characterization of micron size superconducting quantum interference devices (µ-SQUIDs) of lead (Pb)

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Content :

Micron size superconducting quantum interference devices (µ-SQUID) of Cr/Pb/Cr trilayer, for probing nano-magnetism, were fabricated and characterized. In order to get continuous Pb films with small grain size, Pb was thermally evaporated on a liquid nitrogen cooled Si substrate. Pb was sandwiched between two thin Cr layers for improved adhesion and protection. The SQUID pattern was made by e-beam lithography with Pb lift-off after deposition. The current-voltage characteristics of these devices (down to 1.3 K) show a critical current, which exhibits the expected SQUID oscillations with magnetic field, and two re-trapping currents. These devices have hysteresis at low temperatures, which disappears just below the critical temperature. Niobium (Nb) µ-SQUIDs of similar design are being implemented to probe magnetic response of submicron size magnetic particles and we are presently interested to do the same with lead (Pb) µ-SQUIDs.

Summary :

We demonstrate the fabrication process of lead (Pb) weak link (WL) and µ-SQUID devices. Study on WL devices is important since the applications of WL based µ-SQUIDs, as a probe of very small scale magnetic field with high precision, facilitates various areas of applied science. So far, many studies have been reported on fabrication and characterization of niobium (Nb) WLs and µ-SQUIDs due to robust superconductivity of Nb. But lead (Pb) WLs and µ-SQUIDs are not explored much since fabrication of Pb thin film nano-structures has many difficulties. In this work, we have optimized each fabrication step and successfully made reliable Pb WL and µ-SQUID devices. Transport measurements (down to 1.3 K) of these devices showed thermal hysteresis in the I-V characteristics and expected SQUID oscillations of critical current with magnetic field.

Furthermore we have implemented niobium (Nb) µ-SQUIDs to probe magnetic response of single domain nanoparticles placed very close to the SQUID loop and very recently we have been successful to probe the magnetic response of a sub-micron size permalloy ellipse shaped particle deposited few microns away from the SQUID loop by electron

beam lithography (EBL). Presently we are designing lead (Pb) μ-SQUIDs, with ferromagnetic permalloy particle deposited close to the SQUID loop, to be used in nano-particle magnetometry.

All transport measurements are done using a closed cycle refrigerator (CCR) which facilitates to cool the sample down to 1.3 K temperature and also a built in solenoid which can provide fields up-to 800 mT.

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