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DYNAMIC MAGNETO-OPTICAL STUDY OF THE INTERMEDIATE STATE, CURRENT-VOLTAGE CHARACTERISTICS.

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Abstract.

Systematic measurements of current-voltage characteristics have been performed on superconducting samples in the intermediate state. Single crystalline lead plate samples were always of the same section but with differents edges geometries. The magnetic field is normal to the plate. Our observations shows that the current-voltages curves look is strongly dependant of the single crystal edge form, flux penetration and flux-flow mechanisms are differents. With a single crystal with one sharp edge we can see differents voltages depending of the current sense. These measurements are confirmed by optic dynamic observation of the magnetic flux in the sample.

Methods.

The magneto-optical observation technique previously published (1) was used to make visual the motion of intermediate state structures in single crystalline plates of lead. Theses are prepared in a matrix made of two glass plates with stainless steel pieces cut in a way to obtain the required form. To avoid adherence, a carbon film is deposed with an alcohol flame on the surfaces in contact with the sample. Fused metal is injected in the matrix, who moves regular in a sharp temperature gradient of about 20°C centered on the fusion temperature.

Geometry of the flux-flow in the sample

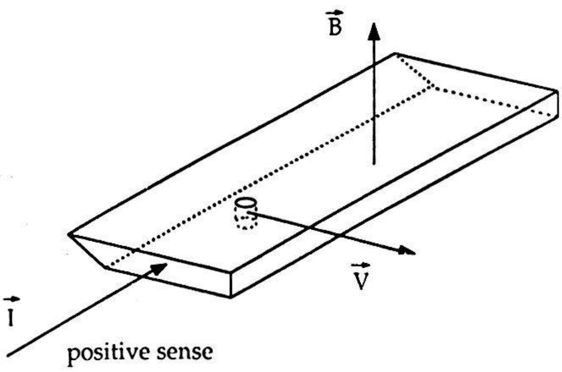

Figure 1.

The sample is directly placed in helium bath, in a way to have good thermal exchanges. Its a four wire electrical arrangement, a particular care has to be given to currents contacts to permit intensities to 80 A without excess heating. Voltage probes are gold electrodes 15 mm distant on the back face of the sample, a great care is necessary in wiring, to avoid voltage jumps due to field variations. potential is measured vith a Keithley 180 nanovoltmeter, and we disabled all filters. Acquisition is made with a real time VME bus system. A video recording of magnetics structures is simultaneously performed.

Three samples ar compared in this paper: the first is of rectangular section 3mm width and 0.5 mm thick. The second has one sharp edge as we can see on figure 1,. the third has two sharps edges.

Measurements.

After optical determination of the critical field, when all superconducting zones disappeared, a measurement of current-voltage characteristics is done for reduce fields from 0.2 to 1 with a step of 0.1. We then obtain a graphic like the one of figure 2, where we see critical currents and flux-flow resistivities. The same measurements can be done for the two sense of current and field. Those are DC measurements, and each is made after a steady state is reached. Current, voltage, field and temperatures are recorded simultaneously.

Observations.

It is interesting to remark that the critical current at flux-flow starting is very different with only the edge geometry changed. On figure 3, the first curve is the one of a normal sample with quadratic section. The second is for a sample with one sharp edge, as we see on figure 1, the flux penetrating the sample by the modified edge, we remark that currents densities are lightly lower. The next curve is from the same sample but with reverse current, we can see a drastic diminution of critical currents densities.

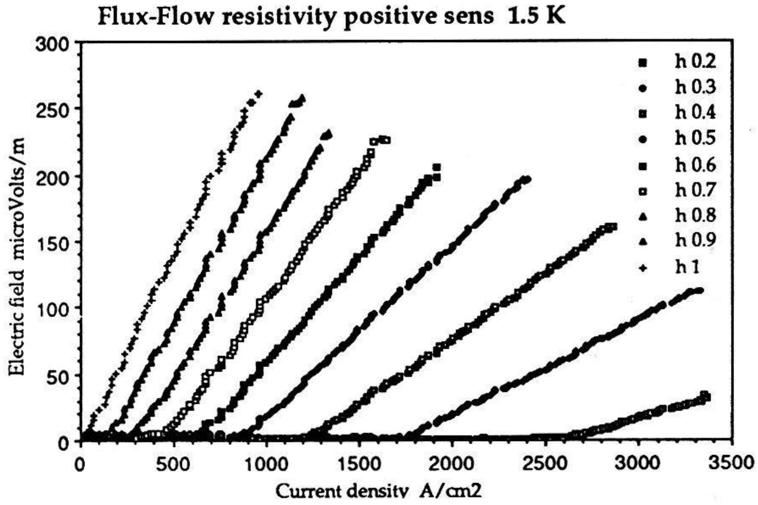

Figure 2.

The last curve is the one of a sample with two sharp edges, and shows critical currents about 70% lower comparing to the normal sample. Magneto-optic observations shows a macroscopic shielding current flowing around the sample, influenced by the modifications done to the edges. The structure parameter is different depending of the flux coming thru a sharp edge or not.

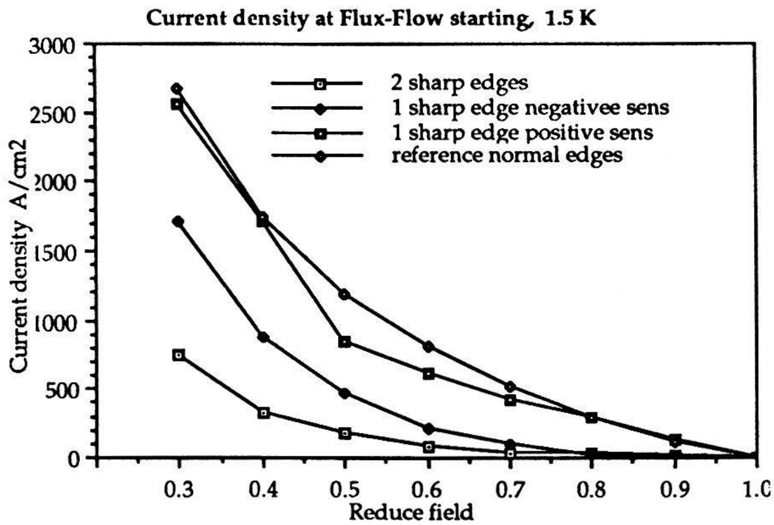

Figure 3.

Conclusions.

Theses measurements uses samples where we tend to eliminate pinnigs effects, this is well shown by the quasi absence of a non linear part in the current-voltage characteristics. The only remaining pinning forces are theses of surface, more precisely from the edges of the sample, and that is where we found the more significants effects. By modifying edges we also change the screening current, which has also a great importance on critical current.

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(1) B. Dutoit & L. Rinderer HPACAK vol 22 No 2/3 191 1989