MINIATURE UHV SPLIT PAIR PULSED MAGNET FOR SAMPLE MAGNETISATION

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Abstract

For spin polarised photoelectron spectroscopy measurements at the ESRF soft x-ray beamline ID08 the sample magnetisation must be periodically reversed. A miniature pulsed field UHV compatible split pair magnet has been designed for this purpose. Maximum field generated in the center between the poles is 0.6 Tesla for a coil current of 730 A; total pulse duration is 2 ms.

1 Measurement

Unraveling the spin states in photoelectron spectra provides additional information for a large class of problems. One particular application has been to combine the circular polarisation, spin resolution and absorption resonances to study high temperature superconductors [1]. Another application is half-metallic systems. For these latter studies, a relatively large magnetic field (~0.5T) is often needed to reverse the magnetisation of the sample.

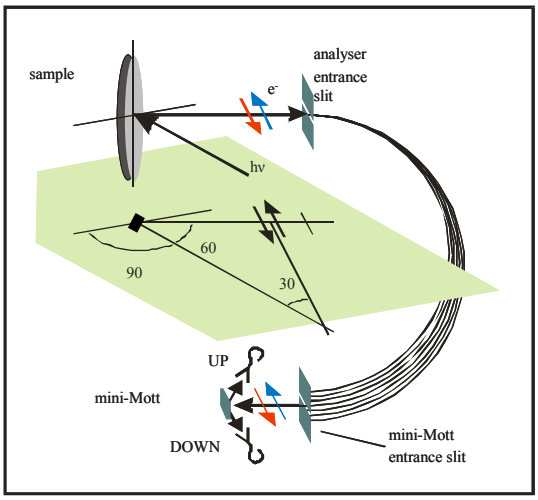

Fig 1. Measurement principle.

2 Coilset specifications

- Magnetic field > 0.4 Tesla in sample plane
- Pulse duration >1 msec
- Positive and negative pulses
- The coil-set has to fit into actual system, so:
  - UHV compatible, p = 10-10 mbar
  - Coil distance >Sample holder size (26 mm)
  - Proximity entrance lens shielding limits coil diameter to 24mm
  - Stray field can magnetise mumetal chamber wall
  - Coilset has to move vertically

3 Method

Design and optimisation of the system:

1. Calculate field along the coilset axis, optimisation of the field vs coil dimensions
2. Coil dimensions yield inductance and resistance
3. Choice of capacitance and charge voltage to get pulse height and duration

To be taken into account:

- Energy absorbed in the coils will yield temperature rise for a given pulse. A longer pulse gives the sample more time to magnetise but generates more heat. As the coilset is in UHV cooling back to ambient temperature will be slow. As designed the coils will warm up 4 degrees for a 0.4 Tesla pulse.
- Coils stray field at the mumetal shield wall < 2 mT to prevent magnetisation of the shield wall as this would change the electron trajectories.
- The coil hoop stress due to Lorentz forces is calculated at 10 Mpa: this is largely within the stress the copper windings can sustain.
- Magnetic attracting force between the coils calculated to be a few Newton.

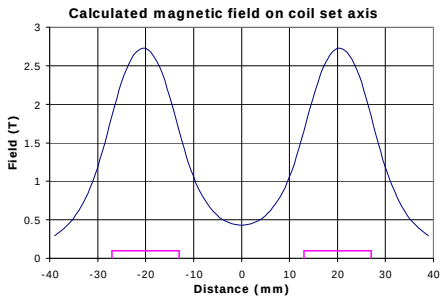

Fig. 2. Calculated field at the coil center 2.7 Tesla to get 0.4 Tesla at the sample position!

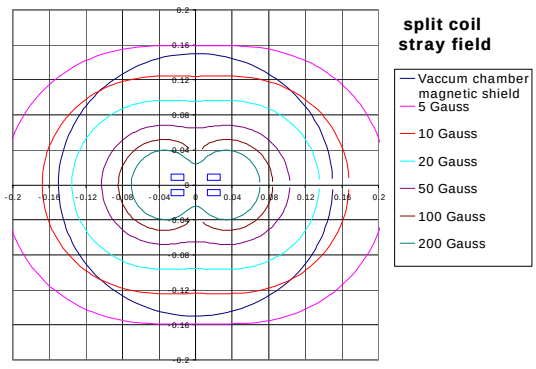

Fig. 3. Stray field plot of the coilset.

4 Test field measurement

The figure below represents a simplified circuit diagram of the system. Capacitor C is charged by closing switch S1; to create the pulse S1 is opened and S2 is closed so that the capacitor discharges into the coil L (with resistance Rl). As the L-C system is oscillatory the crowbar diode Dc and the crowbar resistor Rc are added to prevent further oscillations after the first peak.

Power supply as built by Metis (Belgium): Capacitor 1.3 mF

Maximum Energy stored 150 Joule
Maximum charge voltage 500 V
Maximum discharge current 2000 A

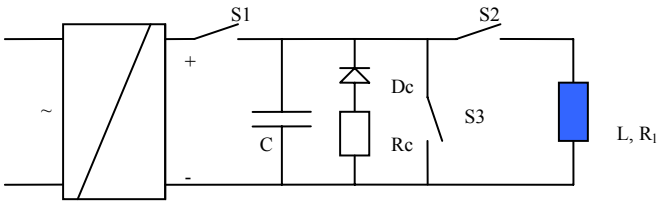

Fig. 4. Electric diagram of the system.

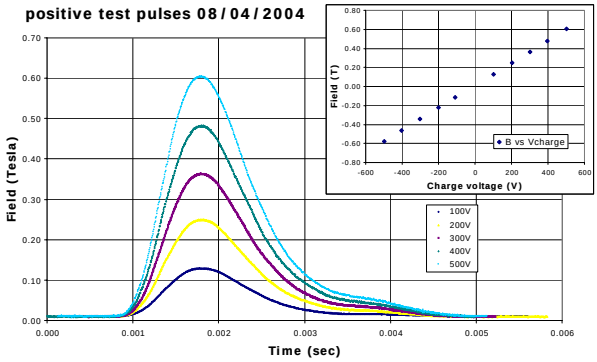

Fig. 5. Magnetic field test pulses as measured using a Lake Shore model 450 Gaussmeter.

5 Results and conclusion

The most important design parameter, the magnetic field, has been exceeded by 50%. There is no effect of the mumetal shield wall or entrance lense magnetising, the photon count rate is not changed by the field pulses.

We have successfully measured spin polarised spectra through the 2nm barrier in order to see the effect of the barrier on the half metallic nature of the Fe3O4 (the data is still being analysed). This is important for developing Fe3O4 as a material for spin electronics. Fe3O4 with the Al2O3 barrier is 2/3rds of a spin valve.

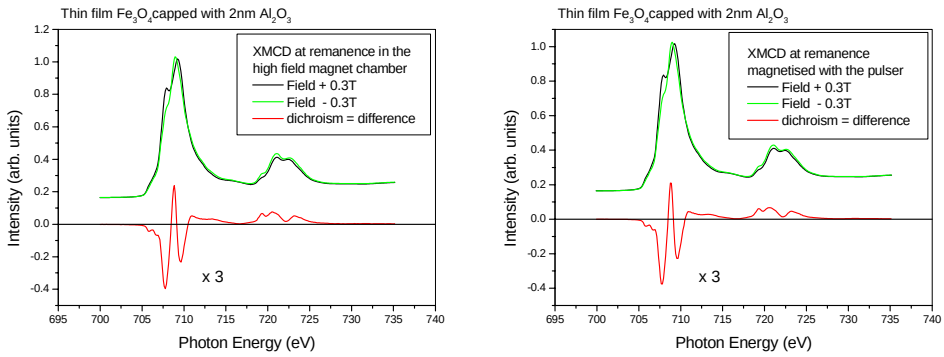

Fig.6. Comparison of measurements in a superconducting magnet and the split pair.

6 Acknowledgements

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7 References

[1] Ghiringhelli *et al*, Rev. Sci. Instrum. **70**, 4225 (1999)