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Pulsed laser deposition and nanofabrication of mesoscopic devices based on cuprates and manganites

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This thesis explores the growth, the nano-fabrication and the magneto-transport properties of Superconductor/Ferromagnet/ Superconductor (SFS) structures from complex oxides such as the high T_c superconducting cuprate $YBa_2Cu_3O_7$ (YBCO) and the ferromagnetic manganites $La_{2/3}Ca_{1/3}MnO_3$ and $La_{2/3}Sr_{1/3}MnO_3$ (LCMO and LSMO), deposited with the pulsed laser deposition (PLD) technique. The present work has been possible thanks to the collaboration between the "Magnetism and Superconductivity" Group at the University of Fribourg, in Switzerland, and the "Experimentell Kondenserade Materiens Fysik" Group at Stockholm University, in Sweden.

Earlier, the two research groups in Fribourg and Stockholm had studied SFS structures from YBCO/ $LaMnO_3$/YBCO multilayers with 20 nm thick ferromagnetic and insulating $LaMnO_3$ barriers, and obtained signs of an unconventional spin-triplet current across these structures. This finding motivated the present thesis work with a focus on two main aspects.

Firstly, to explore other candidate materials suitable as barriers and optimise their growth conditions as to maintain a large ferromagnetic moment and thus a high spin polarisation of the charge carriers. Secondly, to study what happens when the thickness of the ferromagnetic and insulating $LaMnO_3$ barrier is reduced well below 20 nm to enable larger supercurrents.

It has been shown for a series of YBCO/LCMO multilayers that the ferromagnetic moment of LCMO depends critically on the PLD growth conditions as well as on the thickness and even structural details of the YBCO layer on which they are grown. Furthermore, a protocol has been established to grow heterostructures with strongly ferromagnetic manganite layers embedded in thick YBCO layers by optimising the PLD growth conditions and by substituting the bottom YBCO layer with a Co and Ca substituted version of YBCO that has a tetragonal structure (tYBCO) instead of the orthorhombic one of plain YBCO.

Devices suitable for perpendicular magneto-transport measurements have been nano-fabricated from YBCO/manganite/YBCO multilayers with ∼10 nm thick LCMO and LSMO layers as the F barriers. While no clear indications of a spin-triplet component of the superconducting order parameter have been obtained yet, a negative and hysteretic magneto-resistance has been observed that is indicative of a strong ferromagnetic order in the thin manganite barrier. The latter suggests a potential memory functionality of such structures that could be exploited in future spintronic memory devices.

Moreover, devices have been fabricated on SFS structures with a reduced thickness of the $LaMnO_3$ barrier of 10 nm and 5 nm. These samples were grown prior to the beginning of this PhD work using non optimised growth conditions, and it was found that the ferromagnetic properties of these $LaMnO_3$ barriers are strongly deteriorated. It remains to be seen whether the ferromagnetic order of such thin $LaMnO_3$ layers can be also recovered by using the optimised growth conditions as for LSMO and LCMO.

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