SUMMARY OF DOCTORAL RESEARCH

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Description of the PhD project

During my PhD at the University of Strasbourg (2013-2016), my work mainly focused on the impact of oxygen vacancies present within oxide layers integrated in working electronic devices. In particular, my goal was to characterize the effect of such defects on spin dependent tunneling in MgO based magnetic tunnel junctions. Basically, the objectives of my work can be divided in two fields that are described in what follows.

Impact of oxygen vacancies on spin dependent tunneling

The first line of research aimed to characterize the impact of localized states induced by oxygen vacancies on the properties of CoFeB/MgO/CoFeB devices. Firstly, we took advantage of the optical activity induced by oxygen vacancies in order to gain useful information on the localized states energy position in the gap of the insulating layer. Secondly, we carried temperature and bias dependent magnetotransport measurements and used a simple experimental technique in order to determine the device tunneling barrier height, which in turn reflects the energy position of localized states. Finally, we explicitly identified defect species involved in the electrical transport by comparing photoluminescence and magnetotransport measurements[1,2].

Coupling the optical, electrical and temperature degrees of freedom.

The second direction of the research project was the natural continuation of the first one and aimed to actually take advantage of properties induced by oxygen vacancies. The idea was to combine the optical, electrical and temperature degrees of freedom in the same experiment. Exciting the MgO barrier with photons with a specific energy is expected to change the defects population and thus modify the potential landscape felt by tunneling electrons. The concurrent temperature dependent electrical measurements allow to directly probe any optically induced changes to the device properties. Because our measurements involved a large parameter space, my work also consisted in automating the experimental setup and data processing.

Concurrent synchrotron XAS and electrical transport measurements

Besides these two research axis, I had the chance to work on synchrotron experiments. The mission involved a total of five weeks at the Synchrotron SOLEIL in Paris, France. My work focused on the integration of a magnetotransport setup on the Synchrotron beamline for in operando studies: using X-ray photons in order to probe the properties of an operating device. In order to do so, we used a new versatile insert developed and installed by my home institute on the synchrotron beamline. We used the technique to probe the impact of interfacial oxide in CoFeB/MgO/CoFeB magnetic tunnel junctions[3] and to probe the electronic and magnetic properties of hybrid inorganic/organic spinterfaces[4].

References

1. F. Schleicher, U. Halisdemir *et al.* Localized states in advanced dielectrics from the vantage of spin- and symmetry-polarized tunnelling across MgO. *Nat. Commun.* 5, 4547 (2014).
2. F. Schleicher, U. Halisdemir *et al.* MgO magnetic tunnel junctions of enduring F-type upon annealing. *J. Phys. D. Appl. Phys.* 48, 435004 (2015).
3. M. Studniarek, U. Halisdemir *et al.* Probing a device's active atoms. *Submitted* (2016).
4. Studniarek, M. *et al.* Modulating the ferromagnet/molecule spin hybridization using an artificial magnetoelectric. *in preparation* (2017).