

2016-2017

## Internship proposal (Master or final project engineering school) at LMGP Lab.

**As key component for transparent electronic development, study of the growth of Sr and Mg doped copper(I) oxide as p-type transparent conducting material and of its integration in transparent p-n junction.**

### Abstract

As key component for transparent electronic development, the internship focuses on the study of the deposition by CVD of Sr and Mg doped copper(I) oxide thin films and especially on the integration of this new p-type transparent conducting material in transparent p-n junctions and p-type based transparent thin film transistors.

### Context

Oxide electronics, also referred as transparent electronics, is an important emerging area, notably for the development of thin film transistors (TFTs) and more complex electronic circuits. The significant research interest in this field has been spurred by the enormous success of n-type oxide semiconductors, specially amorphous oxide semiconductors, in particular gallium-indium-zinc oxide ( $\text{InGaO}_3(\text{ZnO})_5$ , or GIZO). The successful application of n-type oxides to TFTs has motivated the interest in p-type oxide based semiconductors also to be applied to TFTs or to complementary metal-oxide semiconductor (CMOS) technology. However, until now there is a lack of p-type oxide semiconductors with performance similar to that of n-type oxide. In fact, for p-type oxides, the carrier conduction path (valence band) is mainly formed from the oxygen *p* asymmetric orbitals. However, due to the ionicity of the metal-oxygen bond in most of metallic oxides, this leads to the formation of a deep acceptor level which limits the hole mobility. Among the different metallic oxides, Cu(I)-based oxides exhibit one of the lowest ionic character. These compounds are therefore one of the most promising candidates as p-type transparent semiconductors. Different doping elements, as Sr or Mg, have an important impact on electric properties of  $\text{Cu}_2\text{O}$ , improving both electric and chemical features.

### Project description

Within this context in order to improve the electrical properties of the p type transparent conducting films,  $\text{Cu}_2\text{O}$  thin films doped with Sr or Mg grown by metal-organic chemical vapor deposition (MOCVD) will be investigated. The optimization of the growth conditions will be performed by a detailed characterization study using a wide range of standard physicochemical analysis techniques (X-ray diffraction; scanning and transmission electron microscopy; energy- and wavelength-dispersive X-ray, Fourier-transform infra-red and Raman spectroscopies). Transparent p-n junction devices will be subsequently fabricated by depositing the doped  $\text{Cu}_2\text{O}$  films on well-known n-type layers such as Al:ZnO or F:SnO<sub>2</sub>, and their transport properties as well as their optical transmittance will be measured.

### .Location

The candidate will work within the LMGP, Materials and Physical Engineering Laboratory, in the group FM2N.  
LMGP Web Site: <http://www.lmgp.grenoble-inp.EN/>

### Profile & requested skills

The candidate is a high school, engineering school and / or Master student whose training focuses primarily on materials science. Aptitude for teamwork, good spoken and written English will be appreciated. We are looking for dynamic students, motivated and interested in pursuing with a PhD.

**Subject could be continued with a PhD thesis : YES**

**Internship stipend**: 554€ per month.

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