# SYNCHTRON RADIATION IN SOLID STATE CHEMISTRY

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*Keywords: solid state chemistry, reactivity, reaction mechanisms, XAS*

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Solid state reactivity in its various aspects plays a significant role in many different areas of science, such as Crystallography, Mineral Physics and Earth Sciences, Physical Metallurgy, Ceramic Science, Semiconductor Physics, Solid State Chemistry, but the basic knowledge and the main results (not to speak of the language itself) are not always well shared among the disciplines. Surface Science and Catalysis provide an ample background of knowledge on the transformations and reactions occurring at a free interface, while the processes occurring at the boundary between two condensed phases are an important topic in many of the scientific areas above quoted, for instance in the investigation of phase transformations or growth of thin films. All this knowledge provides important starting points but does not directly face the processes occurring when a *single* interface between two grains of the reagent phases is progressively turned into *two* different interfaces between each reagent and the newly formed product. So, for an extremely ample set of heterogeneous reactions, *i.e.* the reactions involving two condensed phases as reagents and producing a different crystalline phase, the present state of art is that thermodynamics gives tools to predict whether or not the formation of a particular product can occur, and the assessed kinetic theory gives tools to predict the growth rate of this product when diffusion is the rate determining step. However, we do not really understand the mechanism through which this product is formed. This means that we have no general knowledge of the very basic aspects of the chemical reactivity in the solid state; for instance we ignore how and why a reaction actually goes towards one or another polymorph, a compound or a broad range solid solution, a stable or metastable product.

Quite impressively, the scientific community still needs an assessed agreement concerning the procedures and the aforementioned experimental probes required to investigate this topic, as well as a sound common background connecting the different areas that can seemingly provide important contributions to the advancement of knowledge, and that conversely can profit from that advancement.

As a matter of fact, in quite recent series of papers by our group, it has been demonstrated that some insight into the mechanisms and the kinetics of solid state reactions in the early stages can be obtained by: i) performing the reaction using at least one of the reactants in form of a very thin film (of the order of 10 nm), ii) using a local probe for the local chemical environment of one of the constituents such as XAS (X-Ray Absorption Spectroscopy) [1-4].

Aim of this lecture is to show how important insights into the mechanisms of a solid state reaction in its early stages can be retrieved. The use of different Synchrotron Radiation based techniques is of fundamental importance in this respect.

**References**

[1] P. Ghigna, G. Spinolo, I. Alessandri, I. Davoli, F. D'Acapito, "Do we have a probe for the initial stages of solid state reactions? Complex oxide: defect chemistry, transport and chemical reaction", *Phys. Chem. Chem. Phys.* **5 (**2003) 2244–2247.

[2] F. D'Acapito, P. Ghigna, I. Alessandri, A. Cardelli, I. Davoli, "Probing the initial stages of solid-state reactions by total reflection EXAFS (reflEXAFS)", *Nucl. Instr. And Meth. in Phys. Res. B* **200** (2003) 421–424.

[3] S. Pin, P. Ghigna, G. Spinolo, E. Quartarone, P. Mustarelli, F. D'Acapito, A. Migliori, G. Calestani, "Nanoscale formation of new solid-state compounds by topochemical effects: The interfacial reactions ZnO with $Al_2O_3$ as a model system", *J. Solid State Chem.* 2009, **182**, 1291–1296.

[4] P. Ghigna, S. Pin, G. Spinolo, M.A. Newton, M. Zema, S.C. Tarantino, G. Capitani, F. Tatti, "μ-XANES mapping of buried interfaces: pushing microbeam techniques to the nanoscale", *Phys. Chem. Chem. Phys.*, (2010), in press.