STUDY OF COMBUSTION SYNTHESES BY TIME-RESOLVED X-RAY DIFFRACTION: COMPARISON OF SYNTHESIS MECHANISMS FOR DIFFERENT COMBUSTION MODES

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Combustion synthesis is a cheap, quick and easy technique to fabricate a large range of materials, including ceramics and composites. It is based on the exothermic properties of the chemical reaction to synthesize a whole sample. Two combustion modes exist depending whether the synthesis occurs in the form of a wave traveling through the sample (Self-propagating High-Temperature Synthesis SHS) or if it occurs simultaneously in the whole sample (Thermal Explosive Synthesis TES).

In this study, both combustion modes have been used to synthesize an equiatomic mixture of Aluminium, Nickel, Titanium and Carbon powders in order to obtain NiAl/TiC composites.
The reactions have been followed in-situ by time-resolved diffraction using synchrotron X-rays within time scales of the order of several hundreds of milliseconds. The combustion by self-propagating mode (SHS) has been performed in air, triggered by a tungsten wire heated by the Joule effect, to ignite the reaction. The combustion by thermal explosion mode (TES) was carried out in an induction furnace, specifically made for in-situ diffraction. In both combustion modes, experiments were performed in transmission in order to probe the crystallographic changes occurring in the bulk materials.

Scanning Electron Micrographs and X-ray diffraction patterns of the samples after synthesis have shown that the same final products were obtained when the mixture was synthesised under both combustion modes: a composite made of small and round TiC particles (~1 micron) embedded into a matrix of larger NiAl grains (5 microns). However, the time-resolved diffraction studies have shown that, even with the same reactants and final products, the two combustion modes follow two different routes.