PhD offer (36 months)

TITLE

HiPIMS deposition process monitoring for the sputtering of complex multielements targets

DESCRIPTION

Growing industrial constraints regarding productivity, performances and environmental concerns require increasingly optimized components and efficient synthesis routes. Metallurgy explores in this context new concepts such as multielements alloys. This material family, studied for several years already, intends on injecting innovation, in particular via high entropy alloys (HEA), complex concentrated alloys (CCA) and even bulk metallic glasses (BMG). Their elaboration as thin films for instance by sputtering is of particular interest. In addition to the exploration of new materials exhibiting properties surpassing conventional alloys, sputtering allows an easy and convenient navigation through a vast continuum of compositions. This high-throughput synthesis capacity is essential to target compositions of interest regarding specific applications.

Sputtering deposition processes such as high power impulse magnetron sputtering (HiPIMS) are very flexible in order to synthetize multielements alloys. The identification of compositions of interest by combinatorial synthesis generally requires elemental targets at a small scale (research laboratory). Then, an alloyed target is more suitable for the scale-up of the deposition process to a larger scale (pilot installation). Indeed, the sputtering of a complex target made from several elements rarely lead to a thin film with a similar composition. Moreover, the deposition parameters directly influence the coatings composition with a fixed target composition.

The goal of this PhD project is to monitor the HiPIMS deposition process applied to the sputtering of multielements targets. The phenomena involved during the sputtering of such sources will be identified thanks to suitable analytical techniques monitoring the growth of the coating and the pulsed plasma. Selected techniques comprise (i) LIBS (Laser Induced Breakdown Spectroscopy) analysis to relatively trace elements in the coating and in the target, (ii) optical emission spectroscopy coupled with (iii) an ultra-high-speed camera to study the species in the plasma along with their dispersal between pulses, (iv) the measurement of the energy distribution of ionized species from the plasma and finally (v) the quantification of coating thicknesses and growth rates by PTR (PhotoThermal Radiometry). Other relevant methods may later supplement the coating and plasma analysis. Except for LIBS and PTR, the techniques are already available inside a HiPIMS deposition chamber. For LIBS, therefore, the ex-situ definition of all technical specifications necessary to measure various compositions, the demonstration of the feasibility of these ex situ measurements and the design of an implantable analysis device inside a deposition chamber should be carried out. PTR analyses are already possible thanks to a compact measurement head but its integration has not been done yet. LIBS and PTR in-situ developments should be considered in a second time.

The PhD project will be fully integrated to the industrial IMPACT Chair (Innovative Materials and Processes Accelerated through Computing Technologies) from INSTN (French national institute for nuclear science and technology). SAFRAN and FRAMATOME, industrial partners of the Chair, will be involved. These alloys do not only represent a strong interest for them, but they will also benefit from a better understanding of the phenomena related to the sputtering of complex targets and a greater control of the monitoring tools. The PhD candidate will benefit from the skills and the researchers of Physical Chemistry Department of CEA (The French Alternative Energies and Atomic Energy Commission) regarding thin films deposition along with the monitoring tools. Polytechnique Montréal technological University will contribute thanks to their unique experience on ultra-high-speed camera and plasma characterizations.

LOCATION

CEA Saclay
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START DATE

September to October 2019

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