Contribution ID : **17** Type : **Presentation**

ION BEAMS AND SYNCHROTRON LIGHT IN PERSPECTIVE

Friday, 25 June 2021 10:00 (1:00)

Abstract

This work is devoted to reflecting on the very different features and dynamics of ion beam and synchrotron facilities and user communities. Whereas both suites of techniques are highly interdisciplinary and offer good science opportunities to similar fields of science, traditionally the two communities have lived in separate worlds, with scarce knowledge of one another and very limited collaboration. Many different techniques have been developed based on synchrotron light during the last decades. If one adopts a very global and non-exhaustive view, some of the main ones may be grouped and summarized as follows: diffraction, photon spectroscopies, electron photoemission spectroscopies and imaging/tomography. The features of each group of techniques may be found elsewhere. These techniques are based on large facilities, with wide user communities, many in-situ possibilities and time-resolved capabilities. Ion beams, again with a broad and non-exhaustive view, may be classified as follows: analysis based on nuclear interations, ion in/ion out, analysis based on atomic/nuclear interaction (ion in/photon out), channeling configuration, modification. The features of each technique may also be found elsewhere. Facilities tend to be medium/small, with a smaller user community, limited in-situ capabilities and rare time-resolved setups. In summary, synchrotron techniques provide extremely rich and diverse tools to understand matter at the nano and mesoscale. This implies a large investment effort and the size of the facilities makes them, as a side-effect, very powerful science hubs, beyond the base contribution of the techniques offered. Ion-based techniques are an excellent complement to synchrotron techniques when depth profiling or trace element detection (possibly with 2D resolution) plays a relevant role. In addition ions may be used to modify materials in unique ways and to understand how these damage processes, crucial in areas such as fusion energy devices, take places and may be managed or mitigated. Ion facilities, being small or medium size, provide a very natural scientific landscape complement to larger synchrotrons in a country. ALBA and CMAM are respectively synchrotron and ion beam facilities located in Spain. They were both built during the 2000 decade, CMAM starting a few years before ALBA. Their relative size may be exemplified by the initial investment (at the level of 200 ME for ALBA and 10 ME for CMAM. Further details may be found in [1, 2] for ALBA and [3, 4] for CMAM. Some examples in which ion beams and synchrotron light may be used in a complementary way are given below. XANES, XRD (synchrotron) and RBS (ions) were used in a complementary way to understand the better the preparation process of Ti oxide films [5]. Here XANES was used to look at the valence states of Cr or Ti averaging along the sample depth, whereas RBS was used to verify the Cr-O or Ti-O stoichiometry as a function of depth. XRD was used in both cases to check crystallinity. PIXE (ions) and XRD (synchrotron) were used to characterize samples which emulate the historical features of Co and As based pigments for ceramic archaeological pieces in [6]. In situ temperature cycling of the samples while doing XRD characterization was used to emulate the ancient manufacturing processes and shed light on the composition differences observed in objects from different periods of the 15th-16th century. An ongoing collaboration between CMAM and ALBA is exploring the possibility of manufacturing X-ray gratings by using ion beam lithography [7]. A particularly challenging material, synthetic diamond, is being used as a possible future option for ultra-high heat load applications in X-ray science. Synchrotron and ion beam facilities and user communities are very different and have historically held very limited collaboration. However the

techniques are clearly complementary in a number of ways. This paper aims at illustrating and exemplifying such possible collaborations. One may expect that progress in both synchrotron and ion beam techniques may unlock in the future some scientific opportunities which are today out of reach.

References: [1] G. García, S. Ferrer, The Spanish light source ALBA, Synchrotron Radiation News, 27:1, 30-33 (2013). [2] www.cells.es [3] A. Redondo-Cubero, M. J. G. Borge, N. Gordillo, P. C. Gutiérrez, J. Olivares, R. Pérez-Casero and M. D. Ynsa, The European Physical Journal Plus, pp. 136-175, 2021. [4] www.cmam.uam.es [5] R. Gago et al., Structural impact of chromium incorporation in as-grown and flash-lamp-annealed sputter deposited titanium oxide films, Journal of Alloys and Compounds, 2017, 729, 438-445. [6] J. Molera, A. Climent-Font, G. García, T. Pradell, O. Vallcorba, A. Zucchiatti, Experimental study of historical processing of cobalt arsenide ore for colouring glazes (15-16th century Europe), J. of Archaeological Science: reports 36 (2021) 102797. [7] G. García, M. Díaz-Híjar, V. Tormo-Márquez, I. Preda, O. Peña-Rodríguez, J. Olivares, Structural damage on single-crystal diamond by swift heavy ion irradiation, Diamond and related Materials 58 (2015) 226-229.

About

Gastón García López, director del Centro de Microanálisis de Materiales (CMAM), es licenciado en Ciencias Físicas y en Matemáticas por la UAM y diplomado en Derecho por la Universidad de Valladolid. En el año 2000 se doctoró en Física con la calificación de sobresaliente cum laude. Durante los últimos 13 años ha estado ligado al sincrotrón ALBA (Barcelona), ocupando el cargo de subdirector desde 2013 hasta 2019, periodo en el que fue responsable de proyectos estratégicos. De 2000 a 2006 estuvo ligado al CMAM de la UAM, donde fue coordinador del equipo técnico y vicedirector. Con una amplia experiencia en gestión de infraestructuras de investigación, dirección y coordinación de equipos multidisciplinares y planificación estratégica, Gastón García representa a España como asesor en el Consejo del ESRF (European Synchrotron Radiation Facility) y es presidente del comité de coordinación de LEAPS, red que une a todos los sincrotrones y láseres de electrones libres europeos. Inició su carrera investigadora en el campo de Fisica de Altas Energías, para dedicarse posteriormente a la Ciencia de materiales aplicando técnicas basadas en aceleradores de partículas, con especial énfasis en el daño de materiales inducido por irradiación. Durante los últimos años ha realizado numerosas actividades de divulgación científica.

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Session Classification : Guest Lecture