

**Developments in Processing by Severe Plastic Deformation  
at the 3<sup>rd</sup> Pan American Materials Congress**

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**ABSTRACT**

The 3<sup>rd</sup> Pan American Materials Congress in San Diego in February-March 2017 gave an opportunity to bring together many participants working in the field of severe plastic deformation. This report provides a brief review of these activities.

## **INTRODUCTION**

The Pan American Materials Congress was initially established with a meeting in Brazil in 2010 and then a second meeting, also in Brazil, in 2014. This 3<sup>rd</sup> Pan American Congress was different because it was held in San Diego, California, on February 26th – March 2<sup>nd</sup>, 2017, as part of the TMS Annual Meeting. The Congress was specifically designed to bring together a large number of participants from countries throughout the Americas and at the same time, by joining with the TMS Annual Meeting, to provide an opportunity for participation by active researchers from many countries around the world.

Because of the large world-wide interest in the processing of ultrafine-grained metals through the application of severe plastic deformation (SPD), and especially because of the high participation in a symposium on this topic at the 2<sup>nd</sup> Pan American Congress in Brazil in 2014, it was decided to develop a symposium in San Diego on “Nanocrystalline Ultra-fine Grain Materials and Bulk Metallic Glasses.” This symposium was an outstanding success with a total of 53 papers accepted for oral presentation and an additional 9 papers accepted for presentation as posters. The following brief report describes some of the developments in SPD research in the Americas.

### **SPD RESEARCH IN THE AMERICAS**

A general conclusion from a review of the titles of papers presented in this symposium is that many (if not all) of the topics of considerable current interest to world-wide researchers in the field of SPD processing are now under active consideration and evaluation in the Americas. Thus, it is clear that these countries are now making an important contribution to our overall understanding of the SPD process and in the development of materials with submicrometer and nanometer grain sizes.

For example, there is now much interest in examining the strengthening and weakening that may occur in different materials when processed to produce ultrafine grains.

Although SPD processing produces significant grain refinement and this generally leads to a strengthening of the bulk solid, it is now apparent that there are examples where the material is weakened by SPD rather than strengthened. This may occur if, for example, the hardening precipitates within the crystalline matrix become fragmented due to the very high pressure imposed in the SPD processing.<sup>1</sup> This topic of hardening/weakening has been addressed in detail in several recent publications<sup>2,3</sup> and it was examined in a comprehensive experimental investigation by Gabriel Torres Villaseñor and his colleagues at the Universidad Nacional Autónoma de Mexico (UNAM). Specifically, tests were conducted to investigate these hardening and weakening effects in a Zn-21% Al-2% Cu alloy processed by equal-channel angular pressing (ECAP). There were also other reports from Mexico on processing by ECAP including research on the AA6061 alloy by Carlos Reyes Ruiz at UNAM and on the 2014 and 5083 Al alloys by E. Garcia-Sanchez at Universidad Autónoma de Nuevo León.

A detailed report by Jorge Cubero-Sesin of the Instituto Tecnológico de Costa Rica provided information on the microstructural evolution occurring in a Ti-6% Al-7% Nb alloy after processing by high-pressure torsion (HPT). Microstructural evolution during and after HPT is again a topic of considerable current interest within the SPD community<sup>4</sup> and this presentation dealt specifically with a material of considerable interest for use in orthopaedic applications and as dental prostheses.

A review of several years ago showed there is a very significant interest in SPD processing in Brazil<sup>5</sup> and this was further supported by several papers presented in this symposium. Roberto Figueiredo of the Universidade Federal de Minas Gerais described research on the biocompatibility and corrosion of pure Mg using processing by both ECAP and HPT: a report on some of these results was published almost simultaneously with the Pan American Congress.<sup>6</sup> Other reports from the Universidade Federal de São Carlos in Brazil extended the processing techniques to accumulative roll-bonding (ARB) of an AA1050

aluminum alloy by Andrea Kliauga and her colleagues and cyclic closed-die forming of pure copper at room temperature and subzero temperatures by Vitor Sordi and his colleagues.

Processing by HPT was also reported by Diana Marulanda Cardona of the Universidad Antonio Nariño in Bogotá, Colombia, by experiments in which it was shown that it is possible to process successfully a hard AISI 1020 low carbon steel. Following processing, this material was investigated using scanning electron microscopy, X-ray diffraction and microhardness measurements.

### **CONCLUSIONS**

The Pan American symposium on SPD processing and bulk nanostructured materials attracted much interest at the TMS Annual Meeting in San Diego in February-March 2017. The symposium was a great success with many presentations by active researchers in the Americas and many countries all over the world, and with these presentations demonstrating advanced techniques of SPD processing and characterization and documenting innovative studies on the superior properties of ultrafine-grained materials. It is clear that researchers are making important contributions to this area of materials science throughout the Americas and there is no doubt that their publications will become of increasing importance in the future. Accordingly, we await with interest the many presentations that will be forthcoming at the 4<sup>th</sup> Pan American Congress to be held in Monterey, Mexico, in 2019.

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## REFERENCES

1. C. Xu, M. Furukawa, Z. Horita, and T.G. Langdon, *Acta Mater.* 53, 749 (2005).
2. M. Kawasaki, *J. Mater. Sci.* 49, 18 (2014).
3. T.G. Langdon, *Kovove Mater.* 53, 213 (2015).
4. S.A. Alsubaie, P. Bazarnik, M. Lewandowska, Y. Huang, and T.G. Langdon, *J. Mater. Res. Tech.* 5, 152 (2016).
5. R.B. Figueiredo and T.G. Langdon, *J. Mater. Res. Tech.* 1, 55 (2012).
6. C.L.P. Silva, A.C. Oliveira, C.G.F. Costa, R.B. Figueiredo, M.deF. Leite, M.M. Pereira, V.F.C. Lins, and T.G. Langdon, *J. Mater. Sci.* 52, 5992 (2017).