New Fullerene like materials: TEM and EELS study of the formation of curved MoS_2 fringes.

Virginie Serin

Centre d'Elaboration de Matériaux et d'Etudes Structurales-CNRS, UPR 8011, 31055 Toulouse cédex 4, France

Nathalie Brun

Laboratoire de Physique des Solides, Université Paris-Sud, CNRS, UMR 8502, 91405 Orsay cédex, France

Peter Hatto, Clive Davies

IonBond Limited, Unit 36, No.1 Industrial Estate, Consett, Co Durham DH8 6TS, UK

Fullerene-like materials can be defined as materials made up of two-dimensional lamellar basic units of nanoscale dimensions with closed and curved shapes. They can grow in the solid phase into three-dimensional networks or architectures displaying a wide range of morphologies. The basic origin of these new phases lies in the role of dangling bonds at the periphery of sheets of such small sizes, which destabilise planar structures and induce closing. The atomic-scale structure of these materials involving strong covalent inter-atomic bonding and non-compact space filling, make them strong candidates for breakthrough developments, of potentially high interest in many industrial fields.
R. Tenne et al first discovered this new class of three-dimensional inorganic nanostructures [1]. They found that certain inorganic compounds that normally occur as large flat platelets can be synthesized into much smaller nano-spheres. Due to their size, shape, chemistry, and structure, materials based on these nanoparticles have special properties compared to materials based on conventionally sized constituents of the same composition. This makes them attractive for many commercial applications. Up until the discovery by the Weizmann group it was thought that fullerenes could only be made with carbon atoms. They were the first to discover that certain inorganic (i.e., non-carbon) materials could also be formed into fullerene-like structures, hence the name inorganic fullerene-like materials, or IFLM nanoparticles.

In the present paper we report the study of samples developed with the overall objective to provide industry with radically new composite coating systems. The application of the composite coatings will be for surfaces and lubricants, in order to significantly reduce and control friction and wear in tribological contacts. The ultimate aim is to reduce friction as well as to extend operational life, reduce maintenance requirements and reduce the environmental impact of a wide range of mechanical elements for the aerospace, automotive, power generation (energy) and manufacturing industrial sectors [1, 2,3].

The studied samples have been prepared by arc evaporative PVD by reactive deposition of Mo in SO_2. As displayed in Fig.1, they exhibit a multilayer structure. The chemical composition of the layers varies as a function of the preparation conditions. Chemicals maps (Fig.2) have been established using S L-edge, Mo $M_{2,3}$ edge, O K edge. These samples show a strong modulation of Mo and S content with a period corresponding to the layers thickness. We will discussed in this paper the correlation between the observed microstructure and the local composition which may provide information on the growth mechanism of the layers and on the formation of 002 MoS_2 fringes.

The authors are pleased to acknowledge the financial support of the EC (FOREMOST, Contract no.: FP6-515840)

References

[1] L. Rapaport, Y. Feldman, M. Homyonfer, H. Cohen, J. Sloan, J.L. Huchison, R. Tenne, Inorganic-like fullerene-like material as additives to lubricants; structure-function relationship, Wear, 225-229 (1999) 975-982

[2] M. Choowalla and G.A.J Amaratunga, *Thin films of fullerene-like MoS_2 nanoparticles with ultra-low friction and wear*, Nature, **407** (2000) 164 – 167.

[3] L. Rapaport, V Leshinsky, M. Lovovsky, I. Lapsker, Y. Volovik, Y. Feldman, R. Popovitz-Biro, R. Tenne, *Superior tribological properties of powder materials with solid lubricant nanoparticles*, Wear **255**, (2003) 794-800.

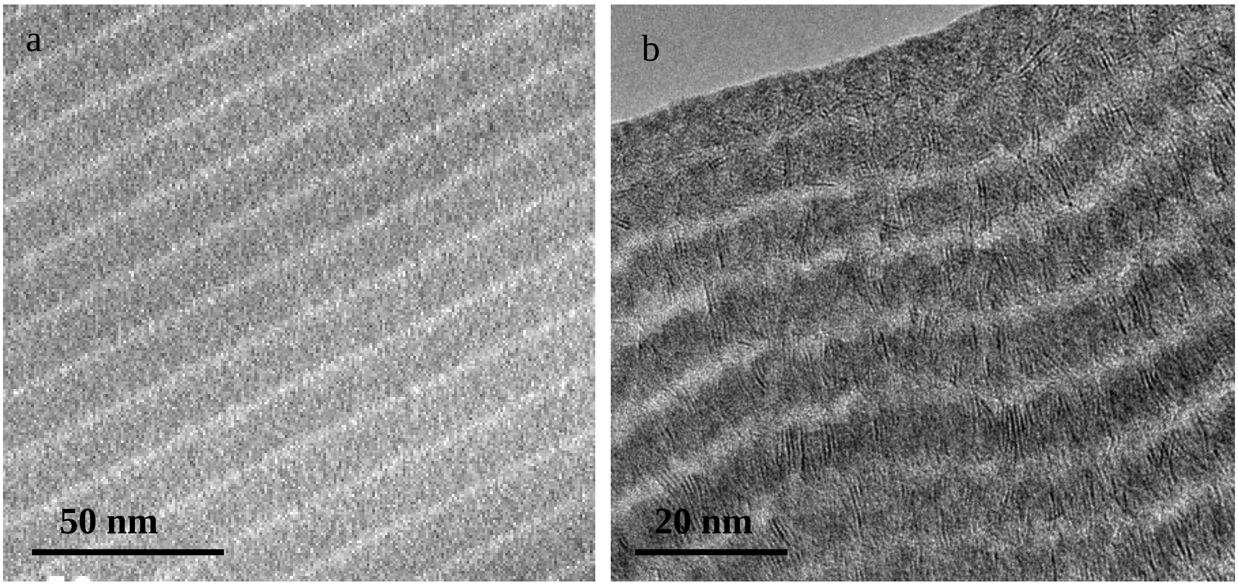

Figure 1 : TEM images of two samples with different S compositions. Note in the case b) the 002 MoS_2 fringes formed perpendicularly to the layers.

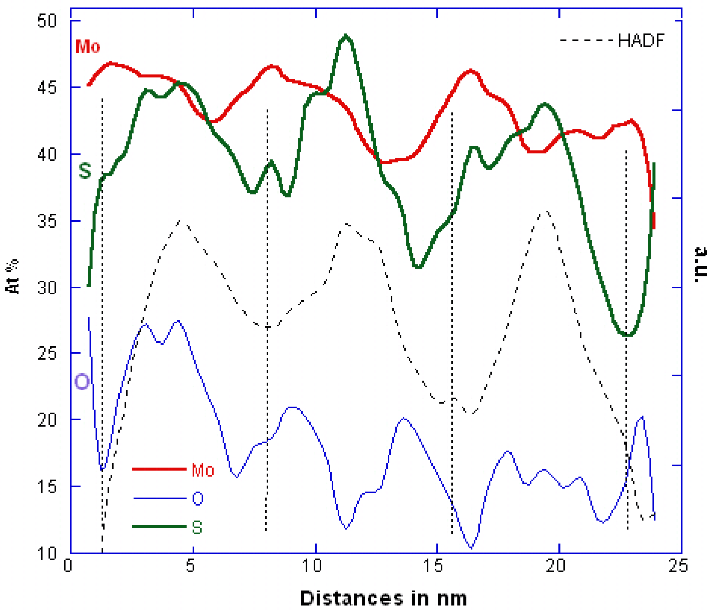

Figure 2 : EELS profile corresponding to the sample shown in fig. 1b