ESRF	**Experiment title:** Residual Stress in wear resistant new generation coatings	**Experiment number**: ME-749
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Names and affiliations of applicants :

Giovanni Bruno[1], Filippo Guglielmetti[2], Carlo Fanara[3]

[1] Institut Laue-Langevin, ILL, Rue Jules Horowitz, BP 156, F-38042 Grenoble Cedex, France

[2] Dipartimento di Chimica Inorganica, Chimica fisica e Chimica dei Materiali, University of Turin, I-10125 Turin, Italy

[3] School of Industrial and Manufacturing Science, University of Cranfield, MK43 0AL, Cranfield, Beds, UK

Report:

Moving parts in automotive components (engines, transmissions, synchronizers) are all subjected to the disruptive effects of various mechanisms, the most important being surface wear.
One of the most valuable techniques to face these effects is the hardening of surfaces by the deposition of a thin layer of a different, wear-resistant material. This process, which is called *thermal spray* coating*,* consists in the atomization of a metallic or ceramic melt directly on the target surface to form the coating.
Indeed all thermal spray coatings contain a degree of internal stress and the deposition process induces stresses in the substrate. This stress generally gets larger as the coating gets thicker; therefore, there is a limit to how thick a coating can be deposited. In some cases a thinner coating will have higher bond strength.
Our investigation has been directed towards the analysis of residual strain in a steel wheel gear (part of a lorry synchronizer) which has undergone a thermal spray coating process resulted in a protective anti-wear molybdenum layer of 100 μm thickness (on average). Its primary aim was to demonstrate the feasibility of the experiment, especially in view of the high absorption of the molybdenum coating. Fig.1 shows schematically the sample and the location of the measurements. The sample had the form of an arc of 100 mm long and with 6 mm edge square cross section.

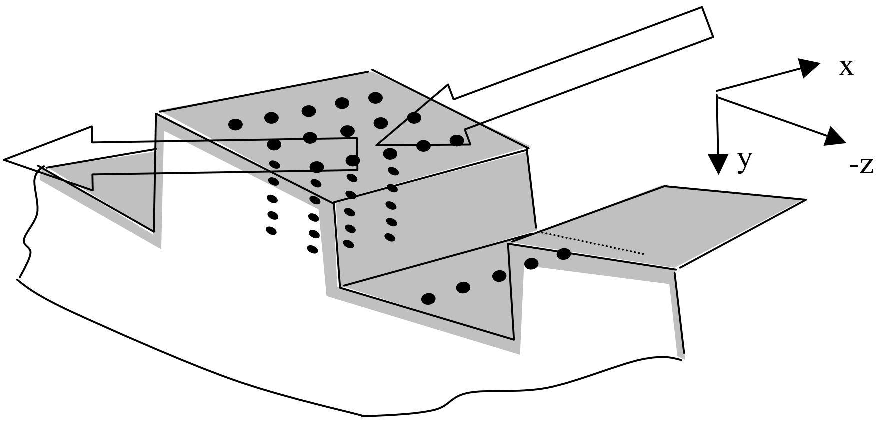

Fig.1. Sketch of the sample, the co-ordinate system and the diffraction geometry used in the experiment. The path length was between few microns in the molybdenum and 6 mm in the steel.

The experiment was performed on ID31 beamline, using monochromatic 60 keV beam energy (λ = 0.206 Å). The scans were performed in the normal direction, i.e. using the reflection geometry. They were aimed at

mapping the near surface strain on a tooth and in the throat of the gear, as a function of depth and of the position on the teeth.
The 211 reflections for both molybdenum and iron have been used, since they are the most elastically isotropic for bcc metals.

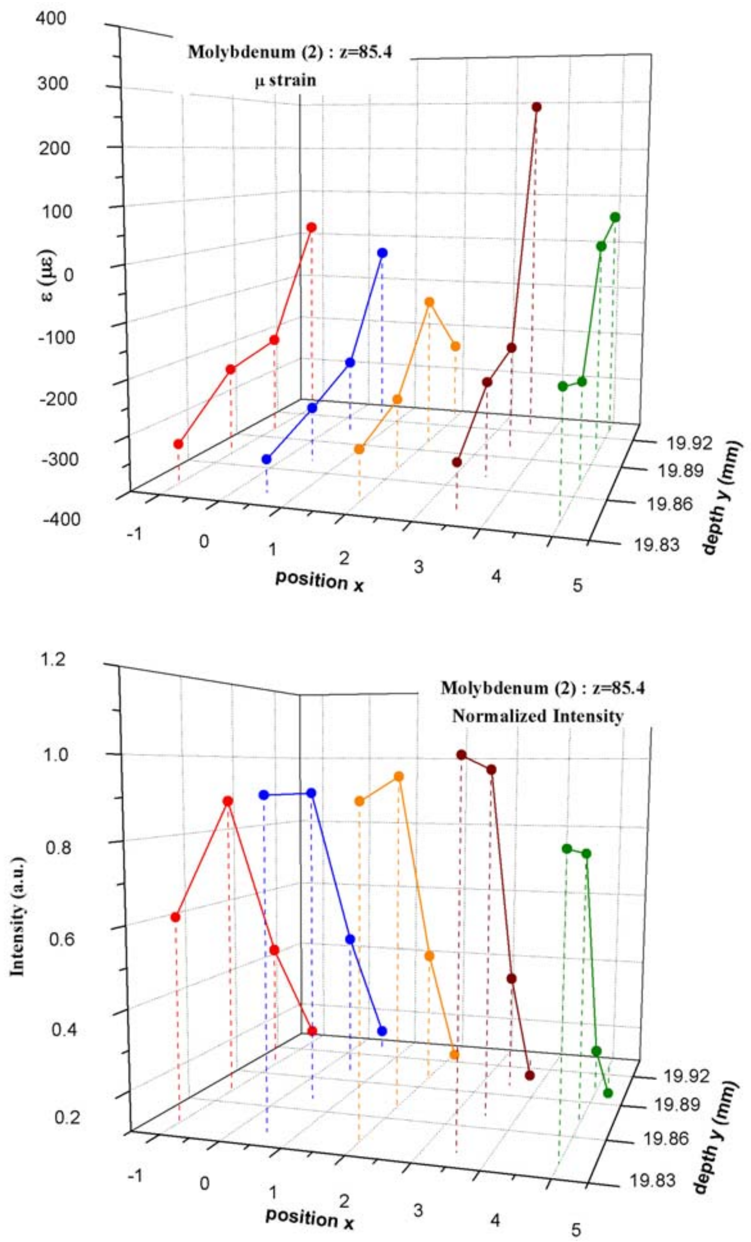

Fig.2. Examples of in-depth scans in the molybdenum coating. Intensities show that the surface was not located at the same y, but surface roughness and waviness creates a displacement effect.
The same displacement was found in the steel substrate.

Results show that the residual strains inside the molybdenum coating (characterized by a fairly high porosity) are of compressive nature whereas those inside the steel substrate are highly tensile. This is a proof of the remarkable influence that thermal mismatch stresses have in thermal spray processes and agrees very well with neutron diffraction experiment carried out at the ILL, Grenoble, France. The surface irregularities were easily corrected with a rigid translation of the scans, based on the diffracted intensities.
In conclusion, we could establish the feasibility of measuring strains in molybdenum coated specimens (despite its strong absorption), up to the depth of 100 μm. The steel substrate could be measured in transmission geometry and 6 mm absorption proved not to be a problem. It was observed that the molybdenum layer hindered the measurements at the very interface between the two phases, but the use of a Eulerian cradle could allow measuring also the first few micrometers beneath of the substrate, upon turning the specimen 180°, and to sample also the other directions in transmission geometry.