ESRF	**Experiment title:** Residual strain mapping in laser clad layers by synchrotrons radiation	**Experiment number**: ME1152
Beamline: ID31	**Date of experiment**: from:10-02-2005 to: 13-02-2005	**Date of report**:
Shifts: 9	**Local contact(s)**: Andy Fitch and Francois Fauth	*Received at ESRF:*

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Report:

The laser cladding technique is used to apply thick protective layers on soft substrates. In this process high thermal gradients involved are responsible for the generation of residual stresses, often of harmful nature because of the tensile character. To improve the quality of these coatings it is essential to characterize the residual stresses formed and the effect of the processing deposition parameters. The residual stresses formed in Co-based claddings deposited on C45 steel were investigated by synchrotrons diffraction techniques in the beam-line ID31.

The phase analysis of the claddings performed with Cu-Kα and synchrotrons X-rays diffraction revealed γ-Co and precipitated M_7C_3 carbide phases. The clad layers were composed by 9 single tracks, 1.3 mm thick with 2 mm distance overlap between the tracks. The (311) fcc plane reflection was chosen for characterization of macroscopic strains and stresses and the stress free lattice spacing used for residual strains calculations was measured from a single-track cladding that was sectioned out by spark erosion from the substrate in order to release the macro-stresses. The experiments were performed in reflection mode, using intact samples, and transmission mode, using 1 mm thick clad layer cross-sections. The horizontal scan of gauge volume through the width of the single track revealed revealed texture in the microstructure, *Figure 1*.

When intact samples were scanned the textured microstructure did not allow to examine the residual strain in depths more than 0.5 mm depth and the diffracted beam intensity was low due to the radiation attenuation of the path length (aprox.18mm), *Figure 2A*. In transmission mode, however, it was possible to make a profile of the residual strains through the entire depth of the coatings when the incidence angle was changed, *Figure 2B*. Further, the intensity of the diffracted beam was much higher than in reflection mode. The peak positions were determined by Gaussian and Lorentzian fit functions. Then the residual stresses were calculated from the local residual strains and assuming the elastic constants: $E_{Co(311)}$= 216 GPa and $\nu_{Co(311)}$= 0.3077. The stress profiles in depth and width were characterized, *Figure 3*. Further, the effects of deposition speed, overlapping of single tracks, geometry of layers were evaluated, *Figure 4*.

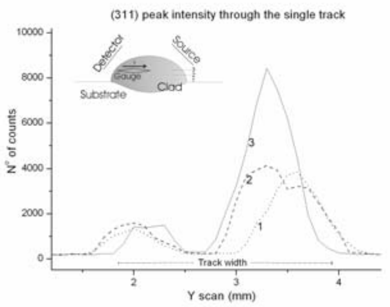

Figure 1: The (311) peak intensity variation through the width of single track. Scans performed at 3 different heights. No reflection in the bulk indicate texture .

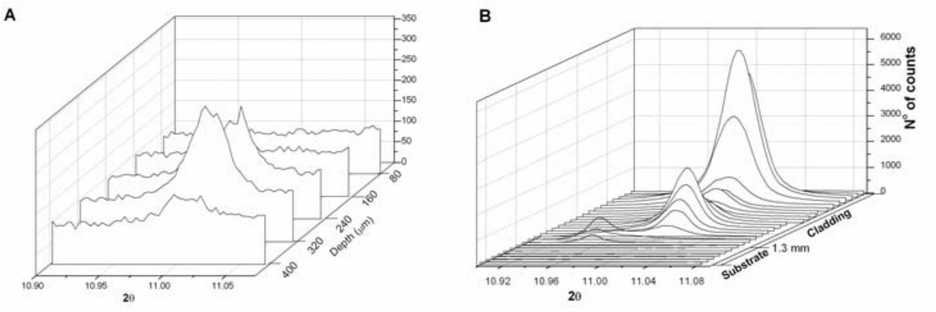

Figure 2: γ-Co (311) diffraction peaks acquired in depth: A) Intact sample peaks depth profile in the range of 0 to 400mm deep. B) Depth profile in cross-sectioned sample acquired in transmission mode. Double peaks, at 10.95 and 11.05^o, are detected close to the interface between cladding and substrate. The zero depth corresponds to the top of the coating.

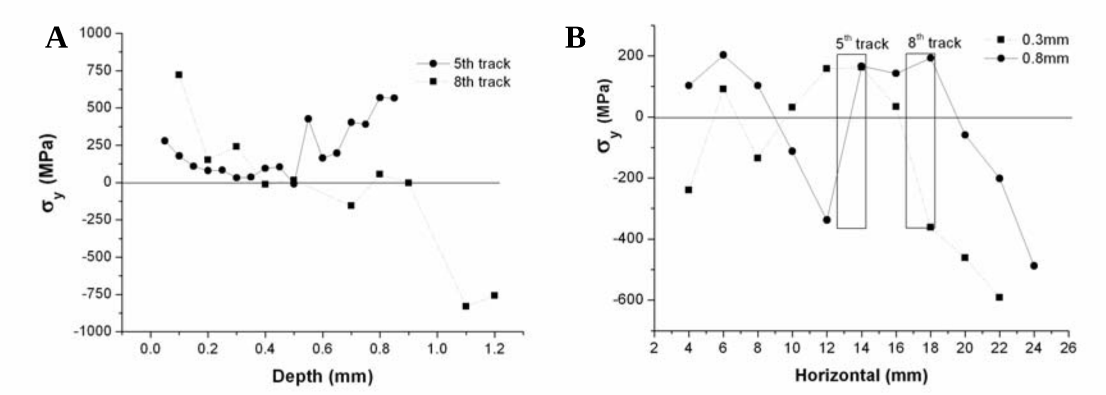

Figure 3: Residual stresses (σ_y) on cross-sections in the 5th and 8th track positions. A) Depth profile B) Horizontal profile .

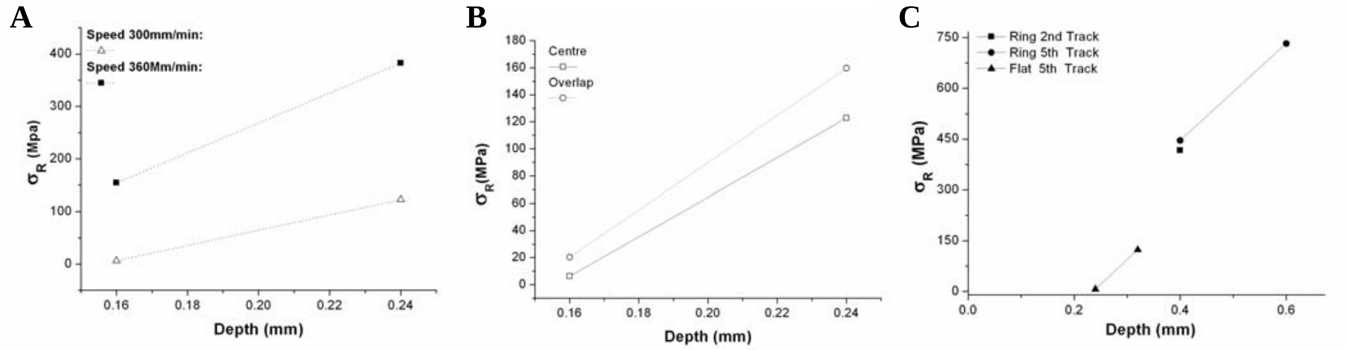

Figure 4: Residual stresses on intact claddings: A) Effect of deposition speeds: 300 and 360 mm/min.; B) Effect of residual stresses in overlapping region; C) effect of cladding shape: ring and flat substrates.

From these observations we may draw interesting conclusions. Residual stresses increases with depth and it may reach the value of yield stress at half of the thickness of the coating. Near the coating/substrate interface the internal stresses are changed to the compression. The variation of the stress as a function of depth is not smooth and also varies from track to track. The residual stress increases with scanning speed, overlapping and change from flat to round shape. The large γ-Co dendrites and strong texture formed during the laser track solidification do not allow an analysis through the whole coating depth in reflection mode.

In forthcoming experiments higher energy will be applied to investigate thicker sectioned samples. Further, 2-D detector will be applied for the analysis of texture, smaller gauge volume and more symmetric gauge volume should be applied for analyis of the strain tensor. For these reasons, experiment SI-1249 will be performed in beam line ID11.

Submitted paper: "U. de Oliveira, V. Ocelik, J.Th.M. De Hosson, *Residual stresses in Co-based laser claddings investigated by lab X-rays and synchrotron diffraction techniques.* Surface/Contact 2005, September 2005, Bologna."