Scientific report

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Title: Tribology of Ni-Co alloys: from micro to nanoscale.

Supervisors:

Prof. Ernst Meyer and Dr. Enrico Gnecco (Basel)

Duration of the stay: from 15th March to 15th July

Report

The aim of the proposed traineeship was to give a contribution to the understanding of the relation between metallurgical and mechanical properties of materials and their mechanisms of energy dissipation and wear.

In this work it was carried out a comparative study of the response of Ni-Co metallic alloys to grooving at micro and nanoscales and also of the influence of composition on the atmospheric friction coefficients. It was chosen the Ni-Co system since this system is quite interesting both from the metallurgical and tribological points of view. At one hand, the Ni-Co have complete miscibility in solid state and, at another hand, the stacking fault energy (SFE) of Ni decreases almost linearly with the proportion of Co.

Samples with compositional ranges changing from 100% Ni to 100% Co were produced by a laser cladding process. Microscale experiments were performed by using conventional indentation and scratch test apparatus, while nanoindentation, nanoscratching and friction (in air) experiments were performed by using an atomic force microscopy apparatus with different probes.

Some interesting results were obtained from these experiments, like the fact that the ratio "extension of the plastically deformed zone surrounding the groove to groove width" in microscratches is much smaller than in nanoscratches. This feature could be observed by using the AFM and the SEM.

Also some similarities between the hardness and scratching tests at both scales could be observed, although in the case of nanoscale experiments the dispersion of results is sometimes large.

In the case of friction experiments in air, no particular tendency of the friction coefficients could be taken, due to a lot of parameters that probably had an important influence in these tests, like humidity and the chemical and structural heterogeneity of the samples. There was no possibility of performing friction tests in UHV due to some technical problems with the apparatus during the time of my stay.

The obtained results from the micro and nanoscale experiments have enabled to establish a preliminary link between nanoscale scratch behaviour and micro/mesoscale scratch behaviour in order to answer the question: down to what level plastic deformation is an important mechanism of energy dissipation during sliding.

This link will be study deeply in my future PhD that will start in October of the present year, with the collaboration of the two investigation groups: *Laser Materials Processing Group* and *UHV Force Microscopy Group*.

Tasks done:

1. Bibliographic research (IST/Basel)

2. Preparation of samples
   2.1 laser cladding (IST)
   2.2 grinding and polishing (IST)

3. Chemical, microstructural and surface topography characterisation of the samples (IST)

4. Microhardness tests (IST) and Conventional scratch tests (CATIM-Lisboa)

5. Nanohardness and nanoscratching tests (Basel)

6. Friction tests in air (Basel)

7. Analysis of the results and preparation of the monography (Basel/IST).