Report on experiment MA1044

STUDY OF MECHANICAL LOSSES IN TANTALA COATINGS

The VIRGO experiment has the purpose of detecting gravitational waves with a Michelson - type interferometer. The most important components of this system are the mirrors, positioned at the end of the two arms.

It is now well established that a major source of noise (limiting the performance of the detector) is the mechanical noise due to the coating of the mirrors, which is formed by a multilayer of SiO_2 / Ta_2O_5 amorphous films.

It has been proven that a prolonged annealing of the coating can reduce the noise, but it is not clear the reason.

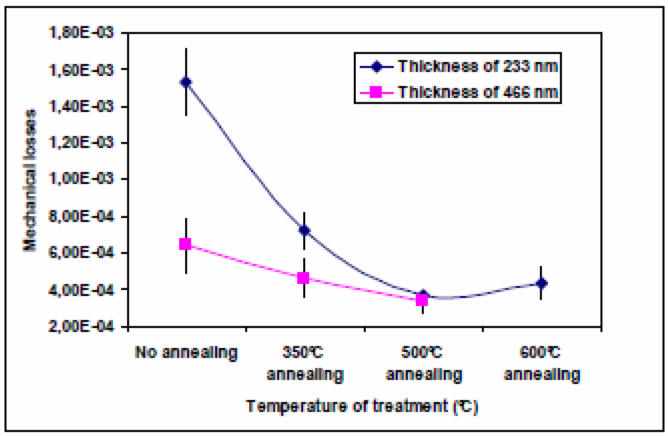

Fig.1: Mechanical losses in function of different annealing temperatures.
These results derive from mechanical studies made by LMA.

In particular, different experiments indicate that the mechanical losses are a bulk-effect in Ta_2O_5 layers, since they are independent on the number of interfaces.

The goal of the experiment was to study the structural modification of a Ta_2O_5 film after different annealing procedures, in order to find the best annealing receipt to be applied to the mirrors.

The experiment has been done in June 2011 at the BM23/ESRF beam line.

The samples were Ta_2O_5 films (thickness 2µm) deposited (Ion Beam Sputtering technique) on an amorphous SiO_2 substrate (200 µm). All the samples had been made during the same run of deposition. After the deposition the samples hadn't been annealed.

Standard was measured at Tantala L3 edge (Energy=9,9 keV)on transmission mod. The sample was aligned and due to the small jump and statistical noise, several scans had to be done. It was used the same reference for both measurements; the reference was another sample not annealed.

To anneal the sample in situ , we used an oven composed by a copper circular shield that was warm with 4 heaters ; the sample was bring in the centre of the oven by a Macor sample holder. Typically, the samples have been annealed at 450°C for 4 hours, with a rate of 10°/min.

Both a sample not annealed and one annealed were measured. In figures 2 and 3 the EXAFS raw data are reported.
The data were analyzed with the program ARTEMIS: the results don't show structural differences between the two samples.

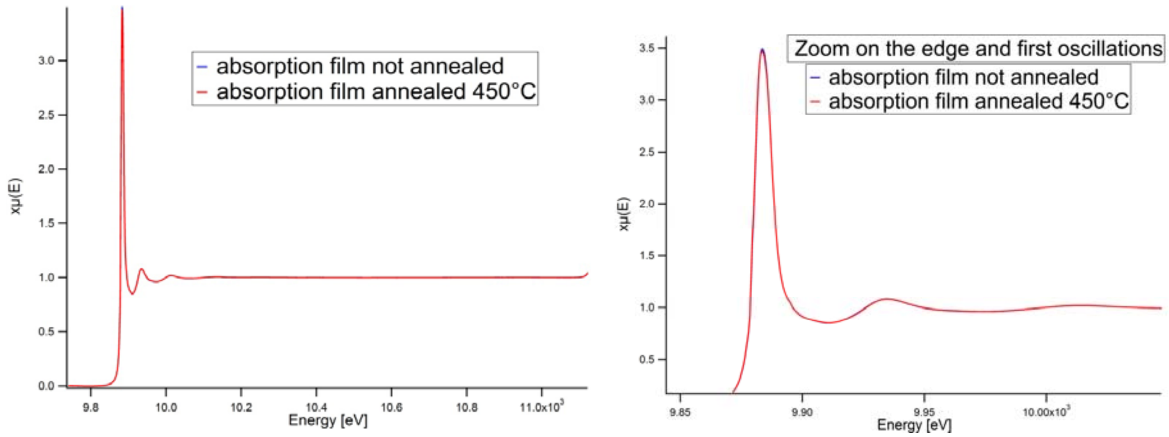

Fig.2: Absorption normalized of the two samples. They are indistinguishable. In the second figure, zoom on the edge and first oscillation.

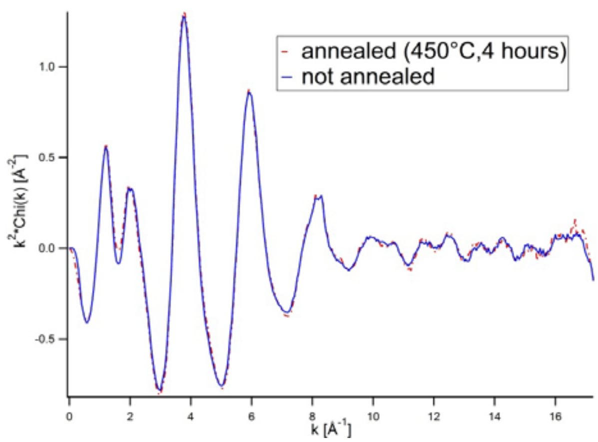

Fig.3: EXAFS spectra k^2*Chi(k)* as a function of the wave-number *k* for non-annealed and 450°C-annealed samples.

This result is in contrast with the theory and with other measurements that show differences between a not annealed sample and an annealed one. In next figure the Reduct Density Functions (RDF) of films annealed at different temperatures are showed. RDF is a Fourier Transform of the information gained from the intensity profile of a diffraction pattern and it gives statistical representation of the atomic sites respect to a central atom. These functions are obtained at the University of Glasgow with TEM electron diffraction measurements. This technique gives results quite similar to EXAFS, but at a lower resolution.

The RDF showed doesn't show different peaks positions, but different intensity: this should be linked with a different coordination number. Annealed samples seem to be more coordinated.

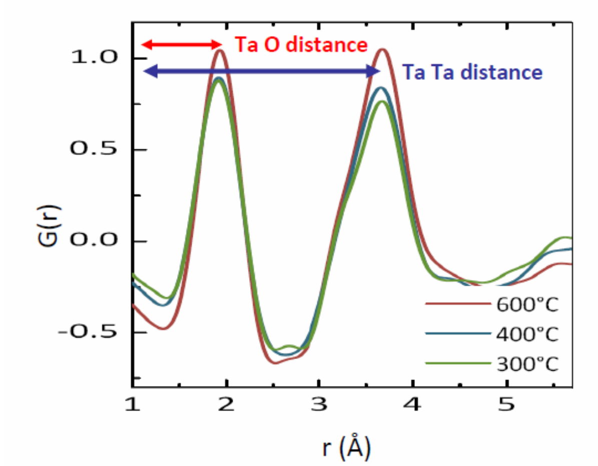

Fig.4: RDF for Ta_2O_5 films annealed at different temperatures.
It is visible that there are some differences.

Probably the annealing we made wasn't the right kind of treatment: a longer annealing or an annealing at different temperature can show the differences in the structure that are expected. Changes in the thermal treatment require new EXAFS measurements to observe the differences in the structure.