# Study and comparison of two polishing methods for platinum-iridium surfaces, by means of three characterization techniques

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Machining the surface of mass standards is still of great importance [1-5]. This presentation details a comparative study of the roughness of two plane surfaces of platinum iridium alloy (90% of platinum and 10% of iridium).We carried out a comparative study of roughness, related to the two sides of a platinum-iridium disc, provided by the BIPM. These surfaces were polished according to two different techniques. Both were machined by means of a lathe using diamond tool. One of these surfaces was afterward treated by a manual polishing using diamond paste. Three characterization instruments were chosen to measure surface roughness: Scanning Near field Optical Microscope (SNOM) with shear force regulation, optical roughnessmeter and X-ray Reflectometer [6-13]. The two latter are based on angle resolved scattering (ARS) theory. The choice of these devices is mainly based on their non destructive character and their complementarities.

Most of statistical and physical parameters characterizing the surface quality (topographical images, auto-correlation functions, distribution of heights, *rms* roughness $\delta$ and power-spectral-densities) are determined by means of SNOM. Visible and X ray measurements, using angle resolved scattering theory, can only provide the *psd* and *rms* height $\delta$ . When comparison is made on topographical images or distribution heights, we can clearly observe the difference between the two surfaces as expected. Thus, we noted that the measured height distributions were in agreement with Gaussian model, only in the case of manually polished surface. However, when comparing roughness ($\delta$) of the two surfaces, we found that these seem to have the same surface state in spite of their different polishing: all results yielded to comparable values of $\delta$ (within uncertainties). This signifies that *rms* $\delta$ is a relative value which depends on several parameters and mainly on the spatial frequency bandwidth corresponding to measurements. This is clearly visible through the SNOM measurements, where the *rms* $\delta$ is determined in three spatial frequency bandwidths. The obtained values are different according to the considered bandwidth. Moreover, $\delta$ is slightly larger in the case of machined surface for low spatial frequencies.

Concerning the autocorrelation function, the undulations observed for the machined surface reveal at least three types of pseudo-periodic defects, with a spatial period of about 7 µm. For the manually polished surface, the successive steps blurred some of the observed undulations, as it appears on the autocorrelation function. The latter presents only one weak peak of positive correlation around 15 µm. This might be correlated to the average spacing between holes observed on the topographic image.

A complete characterization of surface is carried out by comparing the power-spectral-densities. Those provide a complementary explanation according to whether one compares both surfaces on the basis of their topographic images or their roughness. Indeed, by comparing their power spectral densities, one notices that surfaces have a roughness of the same order of magnitude (on a large range of spatial frequencies); however the defects which contribute in a preponderant manner to roughness spectrum do not belong to the same spatial bandwidth, according to the polishing process. These differences are observed on all power spectral densities, i.e. for the three instruments, whose measurements had shown a great agreement, in spite of their differences of technical characteristics: vertical and lateral resolutions, accessible interval of spatial frequencies, sensitivity to local defects, area explored…). All measurements demonstrate that the additional polishing steps do not reduce (as expected) the roughness of surface which had been machined by means of diamond tool. For the machined surface as well as the polished one, *rms* roughness is of about 3 nm. However, the polishing procedure leads to some variations on the roughness spectrum according to the spatial frequency domain (lower or higher than 0.8 $\mu m^{-1}$). Thus, polishing reduces the asperity amplitude of about 20% for frequencies below 0.8 $\mu m^{-1}$, but at the same time, it contributes to increase roughness up to 41% for frequencies higher than 0.8 $\mu m^{-1}$[14].

The topographical images corresponding to the machined surface with diamond tool and the manual polished surface reveal an important difference on the morphology, although all results yielded to comparable values of roughness in the large range of spatial frequencies. It will be of interest to analyse the surface local contamination as function of surface morphology.

The mass variations depend on the environment conditions and mainly of surface contaminants, it is important to control the surface quality: to avoid as possible holes and scratches. Thus, it is suitable to gradually decrease the grain size as well as the pressure exerted on surface to polish, until obtaining the best conditions, appropriate to an alloy such as platinum-iridium.

The optical near field microscope with shear force regulation has the advantage to provide simultaneously two images: the first is the topographical image of the surface as shown in this paper, the second is the optical near field image of the surface. The optical near field images contain complementary information on the surface compared to the topographic images. They depend: on the illumination parameters, the nature, the shape of the probe tip and also of the local surface homogeneities. The optical measurements are in progress and full theoretical analyses have to be improved.

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