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THE FIRST STAGE OF DEVELOPING NEW TRANSFER STANDARD IN MASS METROLOGY

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Abstract: The necessity of making a new transfer standard was proposed to disseminate of mass scale during or after establishing new definition of kilogram unit. It is worthy to find new material or perfect surface characterization of mass transfer standard. It should be confirmed whether a material is suitable to use as a standard after much chemical or mechanical analysis of its surface. In this presentation, we would like to present the first plan for development project of new transfer standard materials.

Keywords: Mass Standards, Redefinition, Surface Analysis

1. INTRODUCTION

Within the work of redefinition researches like the watt balance and Avogadro experiments to link the unit of mass to a fundamental constant rather than an artefact, it is necessary to ensure a direct link between the primary realisations and the reference mass standards that ensure the dissemination of the mass. It is important to construct the knowledge of behaviour in terms of mass stability of materials from which mass standards in order to ensure the stability of dissemination for 1 to 10 years of the new definition and to realize its dissemination with the lowest uncertainties. There are two essential objectives of this research: providing traceability from the current definition with the International Prototype of Kilogram (IPK) to the primary realisations in order to fix the natural constants (Avogadro and/or Planck) reliably and with the required uncertainty, and maintaining the new definition of the unit, in a short/medium term, to the dissemination scale.

From many researches in mass metrology or related fields, some physical conditions were proposed to have the stability of mass transfer standards for the redefinition works: high hardness (Hv > 200), low magnetic permeability (< 0.000 1), ease of machining, and smooth surface finish (Rz < 0.01 µm) in order to optimize their surface behaviour, as well as their mass stability during two different environment (for example, air-vacuum-inert gas) transfer and storage of mass standards [1].

In this Presentation, we would like to explain the preparation status of developing of new mass standards in very first stage in type of small samples. The aim of this work is to choose some material and evaluate the properties to assess their suitability for use as mass standards to disseminate the unit of mass from the new primary realisations. The materials will be evaluated for the properties required when used in the primary realisation experiments and as primary standards for the dissemination of the redefined unit of mass. The density, hardness, and magnetic permeability of the materials will determine which are the most suitable.

2. PREPARING SAMPLES

Several materials were considered the candidates such as stainless steel (SS), titanium (Ti), molybdenum (Mo) and tungsten (W). Table 1 shows the summary of physical property of the candidates [2]. The titanium, molybdenum and tungsten are in the form of single crystal to get a well-defined surface.

Table 1. Summary of physical property of selected materials. The magnetic susceptibility of SS indicated mass susceptibility of OIML class E_1 [3].

	SS	Ti	W	Mo
Density ($g \cdot cm^{-3}$)	7.8-8.1	4.506	19.25	10.28
Mohs hardness	5.5-6.3	6	7.5	5.5
Molar magnetic susceptibility (10^{-6} cm^3 mol^{-1})	0.02*	141	53	72

Because of stainless steel's inexpensive price and popular material in mass metrology as well as other industries, especially, we have considered the modification of surface with ion implantation, ultimate surface finishing, or surface coating with nano-material showing high hardness. For the purpose of these works, we have prepared E_1 weight samples (ϕ10×1 mm, ϕ15×3 mm) of cylindrical shape from a commercial company. Fig. 1 show the result of ultra-finishing of SS samples after several processes like mechanical polishing with alumina and electrochemical buffing, and the roughness analysis of the sample.

One coating was tried on the surface of SS. It has been well known that ultra nano-crystalline diamond (UNCD) shows the fulfilled the conditions mentioned in the

Introduction. Figure 2 shows the trial coating of UNCD on the surface of SS and Si. The adhesion of UNCD on SS is a little bit poor under the condition of 800 W (power) and 570 °C (sample temperature). It needs to do more study of wettability.

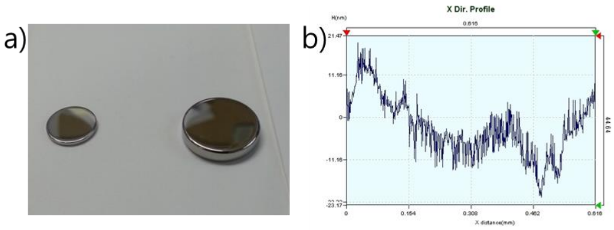

Fig. 1 Typical example of stainless steel (SS). a) ultra-finished SS and b) result of roughness.

We are also designing a chamber to clean the sample with dilute plasma in the type of inductively coupled. Current (mechanical) cleaning techniques such as nettoyage-lavage (known as a BIPM method) and solvent cleaning does not offer the level of repeatability required (less than 5 µg) and new (non-contact) techniques using UV activated O_3 and/or plasma must be optimised and evaluated to provide the level of repeatability required [4].

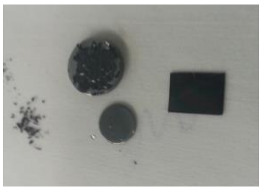

Fig. 2 Trial coating of ultra nano-crystal diamond on SS (circular) and Si (rectangular sample).

Figure 2 shows the schematic diagram of dilute plasma equipment. Several components have already constructed or bought for assembly. The control of process will be done an automatic way by using pneumatic valves. Some gases like H_2 or O_2 can be used in this chamber in cleaning. After completing this construction, the optimized parameter should be traced to get the dilute condition during non-damaged process to the surface of samples by many trials

3. SURFACE ANALYSIS

The stability of mass samples can be monitored by a commercial comparator for a long time. Beside this, the microstructure and chemical property on material surface will also be examined by using a surface sensitive instrument like x-ray photoemission, and atomic force microscopy as this will affect properties such as hardness, ease of machining and mass stability. We have considered the ex-situ way for analysis though in-situ setup is more ideal method.

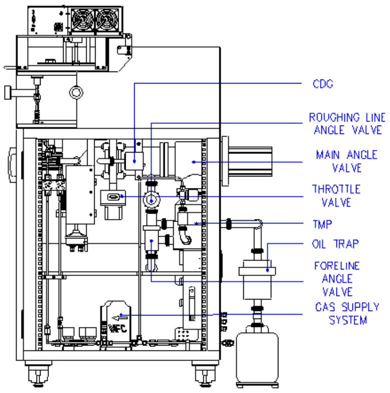

Fig. 2 Schematic diagram for dilute plasma chamber.

4. DISCUSSION

The small sample is enough to be used for investigation of surface property in this first stage of development. However, it will be other challengeable work to make the real standard (for example, 1 kg) because the uniformity over all surfaces should be considered.

5. REFERENCES

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