






## Article

# Comparison of Chemical and Mechanical Surface Treatments on Metallic Precision Spheres for Using as Optical Reference Artifacts

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**Abstract:** The improvement of industrial manufacturing processes requires measurement procedures and part inspection tasks to be faster and faster while remaining effective. In this sense, the capabilities of noncontact measuring systems are of great help, not only because of the great amount of data they provide but also for the ease of the integration of these systems as well as their automation, minimising the impact on the industry. This work presents a comparative study on the influence of two surface treatments performed on low-cost, high-precision metallic spheres on the suitability of these spheres to be used as artefacts for the calibration of optical sensors, specifically laser triangulation sensors. The first surface treatment is sandblasting (a mechanical process), whose effect has been studied and presented in previous work. The second treatment focused on in this paper is acid etching (a chemical process). The comparison has been performed by evaluating the same metrological characteristics on two identical groups of spheres of similar type (diameter and accuracy), each of which was subjected to a different treatment. It was necessary to obtain the reference values of the metrological parameters with high accuracy, which involved measuring the spheres with a coordinate measuring machine (CMM) by contact probing. Likewise, spheres were scanned by a laser triangulation sensor mounted on the same CMM. The results derived from both the contact and laser measurements and before and after treating the surfaces were used to compare four parameters: point density, sphere diameter, sphere form deviation, and standard deviation of the best-fit sphere to the corresponding point cloud. This research has revealed that acid etching produces better optical qualities on the surfaces than the mirror-like original ones, thus enhancing the laser sensor capturing ability. However, such chemical etching has affected the metrological characteristics of the spheres to a greater extent than that produced by sandblasting. This difference is due to the variability of the chemical etching, caused by the high aggressiveness of the acid, which makes the process very sensitive to the time of exposure to the acid and the orientations of the spheres in the bath.

**Keywords:** laser scanning; reference spheres; chemical attack (etching); sandblasting



**Citation:** Meana, V.; Cuesta, E.; Álvarez, B.J.; Giganto, S.; Martínez-Pellitero, S. Comparison of Chemical and Mechanical Surface Treatments on Metallic Precision Spheres for Using as Optical Reference Artifacts. *Materials* **2022**, *15*, 3741. <https://doi.org/10.3390/ma15113741>

Academic Editors: Guijian Xiao, Yun Huang, Kun Zhou and Yi He

Received: 6 May 2022

Accepted: 21 May 2022

Published: 24 May 2022

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## 1. Introduction

Noncontact metrology plays an important role in many industrial processes, not only in the field of part inspection but also in the application of reverse engineering, particularly in areas such as the automotive or aerospace. Among the four types of methods that have been developed in the noncontact metrology (optical, ultrasonic, pneumatic, and electrical), the first two have continuously evolved in accuracy and resolution (mainly profilometers and laser triangulation sensors) and are nowadays extremely popular, either in automated inter-process inspection [1], or in-process [2].

In this sense, it is essential to find solutions that minimise the impact on the industry of the introduction of noncontact verification methods with the aim of providing traceability