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# Silvery-Like Ceramics in the National Archaeological Museum of Florence:

## Virtual Technologies in Analysis and Restoration

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**Abstract:** The National Archaeological Museum of Florence has in storage a batch of about 70 silvery-like ceramic vessels of Etruscan production (late fourth – early second century B.C).
Silvery-like vessels were a production decorated in relief and coated with a white-grey film to reproduce the effect of a silver surface. This factory was intended for funerary matters and for a low cost imitation of toreutics. Damaged by the Florence flood of 1966 and by old restorations, this Florentine collection has never been studied and shown to the public. In this ambit, Dr. Dionisio is developing a PhD project at the University of Florence with the purpose to study, preserve and restore this collection through diagnostic analysis and modern restoration techniques. Within this project, the collaboration with DREAMSLab (Distributed Research Environment for Advanced Modeling and Simulation Laboratory) at the Scuola Normale Superiore of Pisa is particularly interesting. Thanks to the support of Dr. Licari, the silvery-like ceramics collection of the Florence Archaeological collection will be enhanced and presented to the public for the first time exploiting the state-of-the-art of digital technology. The applied techniques will allow a direct visualization both of the first diagnostic tests applied to the artifacts and of the reconstruction of the complete surface coating using 3D technologies and virtual reality application. The virtual restoration and 3D print technology are very useful application in the planning of a subsequent restoration project. We would like to reconstruct virtually the entire silvery-like ceramics collection at the National Archaeological Museum of Florence and print it through a 3D printer. The printed models will be used and enriched by an augmented reality application that integrates tactile sensations to levels of virtual information. This contribution aims to outline the advantages obtained by the application of virtual techniques to this archaeological research.

**Keywords:** archaeology, ceramic, Etruscan, virtual technologies, virtual reconstruction

### The National Archaeological Museum of Florence

From 1880 the National Archaeological Museum of Florence is located in the palace called “della Crocetta”, a residence built for the sister of the Grand Duke Cosimo II de’ Medici.

Since then, thanks to the numerous excavations, purchases and donations by individuals and scientific institutions, the museum has been enriched with many collections of Egyptian, Etruscan, Greek and Roman art. The activity of the Egyptologist Ernesto Schiaparelli, who supervised the preparation and exposure of the Egyptian section and of Luigi Milani, director of the museum from 1884 until 1914, was of particular relevance.

Fig. 1 – The front of the National Archaeological Museum and the garden

Currently, over a hundred thousand items of extraordinary value are stored in the warehouses of the Museum. Because of the lack of an adequate exhibition space and the poor state of preservation of many of them, due to the 1966 Florence flooding, these artifacts are exposed only during temporary exhibitions.

Fig. 2 – The warehouses and the flooded Museum in 1966 (Copyright: archeotoscana.wordpress.com)

## The Etruscan Silvery-like Ceramic Collection

The collection of Etruscan silvery-like ceramics is part of the objects stored in the warehouses of the Museum. Through many purchases, this lot has reached the museum between the end of XIXnt and the beginning of XXth century. This ceramic production dates back between the end of IV and the II century B.C. and was intended for the aristocratic class funerals. Vessels are decorated in relief and coated with a gray-white film to reproduce the chromatic effect of a silver-plated surface and were meant to imitate precious metals. The ceramic forms mainly include symposium and banquet vessels as craters, amphorae, oinochoai, situlas, patere and colanders.


Fig. 3 – An amphora,two oinochoe and a situla in silvery-like ceramic

The National Archaeological Museum of Florence has about seventy silvery-like ceramics from different areas of the Etruscan civilization: the Volsinian area, Volterra and the Faliscan area (northern Latium). With the exception of some findings, kept in better condition and currently displayed on the second floor of the Museum, this silvery-like collection has never been exposed to the public for the poor state of preservation of most of the artifacts. Many of them are characterized by old restorations made in the first years of the twentieth century with unsuitable materials which have compromised their preservation over the time.

Fig. 4 – Old restorations details on the rim and on the food of a kantharos

## Science and Technology for the Archaeology and Restoration

For the beauty and value of this collection, in view of their proper and deserved exhibition, a plan of study that has never been carried out has developed. The project is aimed at:

- reconstructing the historical provenance of the collection carrying out a specific archive research about the place and date of the excavations, the first location of the artifacts and the acquisition to the museum collection;
- performing diagnostic analyses to characterize the ceramic body and its silvery-like coating, to determine the types of raw-materials used and the production technology
- performing diagnostic analyses to identify the degradation products and successively plan an appropriate restoration technique;

- restoring the collection of Etruscan silvery-like ceramics for a future exhibition, removing the old and not appropriate restorations using innovative technologies and reversible materials.

**First Diagnostic Analysis**

First diagnostic tests have focused on the composition of the silvery-like coating to mainly determine the raw-materials used and, if possible, the coating application method on the ceramic surface. Unfortunately, it is still debated today, among scholars, whether this coating has to be attributed to the application of a leaf or to a mixture of a main element and other materials.

*Scanning Electron Microscope (SEM)*

Scanning Electron Microscope allows the visualization and characterization of inorganic materials and displays the morphology of the sample at a high magnification. SEM analyzes have been applied to eight selected silvery-like samples from the Volsinian area. We report, as an example, the data carried out on a fragment of glass, maybe relevant to a kernos (inv. 76552_F2).

Analyzes were performed with the instrument of MEMA (Interdepartmental Centre of Electron Microscopy and Microanalysis- University of Florence).

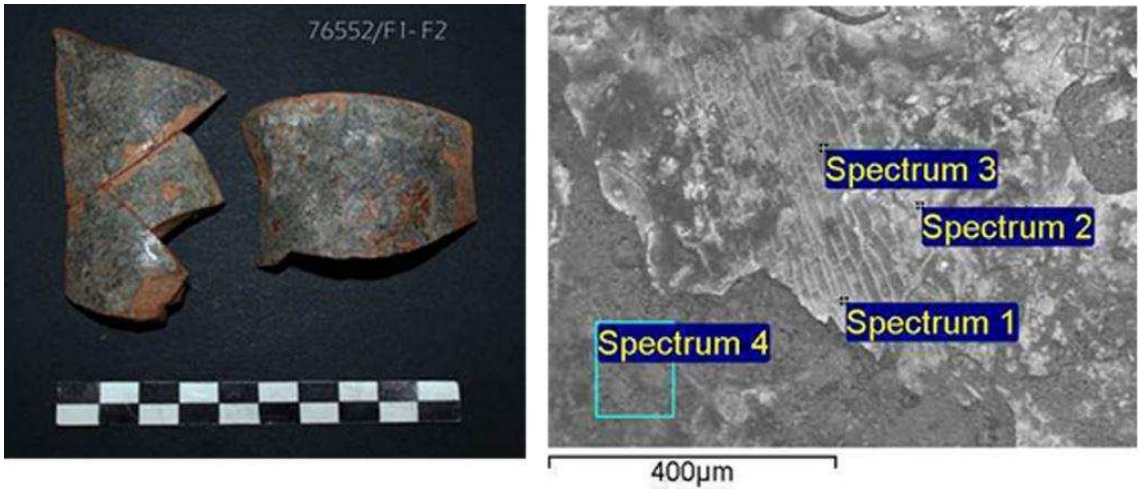


Fig. 5 – The sample 76552_F2 and a SEM view of its silvery-like coating

Spectra show that the coating is mainly composed of tin oxide:

Spectrum 1: $SnO_2$, CaO, $SiO_2$,$Al_2O_3$,$SO_3$

Spectrum 2: $SnO_2$, $SiO_2$

Spectrum 3: $SnO_2$, FeO, CaO, $SiO_2$, $Al_2O_3$, $Na_2O$

Spectrum 4: FeO, CaO, $K_2O$, $SiO_2$, $Al_2O_3$,$SO_3$, MgO, $Na_2O$

In addition, other chemical elements were identified in smaller proportions as silica, iron, calcium and aluminum oxides and some small percentages of sodium and magnesium oxides.

In all the samples analyzed the coating is found to be composed mainly of tin oxide, in agreement with data reported in the few sporadic bibliographic sources available for this topic (DE CHIARA 1960; COTTIER, ET AL. 1997; MICHETTI 2003).

*X-ray Microtomography*

This scientific diagnostic technique allows to obtain three-dimensional images of the internal structure of the artefacts with a micrometer resolution. The same sample reported for the SEM, inv. 76552_F2, was therefore analyzed with the instrument of CRIST (Center of Structural Cristallography- University of Florence) to obtain a three-dimensional image of the structure and texture of silvery-like coating.

The reconstructed three-dimensional image allowed – preliminarily – to separate the silvery-like coating from the ceramic body and show an almost homogeneous surface texture resulting from elements with different densities.

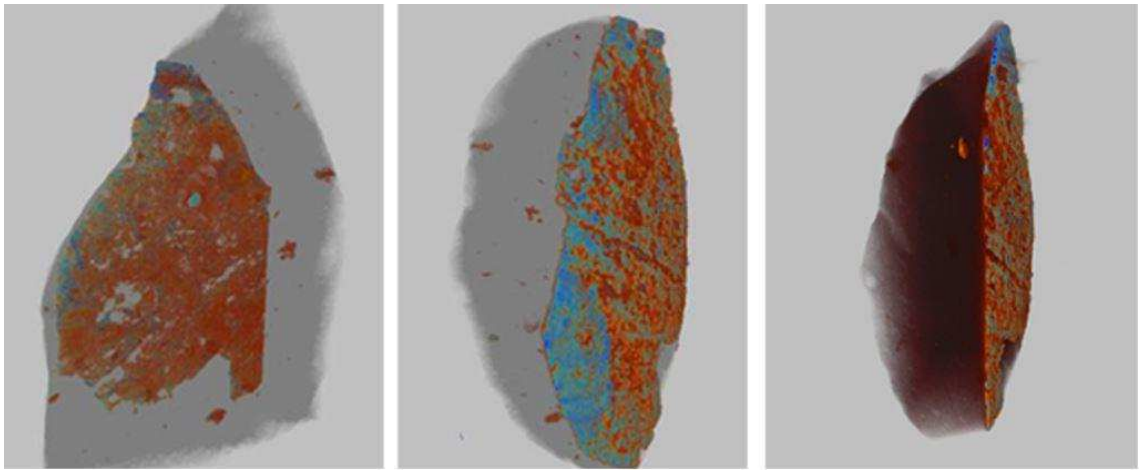

Fig. 6 – Three dimensional images of the silvery-like coating of the sample 76552 _F2 (h. 16 mm)

Analyzes currently underway will attempt to clarify these data and determine the coating application method.

**The Help of Virtual Technology**

As regard the restoration planning of this project, it should be noted that it is not always possible, or -advisable, to perform a traditional type restoration which involves immediately a direct contact with the object to be restored. The virtual technologies have been of great help in the archaeological restoration. Through a reality simulation, they have allowed to reconstruct fragmentary objects and perform the coating reconstruction without directly interacting with the ceramics, hence helping the planning of a subsequent and appropriate real restoration project.

The collaboration with the DREAMSLab (Distributed Research Environment for Advanced Modeling and Simulation Laboratory) created by the Scuola Normale Superiore of Pisa has allowed to create the virtual reconstructions of two Etruscan silvery-like ceramics that did not permit, for their preservation state, a traditional restoration method.


Fig. 7 – The askos and two vision of the oinochoe selected from the volsinian area

The artifacts were selected from the volsinian area: in the first case, the reconstruction of the silvery-like coating of an askos with plastic handle was carried out. This vessel was chosen because its original coating keeps very well; however, the reconstruction of the original appearance of this artifact would not have been possible without the help of virtual techniques.
In the second case, a virtual restoration of a fragmentary oinochoe, of which we preserve only the upper part, was made. Virtual restoration has allowed to bring the object to its original condition without directly interacting with it and avoiding, for the moment, to act with a traditional restoration which would lead to a widely invasive reconstruction. However, if we decide later to act on this object with a traditional restoration, this virtual reconstruction will be crucial because it will allow to understand how to reconstruct the missing parts.
The technical details of the procedure will now be described.

## Virtual Technologies in Analysis and Restoration of two Silvery-like ceramics

Firstly, the process of creating a complete virtual replica and real one of the Oinochoe with a trefoil mouth of the National Archaeological Museum of Florence will be shown.

Fig. 8 – The different phases of the creation a virtual replica and real one of the Oinochoe with a trefoil mouth of the National Archaeological Museum of Florence

The Oinochoe is part of the Etruscan Silvery-like collection, which has never been studied and shown to the public.
Due to its fragmentary state of preservation and its fragile material, and the need for as complete as possible a restoration, and due to the limitation of the traditional restoration methods, a different approach was needed, relying on the 3D technologies.
We would like, in the future, to enhance and present to the public the complete silvery-like Etruscan ceramics collection never shown before relying on state-of-the-art of digital technology.

**Virtual Restoration**

The virtual restoration of the Oinochoe with trefoil mouth was performed based on the analysis of the geometry of its fragment, the typological constraints, the comparison with similar artifacts of the same type and creating a texture taking colors from the best-preserved parts.

*Acquisition phase*

Considering the size, the material, the shape, the color and the surface of the object, the Oinochoe is well suited to be acquired with a NextEngine 3D scanner.
The instrument is equipped with a rotary table which is used in the acquisition of small size objects.
This scanner has a "360 degrees" option which allows acquiring the object from every angle, with the help of the rotating platform.
In order to assure the complete coverage of its entire surface, two “360 degrees” scans were performed, one with the fragment positioned horizontally and the other one with the fragment positioned vertically.
At that point, we had two meshes (one vertical and one horizontal of the fragment) which had to be cleaned, aligned and merged. In order to achieve this, we used ScanStudio HD Pro (ATHANASIOU, ET AL 2013).
ScanStudio HD is proprietary software of NextEngine which allows defining all the scan parameters, aligning multiple scans and post-processing aligned scans data.
To align two meshes was needed to place three pin on a common location between two scans.
After that, we used the “Fuse” function to generate a single surface by making an average between all the scans in order to obtain a unique surface.
NextEngine also acquires the texture of an object that is overlapped automatically on the models, but the result is a low quality because the embedded CMOS image sensor has a low resolution.
In that case, the best solution for a high and precise resolution image was that one to proceed with an external camera to acquire the texture of the Oinochoe.
For this reason, we used a DSLR (Digital Single-Lens Reflex) camera with bulbs with natural day-light balanced color temperature of 5500 K and the texturing activities were carried out with the open source software MeshLab.
MeshLab allows projecting the color information of a set of registered rasters on a 3D model. The color can be stored in the vertices or directly on the texture (CALLIERI, ET AL 2008).

The procedure of the registration of an image on the 3D model is applied using the "Project Rasters on Mesh" function in MeshLab. After that the acquisition stage has been completed, we obtained a faithful digital reproduction of the Oinochoe and we were ready to start the reconstruction phase.

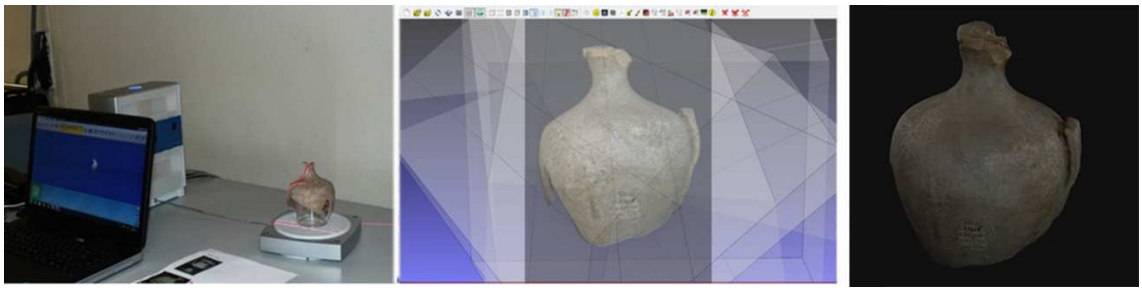

Fig. 9 – A faithful digital reproduction of the Oinochoe was reproducted using NextEngine 3D Scanner and MeshLab software

*3D Modelling*

The virtual reconstruction started with the base of the vessel and continued upward. The OS Blender software was used for the 3D modeling (HERMON, ET AL 2013). We reconstructed the whole lower part extruding circularly through the spin tool of Blender of the half outline of the lower part of the similar image. The images of similar artifacts were used as guidelines for 3d modeling of the missing parts.
The outline of those images were traced and extruded in Blender.
We reconstructed the whole lower part extruding circularly, through the spin tool of Blender, the half outline of the lower part of the guideline image. In the reconstruction of handle we have made two grooves in order to reconstruct the correct geometry of the original one. Finally, the smoothing filter was applied in the whole geometry.

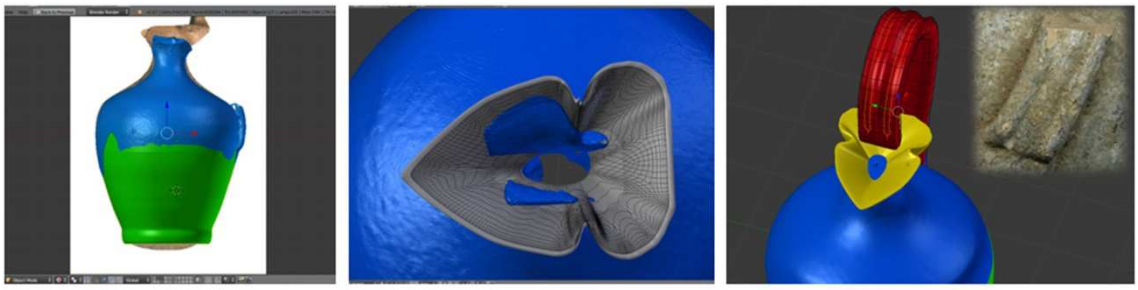

Fig. 10 – The virtual reconstruction phases

*Silvery-Like Coating*

Once the geometry of the Oinochoe was restored we started to reconstruct its silvery-like coating. The Photoshop software was used for creating the texture taking colors from the best-preserved parts. After that the texture was put in whole geometry.

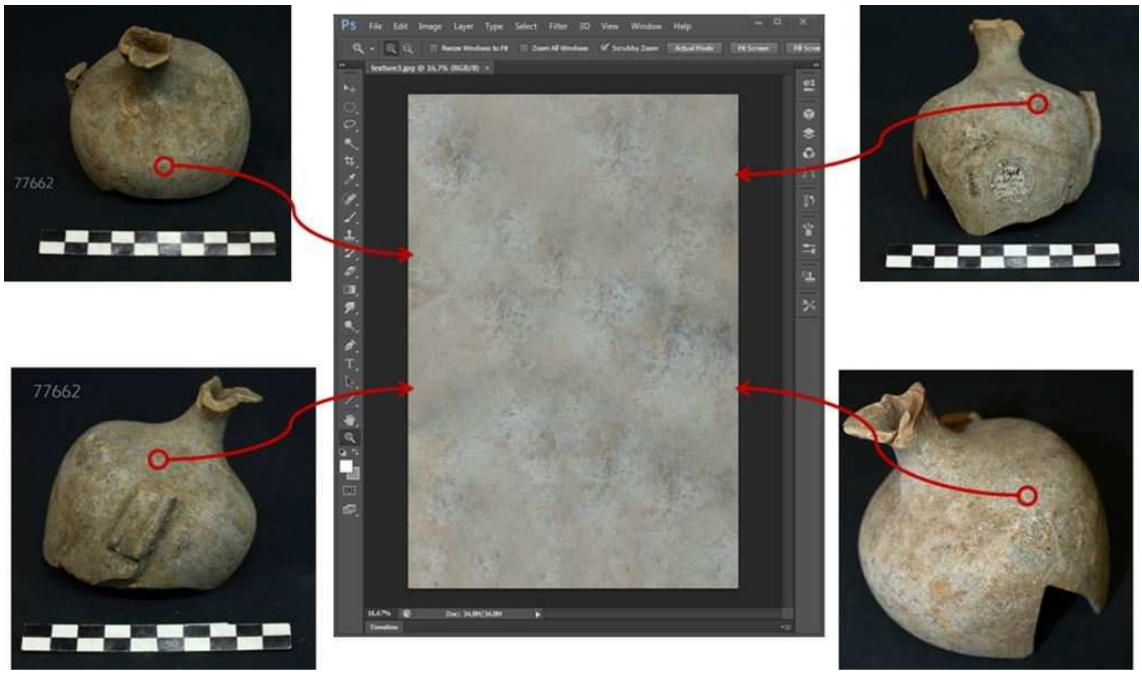


Fig. 11 – Silvery-Like Coating was created taking colors from best-preserved parts of Oinochoe

To increase the realism of the material, we have created a material with a gradient in such a way to simulate the color of the diffuse reflection. Finally, to recreate the porosity of the ceramic we have used the bump mapping. This is used to fake surface imperfections or to create reliefs.

The final result is shown in fig. 12.

The texture created for the silvery-like Etruscan ceramics can be applied to any pots of the same type in order to obtain a realistic color.

Fig. 12 – The final results of virtual restoration

**Virtual Applications**

We have realized a video which contains the all phases of the virtual reconstruction and the final result with the silvery-like coating. The video was also created in Stereoscopic side-by-side mode for 3D TV using an add-on in Blender (SCHNEIDER 2013).

We have printed the model in its entirety through our HP Designjet Color 3D printer in order to recreate a real replica of the ancient Oinochoe. The tactile copy can be used with people who are blind or whose vision is impaired, or with valuable assistance in planning a restoration by experts.

Fig. 13 – Printed 3D model of Oinochoe

The printed model was used and enriched by an augmented reality application on mixed-reality Dreamoc XL. The floating holographic video of the virtual restoration and the printed 3D model of the Oinochoe can be displayed simultaneously and comparatively in the same context.

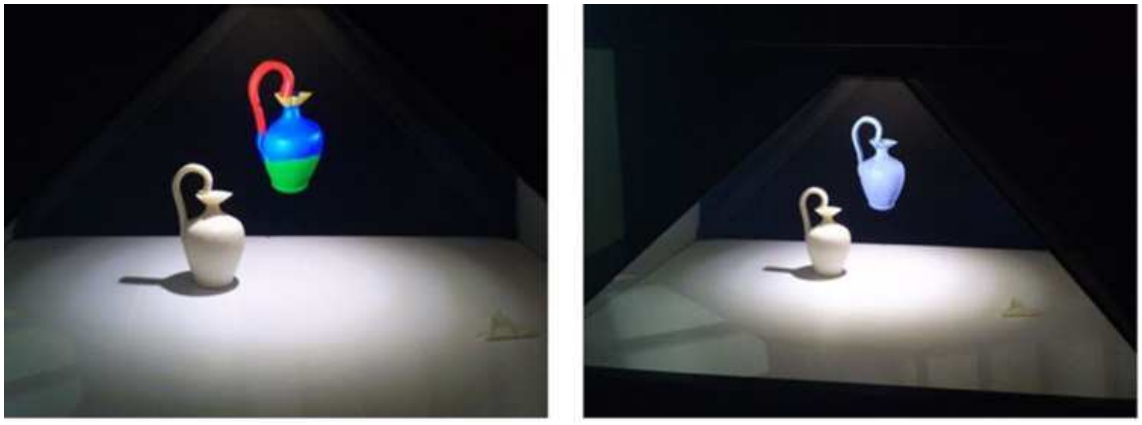

Fig. 14 – Augmented Reality on Holographic display case

**Digital Data and Digital libraries**

At this point the problem arose where to store the large amount of heterogeneous data generated during the virtual restoration (3D models, textures, chemical analysis, images, videos and documents).

The digital data can create conflicts in terms of preservation and long term access, it becomes necessary to ensure continued access to digital information for as long as necessary.
We have stored the digital data about silvery-like ceramics in Florence into SIAS system (BARONE, LICARI, NARDINI 2012) to improve the sharing, preservation and dissemination of these artworks.
SIAS focuses on the production and the use of scientific and humanistic contents. It is a new integrated platform dedicated to archiving, consultation, sharing, analysis and enrichment of digital content (both scientific and humanistic) related to cultural heritage, with particular regard to the cataloging of materials and pigments used in the artworks.
SIAS was extended for supporting 3d model and users can manipulate the preview 3D model with low resolution, download the high resolution model and add the information about the acquisition phase of the model, the preservation status of artwork and the scientific analysis.

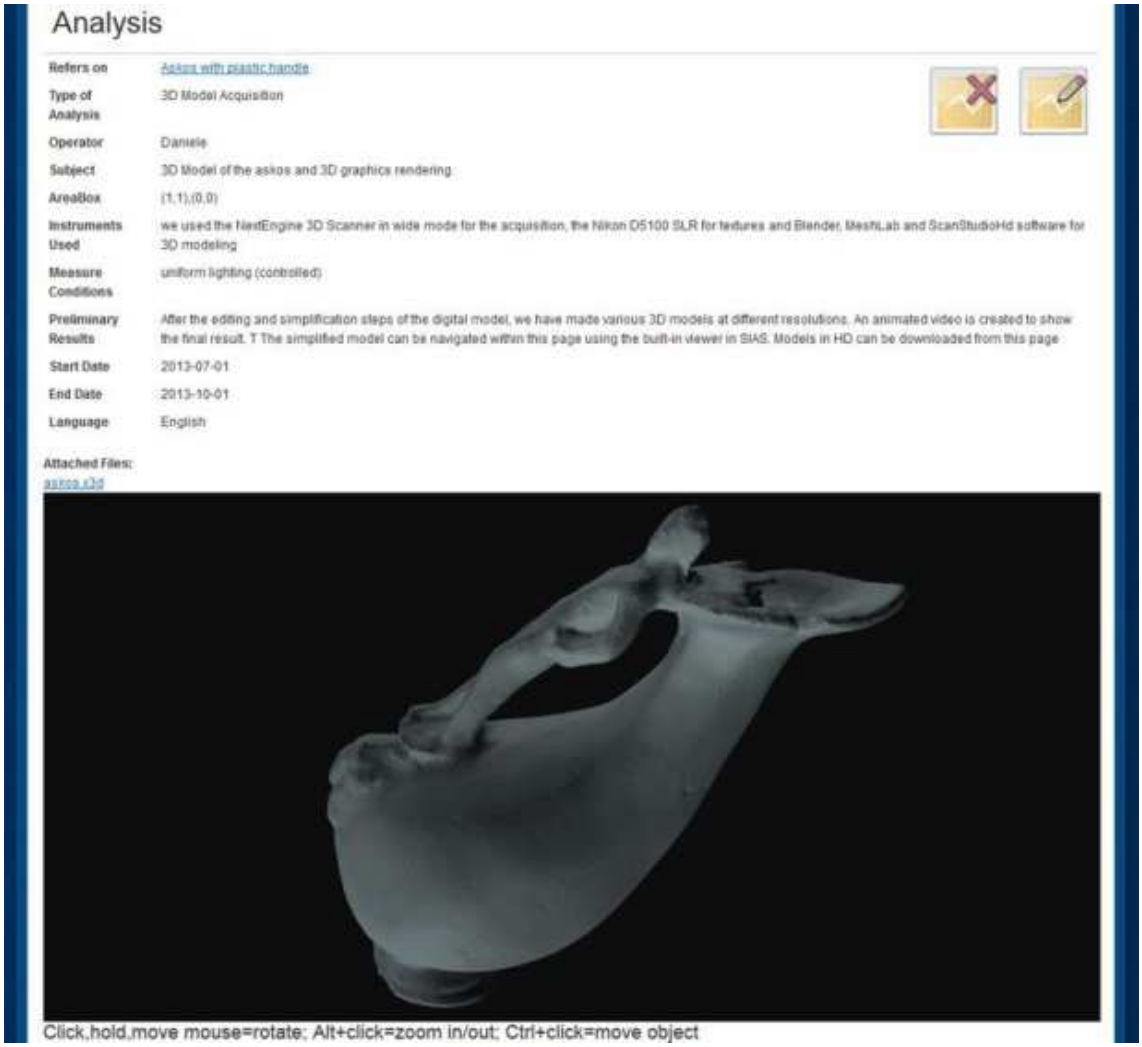


Fig. 15 – SIAS web page that contains silvery-like Askos of the National Archeological Museum of Florence

## Conclusion

Nanoscience and nanotechnology are the state of the art for cultural heritage conservation. New methodologies are been developed for cleaning and consolidation of artifacts, but is impossible a surface

reconstruction when there is a loss of original material and an alteration of the fragments' outline. In these cases, the only way to restore them to their original magnificent appearance and contextualization them is the use of 3D technologies and virtual reality applications.

This work aimed to outline the advantages obtained by the application of virtual techniques to this archaeological research. We used this technology to help to the reconstruction of highly damaged artifacts. We believe that the combination of science and archaeology is now increasingly necessary to understand, study and convey to the public the various aspects of ancient societies.

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