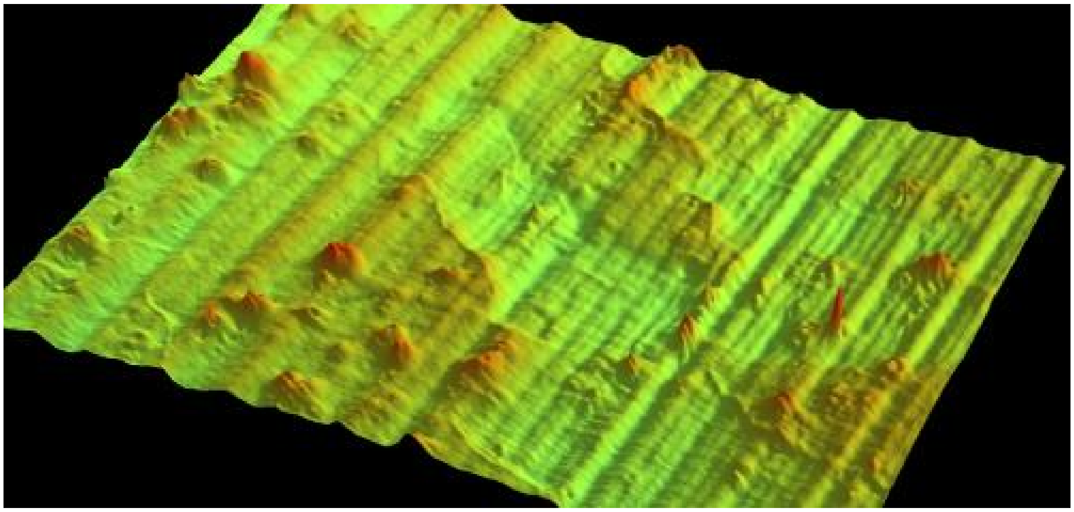
Interferometric microscope images the nano-world

December 5 2013



A microscopic-3D image of a small area of an 'off the shelf' gold coated mirror, produced through diamond-turning. The largest feature size is about 30 nm high and the average roughness of the surface is about 10 nm. For a commercial product this is a satisfactory result for ESA to utilise. The quality of this mirror surface was tested at ESA's optics laboratory to verify that its performance and quality was sufficient for use in a laser communications experiment. The vertical lines running from top to bottom along the surface are an expected characteristic of the process used to manufacture the mirror. This mirror was installed in ESA's optical ground station (OGS) on the Canary Islands (Spain) and successfully used in the recent test campaign with NASA to verify the performance of their new laser terminal on the Lunar Atmosphere and Dust Explorer (LADEE) spacecraft orbiting the moon. Credit: ESA

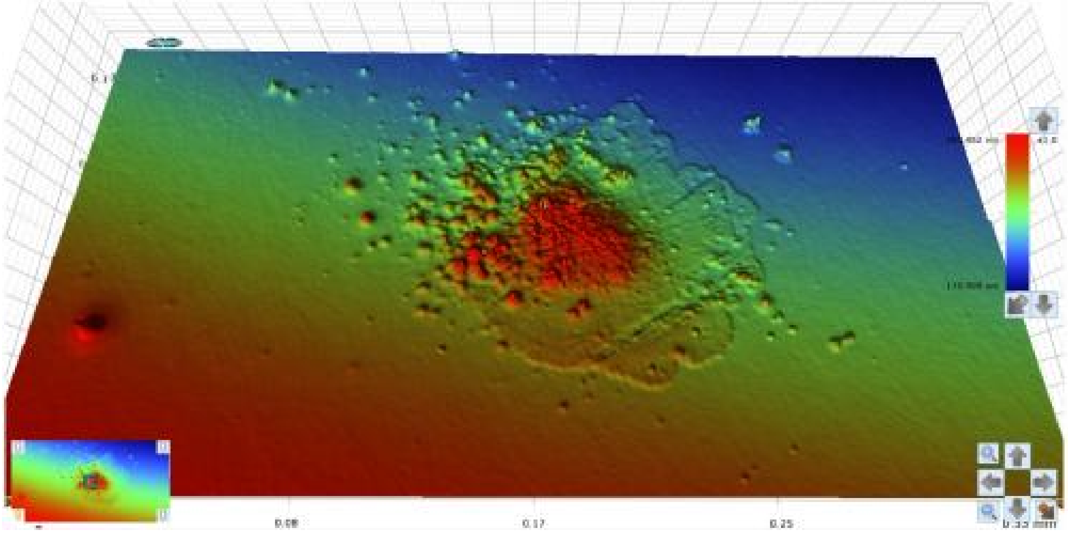
These images might resemble a planetary surface but actually show a different kind of alien environment: a microscopic view across a damaged laser lens, down to the nanometre level – a millionth of a millimetre, smaller than most individual bacteria.

ESA's optics laboratory uses a powerful technique to zoom in on tiny areas, mapping each one in a few seconds.

With the microscope resting on a cushion of air to isolate it from external vibration, white light is split into two beams: one shines on the target while the other illuminates a near-perfect mirror. The reflected beams are then recombined. In a kind of high-tech 'spot the difference', the slightest differences between the two beams are recorded to build up the equivalent of contour lines on a map, revealing deviations from the shape of the reference mirror.

More typically used by the commercial semiconductor industry, its inbuilt software can process results immediately across its small field of view – less than a square mm – or multiple images can be swiftly stitched together into a panorama.

The optics laboratory, one of a suite of technical laboratories at the Agency's ESTEC technical centre in Noordwijk, the Netherlands, uses this 'white-light interferometric microscope' to survey delicate optics for the slightest signs of damage after long series of laser bursts.

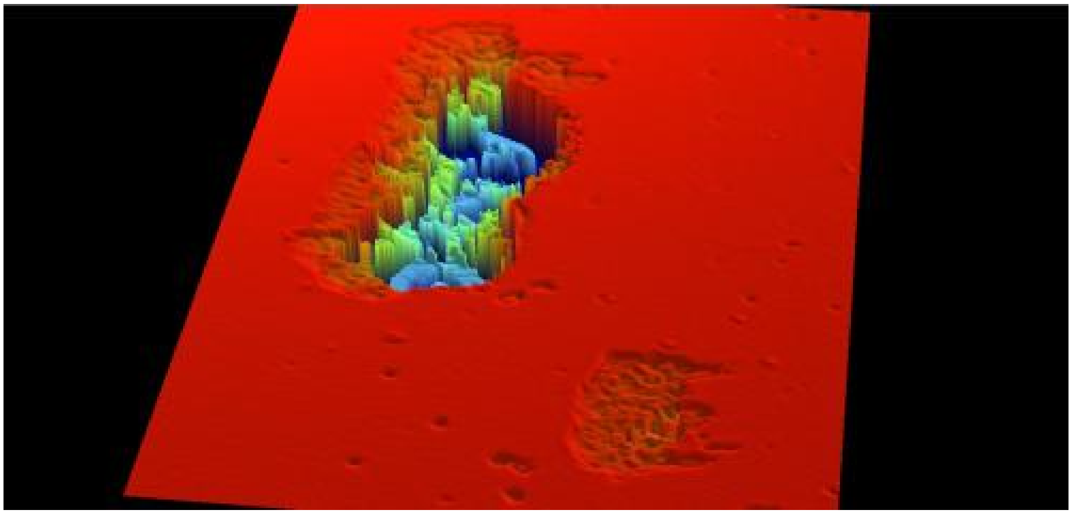


Laser-induced contamination of a mirror measured and visualised in 3D at the nanometre scale. The largest feature height is about 60 nm and the area of the contamination in the image is about 0.15 x 0.12 mm. This image shows suspected laser induced contamination on the coating of a mirror surface, resulting from high power testing under simulated space conditions. The test conditions reproduce those found within the Aladin ultraviolet laser to be flown on the ESA Aeolus mission. This unique satellite will use the lidar – light detection and ranging – technique to measure wind speeds in the lower atmosphere on a global scale for the first time. Credit: ESA

Lasers are versatile tools for space, useful for a variety of instruments such as radar-like 'lidars', which can sense a planet's atmosphere in 3D and accurately measure global wind speeds.

But continuous laser firings can melt and eventually crack optical components, or unwanted condensation from tiny amounts of residual gases can build up on optical surfaces. Both can seriously affect laser performance and life.

ESA is seeking to understand these effects and come up with ways to avoid or eliminate them, perhaps by reducing 'outgassing' emissions or assessing safe laser energy levels.



Laser induced damage to the coating of a precision beam-splitting mirror. This component is intended for use inside a high power laser system. The larger feature on the left is 0.14 mm long by 0.06 mm wide and about 5 microns deep. This is a good example of the type of damage to a coating that can occur due to repeated pulses from an high power laser beam interacting with the surface. In order to avoid this type of damage the optical coating quality, the surface cleanliness and the laser environment must be completely free from defects or contaminants of any kind. Defects within or on the coating surface at a submicroscopic level are not always possible to detect after coating manufacture. The only way to verify is to test under realistic conditions and determine if any damage occurs. Credit: ESA

A laser firing in space must be completely reliable over its entire mission lifetime – typically many years – because it cannot be repaired or serviced after launch. This can only be guaranteed by extensive testing on the ground.

This specialised microscope is sometimes combined with techniques from other ESTEC labs, such as the Atomic Force Microscope – which draws a nanometre-sharp stylus over surfaces to pick out the pattern of individual atoms – and the X-ray Photoelectron Spectrometer – which can identify the composition and structure of surface materials just a few nanometres deep.

Provided by European Space Agency

Citation: Interferometric microscope images the nano-world (2013, December 5) retrieved 25 April 2024 from
https://phys.org/news/2013-12-interferometric-microscope-images-nano-world.html