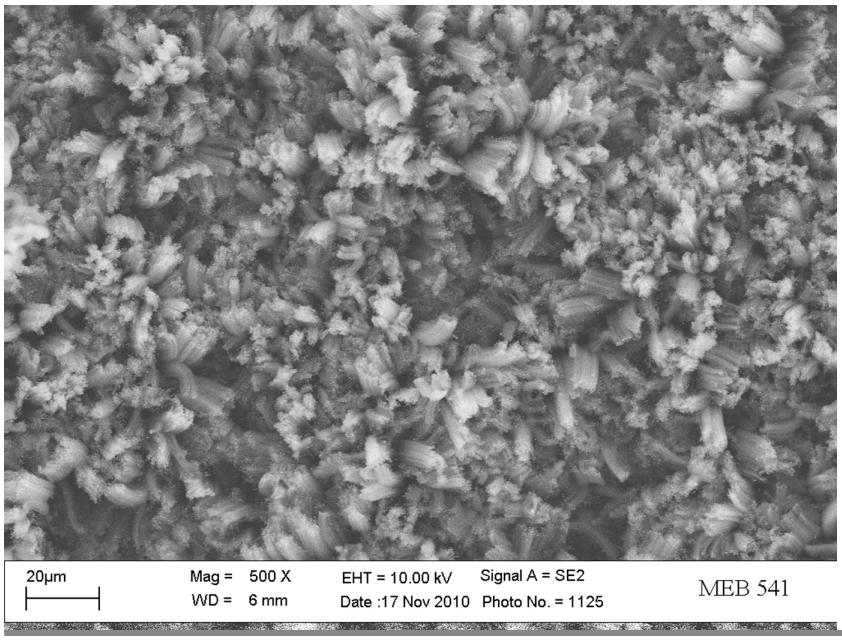


National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Materials and Coatings

Carbon Nanotubes on Titanium Substrates

An enhanced stray light control capability for scientific instruments

Stray light limits scientific observations by scattering light into the signal, degrading the signal to noise. In high contrast regimes this results in loss of data. In low light regimes it limits the ability to discern dim objects near bright ones. This problem is ubiquitous to scientific observations. Prior art materials such as NASA Z306 or other paints are commonly used, but often don't perform as well as expected. Limitations of the previous art were that the hemispherical reflectance (that over all angles) was on the order of 4% in the visible to Near Infrared.

The purpose of the innovation is provide an enhanced stray light control capability by making a "blacker" surface treatment for typical stray light control components.

BENEFITS

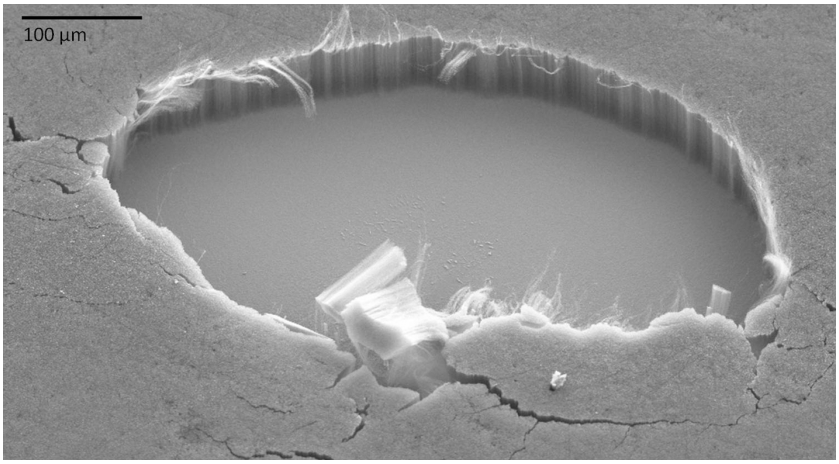
- Highly effective: The nanotubes of the present innovation are darker than current surface treatments over larger angles and a larger wavelength range; based on analyses that have been performed using state of the art modeling codes, a 10 fold improvement in absorption (over existing surface treatments) can result in a a factor of 10,000 improvement in stray light suppression due to the exponential nature of stray light
- Robust: Titanium substrate carbon nanotubes are more robust than those grown on silicon and allow for easier utilization

THE TECHNOLOGY

Carbon nanotubes previously grown on silicon have extremely low reflectance, making them a good candidate for stray light suppression. Silicon however is not a good structural material for stray light components such as tubes, stops and baffles. Titanium is a good structural material and can tolerate the 700 Centigrade nanotube growth process.

Innovators at NASA Goddard Space Flight center have developed the capability to grow carbon nanotubes on a titanium substrate that are up to 10 times blacker than the current NASA state of the art paints in the visible to Near Infrared. This innovation will allow significant improvement of stray light performance in scientific instruments or any other optical system. Since baffles, stops and tubes used in scientific observations often undergo loads such as vibration, it was critical to develop this surface treatment on structural materials.

The nanotech-based coating is a thin layer of multi-walled carbon nanotubes, tiny hollow tubes made of pure carbon about 10,000 times thinner than a strand of human hair. They are positioned vertically on various substrate materials much like a shag rug. The nanotubes are multiwalled and between 50 and 100 microns in length, and are excellent conductors and low density, providing a low impedance mismatch (low reflectance) while gradually absorbing the incoming light. The material absorbs 99.5 percent of the light in the ultraviolet and visible, dipping to 98 percent in the longer or far-infrared bands.



This close-up view (only about 0.03 inches wide) shows the internal structure of a carbon-nanotube coating that absorbs about 99 percent of the ultraviolet, visible, infrared, and far-infrared light that strikes it. A section of the coating, which was grown on smooth silicon, was purposely removed to show the tubes' vertical alignment. (Credit: Stephanie Getty, NASA Goddard)

APPLICATIONS

The technology has several potential applications:

- There is commercial application of this innovation for use on binoculars, night vision goggles and other optical devices that would benefit from stray light suppression. This extends to nearly all optical devices in the UV, visible and Near infrared portions of the electromagnetic spectrum. Since the growth of nanotubes requires a capital investment in technology, its use will be limited to high end consumer, commercial, aerospace and military products.

PUBLICATIONS

Patent No: 8976362

Patent Pending

Hagopian, J., Getty, S., Quijada, M., Tveekrem, J., Shiri, R., Roman, P., . . . Deglau, D. (2010). Multiwalled carbon nanotubes for stray light suppression in space flight instruments. Carbon Nanotubes, Graphene, and Associated Devices III.

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