Single-laser techniques make reproducible artwork on metal without dye or paint

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The researchers created silver jewelry with colored laser decoration to demonstrate the use of subwavelength nanoparticles to create color. This method requires no special sample preparation. Credit: Optical Society of America

A variety of laser-based techniques can be used to produce colorful artwork on metals. However, each approach typically requires a different

type of laser and very specific settings. In a new study, researchers describe how to use a single commercially available laser to achieve three techniques for laser colorization on metal, making the techniques more practical for a wide range of applications in art and jewelry making, with the possibility of mass production.

"By changing the laser processing parameters, we control the heating of the metal surface in the temperature range from the melting point to boiling and above," said Nadezhda Shchedrina a member of the research team led by Galina Odintsova from ITMO University in Russia. "After laser processing, various micro and nanostructures are formed, which create optical effects that change the color of the treated surface."

In the journal *Optical Materials Express*, the researchers report simple and reliable methods for using a laser that emits nanosecond-duration pulses to create a large palette of colors on metal. The techniques are not overly time-consuming and can be used to create large or small images.

"Our results enable a novel type of art and design," said Yaroslava Andreeva, member of the research team. "We want to introduce the laser as a technique for effective artistic expression that offers new possibilities for artists."

Colorful techniques

The researchers applied three methods for manipulating metal coloration with lasers: laser oxidation, laser nanoparticle formation and laser structuring. They created a color palette based on their new approaches and plan to expand it over time.

For laser oxidation, the researchers detail how to use a laser to produce a thin oxide film on the metal surface that creates color due to light interference occurring in the film. This can create color over a wide area

of the metal's surface.

The researchers also outline the second method, which uses a laser to form subwavelength nanoparticles—around 5 to 50 nanometers—on metal. When ambient light hits these nanoparticles, it creates colors through an optical phenomenon known as surface plasmon resonance. The color can be modified by changing the size and shape of the nanoparticles. This method is useful for applying color to precious metals, such as silver, and requires no special sample preparation.

The third method for laser structuring involves using a laser to partially melt the metal surface to form a pattern of fine parallel grooves or slits known as a periodic grating. The light scattering off these structures leads to colors that depend on the observation angle. This technique can be used to create several images on the same metal surface, with each image viewable only at a certain angle, making it applicable for protection against falsification of metal products.

Making art with lasers

The researchers used their new methods to produce a variety of artwork. With laser oxidation, they recreated a color magazine illustration on titanium. They also made silver jewelry with colored laser decoration to demonstrate the use of nanoparticles, and used laser structuring on stainless steel to make images that changed color and appearance when observed from different angles.

"These methods offer a wide variety of ways to implement ideas in jewelry or other types of metal artwork without using any consumable or toxic chemicals," said Lutoshina Daria, a member of Odintsova's research team. V.P. Veiko, who developed the idea for this project, added that the color palette could be expanded by creating a surface with nanoparticles made of different metals.

The researchers say that the laser oxidation and structuring approaches are reliable enough to use for mass production as well as creating individual artworks. They continue to develop the nanoparticle method to make it more stable for everyday use. The researchers are also working to extend the number of metals to which the methods can be applied.

More information: Ya. M. Andreeva et al, Laser coloration of metals in visual art and design, *Optical Materials Express* (2019). DOI: 10.1364/OME.9.001310

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