Surface darkening of different metals using nanosecond pulsed laser ablation

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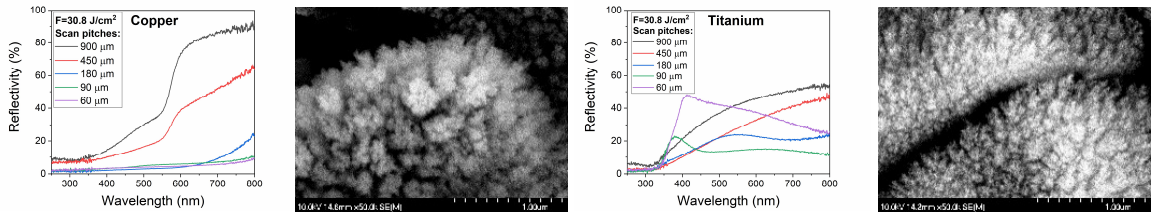
Metal darkening by means of femtosecond and picosecond lasers has been extensively studied concerning both the reflectivity decrease mechanism and the structure forming process on the surface. However, the literature of the darkening with nanosecond pulse laser irradiation remained scarce, leaving open questions related the process. In this work we aimed to study the effect of nanosecond laser irradiation on different metals (copper, titanium and aluminum) with special regard to the evolution process of the relevant micro- and nanostructures and their relation with the alteration of the optical properties.
The applied laser parameters were the followings: Nd:YAG laser operating at 532 nm wavelength, 8 ns pulse duration and 10 Hz repetition rate. The laser spot diameter on the sample was 900 µm and the applied fluence was 5.5, 9.4, 15.7 and 30.8 J/cm², respectively. Larger rectangular area was irradiated by scanning of the target by a motorized X-Y translation stage, the average pulse number reaching a unit area was varied by using different overlap of the consecutive pulses. The equal value X and Y direction scan pitches were 900, 450, 180, 90 and 60 µm, respectively. The total reflectivity (specular and scattered) of the processed areas was measured by a spectrophotometer (Shimadzu UV-3600 Plus) using an integrating sphere in 250-800 nm wavelength range. The morphology of the samples was studied with scanning electron microscope (SEM) and energy dispersive X-ray spectrometer (EDX) was applied for the elemental composition analysis. The mechanical properties were investigated with an IND-1500 nanoindentation system in two different operation modes.



Reflectivity spectra of copper and titanium surfaces ablated with the Nd:YAG laser at different displacement values and SEM pictures about the treated areas (N=50k)

The morphological and spectroscopic investigations proved that the micrometer and nanometer structures formed on the irradiated surface, the falling back nanoparticles and the oxides formed in the surface layer are responsible for the change in the optical and mechanical properties. All these are affected by the degree of overlap of the scanning laser spots. The different reflection behavior of copper and titanium was explained by finite difference time domain calculations using Lumerical software.

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