Femtosecond laser processing of gold-implanted glass: assisted absorption and optoplasmonic tuneability

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Ultrashort laser pulses have a huge potential in material processing, allowing the fabrication of controlled modifications at the nano and micro-scale. The strategy relies on the ability to control and localize the laser energy deposition. In this work, we explore the assisted absorption mechanisms and potential applications of femtosecond laser-irradiated dielectrics doped with Au ions. Different from recent studies on shallow implantation with keV ion [1], we employ deep implantation at by using swift heavy ions (Au at 1.8 MeV [2]) followed by thermal annealing. We investigate the unique properties of the so-prepared nanocomposite materials as well as the local changes induced by subsequent femtosecond laser processing (800 nm, 130 fs, and 1 kHz).

First, we demonstrate the existence of an embedded gold NP layer centered at 480 nm depth. This layer is crucial for energy deposition and triggers ablation of the entire top glass layer, forming deep and morphologically flat craters. This result can be understood by considering a spallative ablation process localized at the NP-glass interface, which can enable ablation depth control by selectively controlling the implantation depth. Second, due to the deep-embedded Au NPs layer, the sample shows both a plasmonic and interferencial behaviour, which has a strong effect on the sample color. This optoplasmonic response can be tuned by the laser conditions , generating vivid blue-shifted colors by surface swelling and red-shifted colors by multi-shot irradiation at moderate fluences.

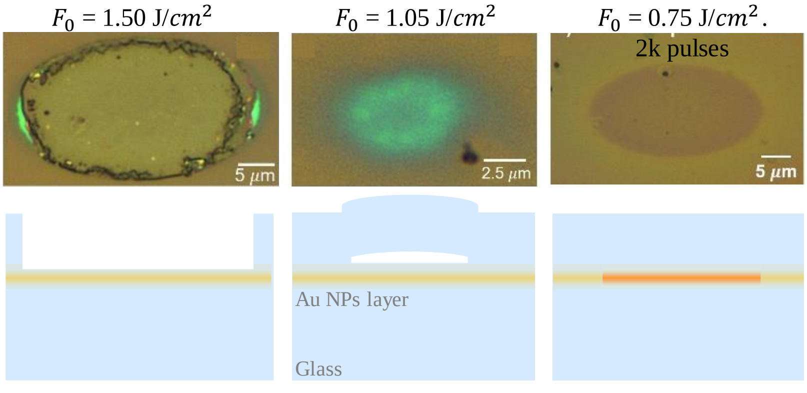

Figure 1. Illustration of three modification regimes of MeV-ion Au-implanted sodalime glass.

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References: [1] H. Zhu et al., Small Sci. 2022, 2, 2200038 [2] A. Redondo-Cubero, et al. Eur. Phys. J. Plus 2021, 136, 175.