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# High electric field induced damages by coherent THz pulses: a new technique to test breakdown phenomena

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High intensity THz pulsed radiation was used to investigate the damage induced on low roughness copper substrates and thin films deposed on copper. Using the THz Free Electron Laser available at the ISIR facility of the Osaka University [1], we irradiated samples in air at different angles, with an energy density of ~100 GW/cm$^2$. We induced a reproducible electric field gradient up to ~4 GV/m and, at this intensity, breakdown phenomena may occur.
In the case of copper, since at THz wavelengths the reflectivity is ~99%, irradiation at normal incidence does not induce any damage and no signature of breakdown phenomena is detectable on the surface. At variance, decreasing the angle of incidence the damage of the surface occurs with a central spot of ~200 μm diameter, surrounded by a visible corona associated to the intense heating induced by the pulsed beam. In addition, in the central region tips made by copper oxides identified by Raman microscopy are induced by the multiple breakdowns [2,3].
To better understand the damage, we performed simulations of irradiations on copper surfaces using state of the art two-temperature modelization of high-intensity ultrafast radiation interacting with matter.
We also tested thin $MoO_3$ films deposed on copper to probe the resistance to breakdown and to probe the damage induced by multiple breakdowns. This van der Walls material, is characterized by a high work function (6.7 eV) and, with its higher mechanical resistance compared to copper, it is an optimal candidate to reduce the damage of the copper surface [2,3]. In spite of the limited thickness, i.e., ~100-200 nm, much lower than the wavelength, experiments again performed at different incidence angles showed that the oxide coatings minimize the damage of the copper surface. In spite the extremely high electric field, there is no evidence of tips in the central irradiated region and no copper oxidation is detected by Raman microscopy on the irradiated surfaces. [4]

References

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