Open-atmosphere laser nanostructuring of silicon using a laser-induced plasma lens

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Nanostructuring of a metal surface by means of laser irradiation is an area of primary interest in nanotechnology. There is a recent trend to use these type of targets for X-ray generation, ion acceleration and the study of intense plasmonics in high intensity laser-matter interaction. Many studies have been carried on the formation of more or less ordered, or periodic, nanostructures when a metal or semiconductor substrate is irradiated with pulsed laser light. Such structures have been obtained with techniques based on laser scanning microscopes with ultra-short laser pulses by a two beam irradiation of a silicon surface achieved using a Lloyd mirror configuration or by the interference between two or more laser beams.

However, the physics behind is not fully understood. So far, none of the mechanisms proposed can fully explain these results, the most accepted mechanism involving the excitation of the semiconductor surface plasmon by the incident laser light. This would occur on the molten surface layer where the free electrons can support the propagation of surface plasmons. The surface would adopt a grating-like shape depending on the relation between the wave-vector of incident laser light and the surface plasmon and its rapid cooling after the laser pulse would retain such morphology.

In this work, we propose a simple plasma lens technique for obtaining a multiple nanostructuring effect without the need of femtosecond laser sources nor a controlled environment. A laser-induced plasma is used as a non-linear optical element for a second laser beam which crosses the plasma perpendicularly to its expansion axis. By varying the time delay between the two lasers beams, and the fluence of the laser generating the plasma plume, various patterns were induced on the surface of the silicon wafers used.

References

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Figures

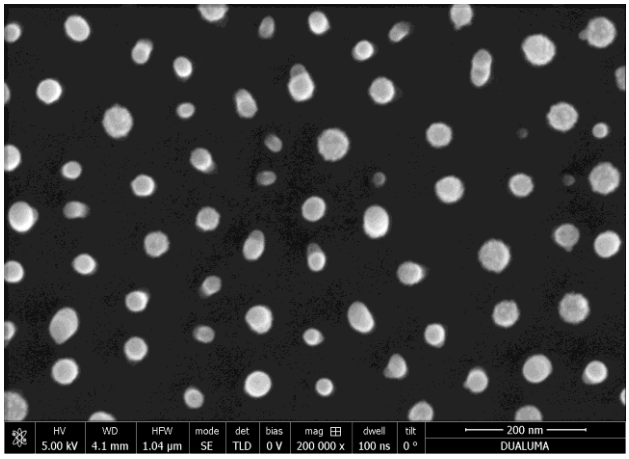

Figure 1: SEM image of a silicon sample showing one of the structures produced by the technique presented in this work.