Advances in Ultrafast Pulse Laser Irradiation of Metal Nanoparticles

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The vast majority of the applications of metal nanoparticles developed during the last two decades have arisen from their unique optical properties.[1] Within this context, rational synthesis and assembly of metal nanoparticles have been the main research focus, aiming at the design of nanoplasmonic devices with tailored optical functionalities. The progress made in this field is thus to be ascribed to the understanding of the origin of the interaction between light and such nanostructures, the dynamics of which have been thoroughly investigated with significant contributions from short and ultrashort pulse laser technologies.[2]

This presentation focuses on the potential of pulse lasers to provide new fundamental insights into the electron dynamics involved in the interaction of light with the free conduction electrons of metal nanoparticles, that is, localized surface plasmon resonances (LSPRs). The excitation of LSPRs with a femtosecond pulse laser is followed by thermalization of the metal nanoparticle electrons and the subsequent relaxation of the nanocrystal lattice and the surrounding environment, which generally results in surface melting.[3] By contrast, nanosecond irradiation usually induces metal nanoparticle fragmentation and uncontrolled melting due to overlapping excitation and relaxation phenomena. These concepts have been exploited toward the preparation of highly monodisperse metal nanoparticles via femtosecond pulse laser irradiation of polydisperse colloids, or in the fabrication of hollow and alloyed metal nanoparticles.[4]

In addition, pulse laser irradiation has been proven a unique tool for the controlled assembly and welding of colloidal metal nanoparticles by electromagnetic field enhancement at the hot spots of assembled metal nanoparticles.[5] The combination of such gold nanostructures with pulse lasers promises significant chemical and biochemical advances, including the structural determination of organic reaction intermediates, the investigation of phase transitions in inorganic nanomaterials at mild reaction conditions, or the efficient photothermal destruction of cancer cells avoiding damage of surrounding tissue.

References

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