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# Ultrafast nanoplasmonics for precision spectroscopy and strong field physics

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## 1. Extended Abstract

Ultrafast laser pulse technology, exploiting femtosecond ($10^{-15}$ s) laser sources have received attention in many research fields to manipulate and observe electrons' dynamics in the matter by the light wave. The extremely short pulse duration allows one to create, detect very fast transient reaction and transition states in the matter. This short pulse also can produce enormous peak intensity, reaching strong field regime whose intensity exceed $\sim 10^{13}$W/cm$^2$. This leads to non-linear applications such as generation of electromagnetic radiation at extremely short wavelengths, known as high harmonic generation. In frequency domain, the femtosecond laser pulse consists of millions of optical mode that are stabilized by ultra-precise atomic clock frequency. Based on this broadband precision optical frequencies, new optical spectroscopy, precision length measurement for high precision manufacturing, and improved surface metrology are available.
These unique properties of ultrafast laser pulse can be maintained and controlled in nanometer scale by exploiting plasmonics. Coupling surface plasmons, collective charge oscillations produced by the resonant interaction of light and free electrons on the interface of metallic and dielectric materials, to ultrafast laser pulse creates numerous advantages, such as local field enhancement, spatio-temporal manipulation of electromagnetic field. Here, we show our recent works based on ultrafast laser technology combined with nanoplasmonics. Firstly, we report that frequency comb successfully maintains superior performances during photon-plasmon conversion in plasmonic extraordinary transmission through metallic nano hole array [1]. This implies that the original frequency comb can be imprinted on a form of surface plasmons on metallic nanostructures and reverted to optical frequency comb without noticeable degradation in absolute frequency position, stability and linewidth. Secondly, Plasmonic high-harmonic generation is introduced as a means of producing coherent extreme ultraviolet radiation by taking advantage of localized electric field enhancement in specially designed metal structure for maintaining megahertz repetition rate of EUV pulses [2]. The single crystalline tapered sapphire tip coated by a gold thin-film is fabricated for generating locally enhanced plasmonic near-field, and intended to induce high harmonic generation by the inter- and intra-band transition of electrons driven by plasmonic near-field.

## 2. References

1. X. T. Geng, B. J. Chun, J. H. Seo, K. Seo, H. Y., D.-E. Kim, Y.-J. Kim, and S. Kim, "Frequency comb transferred by surface plasmon resonance," *Nature Communications*, **7**, February 2016, pp. 10685, doi:10.1038/ncomms10685.

2. S. Han, H. Kim, Y. W. Kim, Y.-J. Kim, S. Kim, I.-Y. Park, and S.-W. Kim, "High-harmonic generation by field enhanced femtosecond pulses in metal-sapphire nanostructure," *Nature Communications*, **7**, October 2016, pp. 13105, doi:10.1038/ncomms13105.