High Harmonic Generation by plasmonic field enhancement

Seungchul Kim

Ultrafast Optics for Ultraprecision Technology Research Group, Korea Advanced Institute of Science and Technology (KAIST)
**Corresponding author :inter99@kaist.ac.kr*

Surface plasmons resonance within metallic nanostructures enables electric field enhancement of a low-intensity femtosecond pulse laser, permitting high harmonic generation without additional power amplification. This new concept of generating EUV light was previously demonstrated by the authors using nano-antennas made of Au bow-ties. The resulting field enhancement factor reached ~20 dB to successfully produce up to the 21^{st} harmonic (38 nm in wavelength) by injection of noble gases onto a moderate femtosecond pulses of 10^{11} Wcm^{-2} intensity. Notwithstanding the high enhancement factor achieved, the 2-dimensional configuration of the bow-tie nanostructure was found not very effective in increasing the total volume of field enhancement to bring the EUV conversion efficiency up to the high level of the traditional method relying on chirped pulse amplification. To cope with the problem, a 3-dimensional type of nanostructure is newly proposed and tested in this investigation. The new design is a cone-shaped tapered hollow hole fabricated within a metal substrate using the focused-ion-beam milling process. The tapered hole functions as a waveguide that induces field enhancement by surface plasmon polaritons being developed as a femtosecond pulse propagates through. In comparison to bow-tie nano-antennas, the use of surface plasmon polaritons offers a much larger volume of enhanced laser field due to coherent accumulation of surface polaritons within the waveguide in response to the incident femtosecond pulse. Besides, the interaction length of the enhanced laser field with injected gases can be readily extended by adding a longitudinal cylindrical tube at the exit of the waveguide.