高エネルギー密度状態を用いた真空紫外光の非線形光学

Nonlinear optics of vacuum ultra-violet light with high-energy-density matter

Objectives

真空紫外からX線の領域で非線形光学効果が利用できるようになれば、従来の可視～赤外光で行われていた様々な機能、技術を応用できる。ここでは、高エネルギー密度状態を使った非線形光学の提案、実証、応用研究を行っている。特に、内殻電子のエネルギーエッジ部で、そのエネルギー差に調整された光を照射することで生成される、内殻励起状態に原子がありながら固体の秩序性を保てる高エネルギー密度状態を利用した新しい物質状態を利用している。この手法を発展させ、将来、X線領域においての非線形光学効果に応用することを目的としている。

By using high densities of excited atoms, we are developing new nonlinear optics in the high-energy photon region. Using high intensity VUV or X-ray lasers we are able to create high-energy density states, in which almost all irradiated atoms are inner-shell excited. Due to band edge shifting as a result of inner-shell ionization we can expect large variations in optical constants before and after irradiation. In the case of metals, which have many free electrons in the conduction band, tuning the irradiation wavelength to the band gap energy of the inner-shell ionization results in little residual energy. This means that the medium temperature can be kept lower so that ordering will be maintained despite the high energy density.

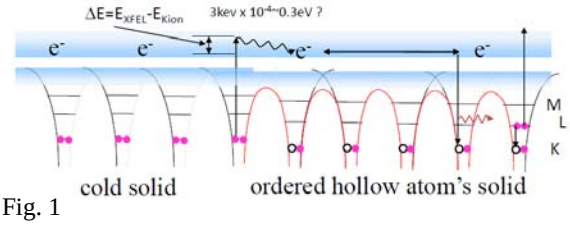

Fig. 1

Achievements

- 真空紫外領域において、高いコントラスト比を持った可飽和吸収現象を初めて観測
- 高密度内殻励起状態が準安定状態で存在し、高エネルギー光子制御可能な媒質であることを実証
- 真空紫外光相互作用実験における表面不純物酸化層問題を解決する新しい実験手法を確立
- 真空紫外域における固体を使った多光子過程の観測にも成功

- We succeeded in creating a high contrast ratio saturable absorber in the vacuum ultra-violet region.
- We demonstrated that inner-shell ionized solid density media can be used to study nonlinear optics in high energy and high intensity light science.
- We proposed new experimental methods to improve surface contamination problems in vacuum ultra-violet laser experiments.
- We also observed multi-photon processes with condensed matter in vacuum ultra-violet region.

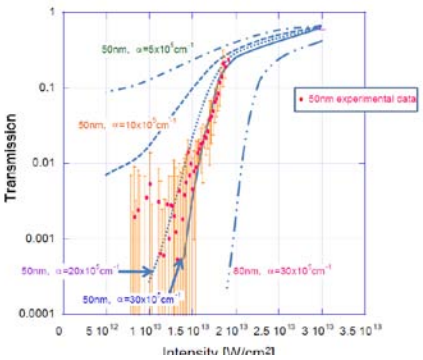

Fig.2

Fig. 1: Concept of ordered hollow atoms solid with well tuned high energy photons.

Fig. 2: Experimental results of high contrast Sn saturable absorber for 50nm vacuum ultra-violet light. The lines indicate simulation results of a four level atomic state model with wave propagation in a thin layer.

References

1) Hitoki Yoneda, et al., Ultra-fast switching of light by absorption saturation in vacuum ultra-violet region, Optics Express, vol. 17 Issue 26, pp.23443-23448 (2009).
2) H.Yoneda, et al., Observation of saturable absorption of Sn metal film with intense EUV laser pulse, Proc. of SPIE vol.7501 (SPIE, Bellingham, WA 2009) pp. 33-43
3) Y.Inubushi, et. al., Measurement of saturable absorption by intense VUV free electron laser using fluorescent material, accepted in Rev. Sci. Instrum. (2010)