PhD Open Days

Ultrafast imaging the solid to plasma transition

Advance Program in Plasma Science and Engineering (APPLAuSE)

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Motivation

The laser induced solid-to-plasma transition presents a dynamic transformation from the well described solid state to the strongly coupled plasma state. The laser induced changes can only be resolved with femtosecond time resolution diagnostics, as the equilibration of the electronic and ion systems is on the scale of picoseconds. Currently, one of the most challenging states to accurately describe is the behavior of matter in the intermediate realm between solid and plasma [1] and some of the most relevant plasma conditions to humans lie in the so-called high-energy-density (HED) states. The new state-of-the-art laboratories at IPFN will be used to drive material through the solid-to-plasma transition, and map the ultrafast dynamics using novel techniques that have developed at IPFN [2, 3].

Objective

- The design and development the femtosecond time resolved imaging system based on the transmission extreme ultra-violet (XUV) light from high harmonic generation.
- We used a grazing incidence focusing and imaging system (KB Optics) that images in transmission a laser heated titanium foil of 100 nm in a single shot.
- Here, we present the experimental setup and preliminary results of this ultrafast transition.

Experimental setup

The schematic of the experimental setup for ultrafast imaging of solid to plasma transitions in titanium foil is shown in the figure 1. The XUV pulses are generated in argon (Ar) gas through high harmonic generation (HHG) and used as a probe pulses. The near- infrared (NIR) pulses of 800 nm, operating at 10 Hz has been used as a pump source. The grazing incidence of focusing and imaging system is used which images the transmission in a laser heated titanium foil of 100 nm in a single shot is shown in figure 1(b).

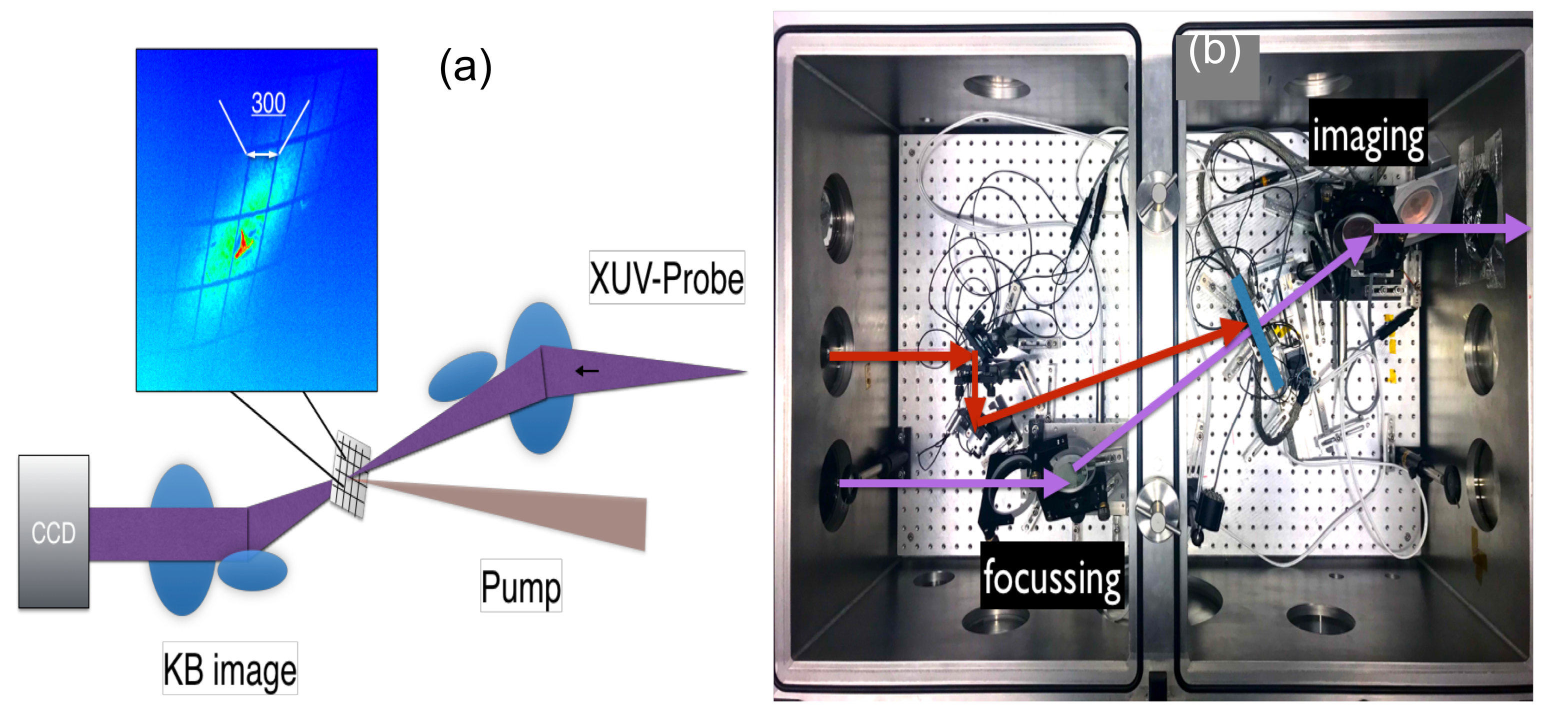

Figure 1: (a) Schematic of experimental setup for the imaging of solid to plasma transitions in titanium foil, (b) XUV KB grazing optics for focusing and imaging setup in the chamber

Preliminary Results

Here, we present the preliminary results of this ultrafast transition (figure 2) and an optical properties of solid titanium foil by DFT calculations (figure 3).

- We used a grazing incidence focusing and imaging system (KB Optics) that images in transmission a laser heated titanium foil of 100 nm in a single shot.
- The preliminary results shows fast (~100 fs) response as shown in figure 2.

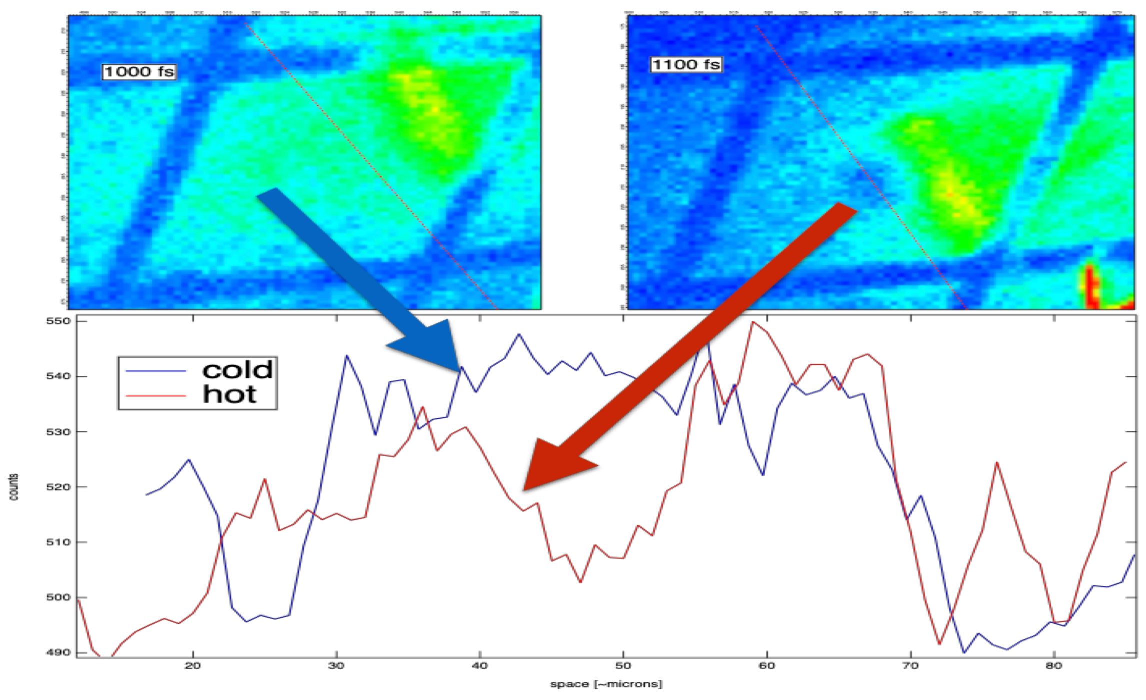

Figure 2: Preliminary results of ultrafast transition in titanium

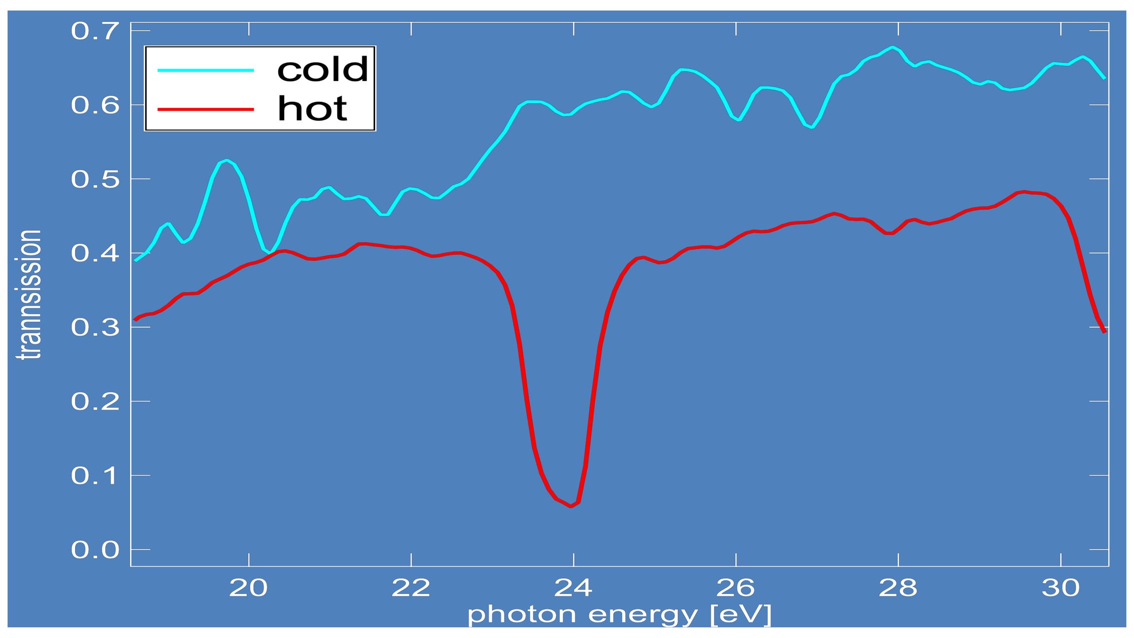

Figure 3: Optical properties of solid titanium foil by DFT calculations

In conclusion, we have designed a way to take photographs of a plasma with an XUV source on a femtosecond time scale. The ultrafast changes appear electronic, suggesting ionisation occurring within the first 100 fs of the IR heating pulse. Future studies will further improve the temporal resolution, and reveal the delay (if any) between IR heating and ionisation of the bound electron states in solids.

References

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[2] G. O. Williams and H.-K. Chung et al., Phys. Plasmas 20, 042701 (2013)

[3] G. O. Williams and S. Künzel et al., Phys Rev. A 97, 023414 (2018)

Acknowledgements

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