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Table top x-ray and terahertz radiation sources for molecular science

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High intensity, ultrashort light pulses are revolutionizing science and technology in very exciting ways, whether it is laboratory simulation of astrophysical phenomena, relativistic optics, particle acceleration on a table top, real time x-ray diffraction of molecules, or medical therapies for cancer [1,2] . Such pulses can heat a piece of matter to intra-stellar temperatures ***at*** high density. It is this feature of ultrashort pulses that helps us devise compact, novel radiation sources for applications.

This talk will present some novel efforts in the generation of x-ray and high energy electron sources that can be applied to studies in molecular physics. Hard x-ray sources are mainly derived from solid target plasmas and great progress has been made by the discovery that the nano spatial scale has a very important role play in the interaction of intense, pulsed light with matter [3-6]. We will see how nanoparticles, nanowires and nanotubes influence the generation of very high energy electrons, which in turn generate hard x-rays. We will review applications of these x-rays in dynamics of molecules as well as solids. Our recent work on metal nanoparticle coated thin films has revealed the existence of an optimum film thickness corresponding to the highest x-ray yield as shown in the Figure 1 below.

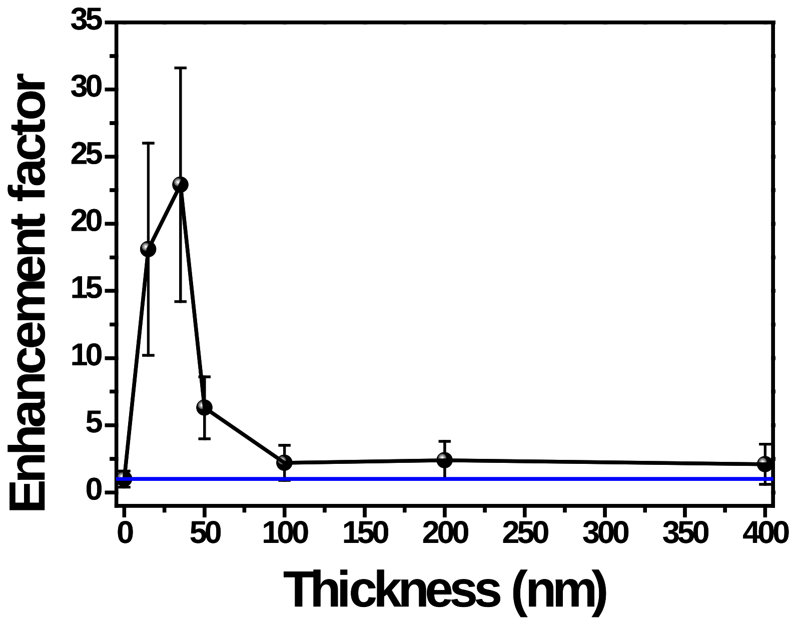

Figure 1: Enhancement factor for x-ray yield as a function of nanolayer thickness (black), in

comparison to the yield from a plane, uncoated target (blue line).

In an earlier study, we compared electron energy spectrum from silicon nanowire (SiNW) arrays with that of plane silicon [6] and showed that the electron energy and yield were higher in the former. The raw electron traces and the energy spectrum of electrons for the two cases are shown below (Figure 2)

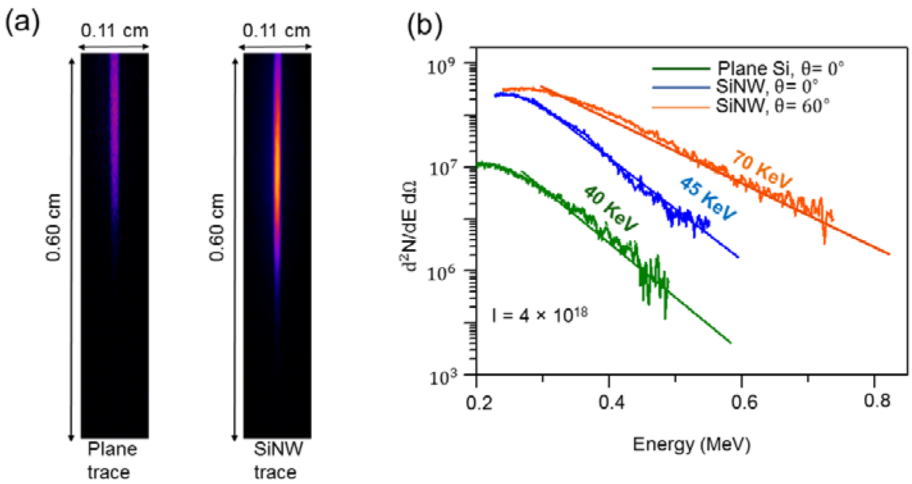

Figure 2: Si nanowire x-ray emitters: (a) Electron traces on an image plate in the magnetic electron spectrometer. The length indicates the extent of electron energy and the brightness indicates flux. (b) Electron energy spectrum obtained from (a).

It is also interesting to see that the study of the x-ray emission process itself is leading to great advances in attosecond dynamics in atoms and molecules. We will conclude by presenting the emergence of high efficiency table top sources at the other extreme, namely terahertz region and the potential for probing molecular nonlinear behavior at these low frequencies [7].

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