Photoconductivity in Vanadium Dioxide Nanowires

Xi Wang and Hanwei Gao
Department of Physics, Florida State University

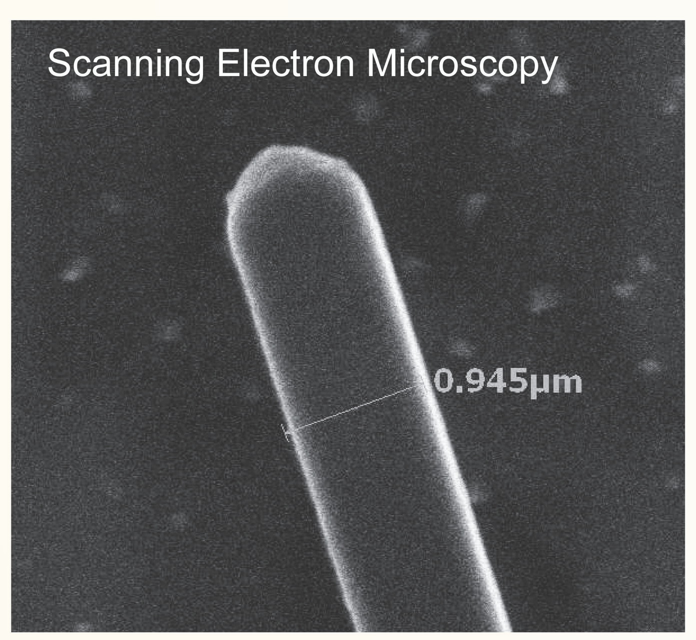
Introduction

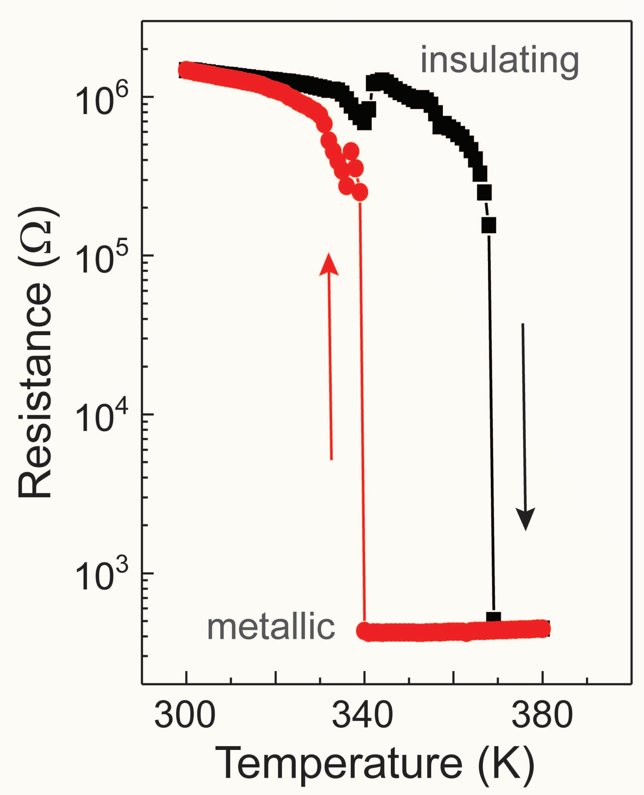
Vanadium dioxide (VO_2) exhibits the unique metal-insulator transition near the room temperature. The high electrical resistivity indicates strong electron-electron correlation below the transition temperature (~64°C). Such interactions can potentially result in efficient impact ionization, a process which can generate multiple charge carriers from each photon absorbed and, therefore, is desirable for optoelectronic and photovoltaic applications.

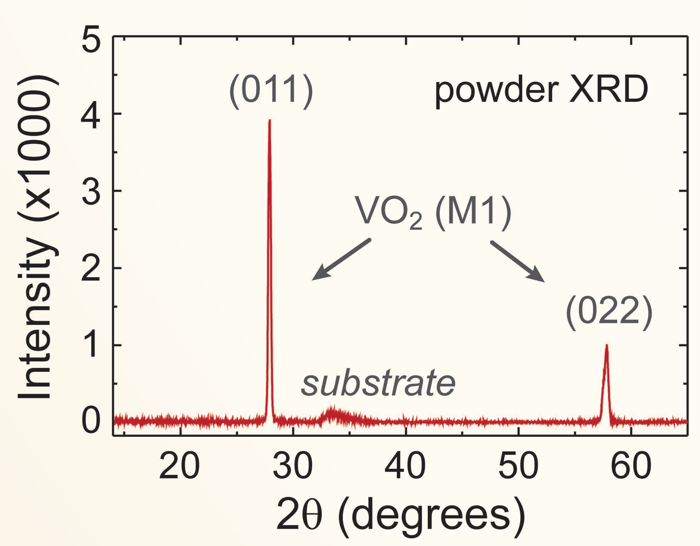
Because of the highly temperature-dependent resistivity, changes of conductivity in VO_2 under optical excitations were often attributed to the photothermal effects. ***In this work***, ***we found*** that both the photothermal effects and the photo-generated charge carriers contributed to the observation of photocurrent. By increasing the chopping frequency of the optical excitation above 2 kHz, ***we are able to*** well suppress the relatively slow photothermal processes, leaving behind the ultrafast photo-generation of charge carriers dominating the photocurrent.

Nanowire Synthesis

VO_2 nanowires were synthesized using the physical vapor transport method. The X-ray and electron diffraction patterns indicate these nanowires are in the desirable phase (M1) and single crystalline. A sharp metal-insulator transition is observed around 340 K with a change of the resistance more than three orders of magnitude.

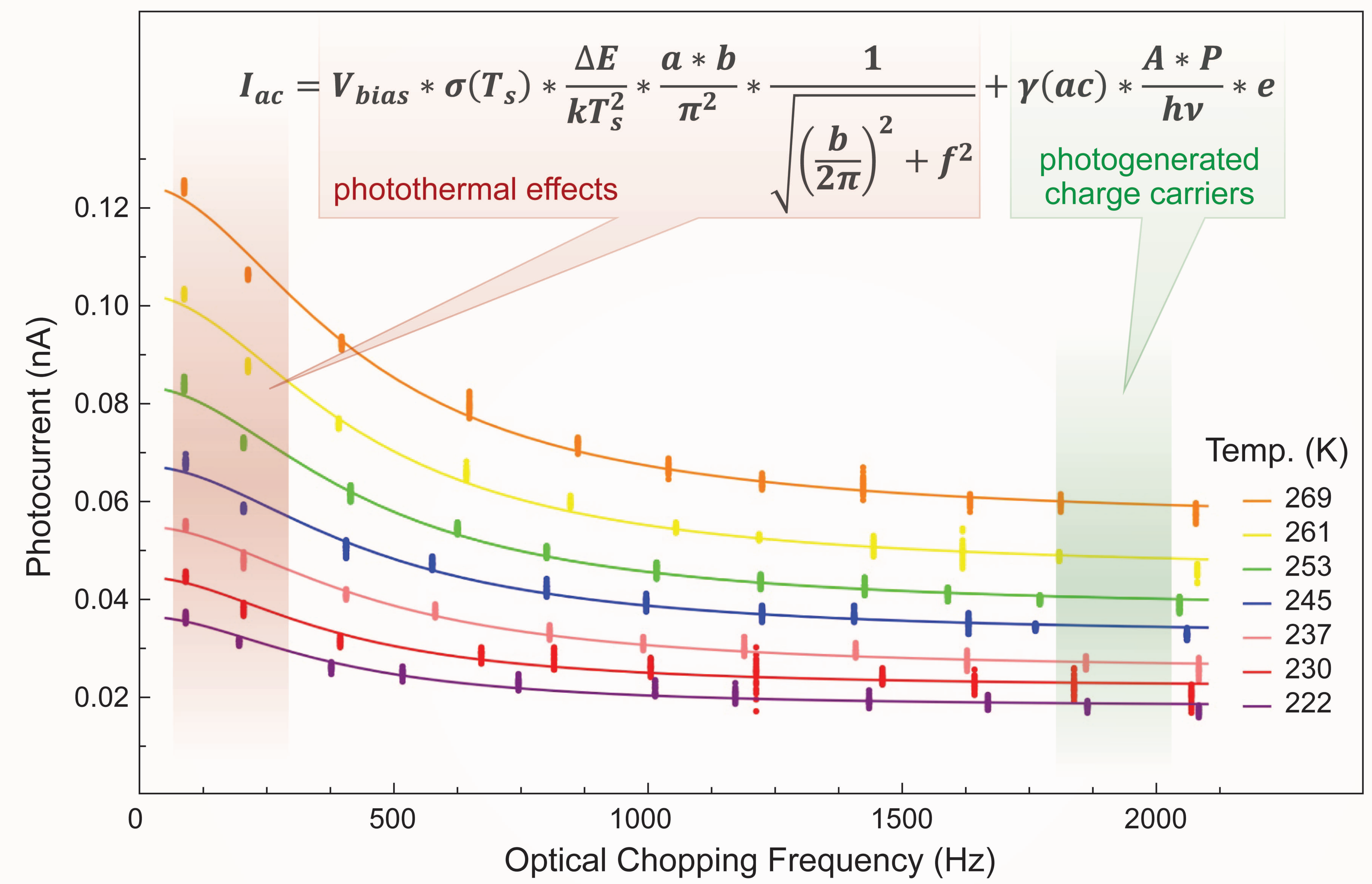




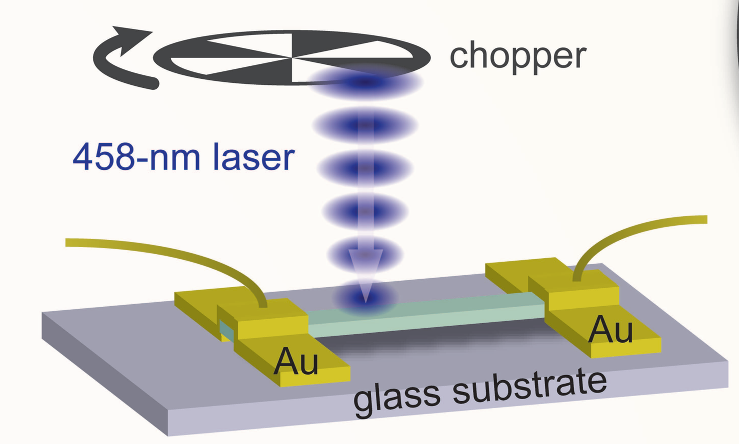


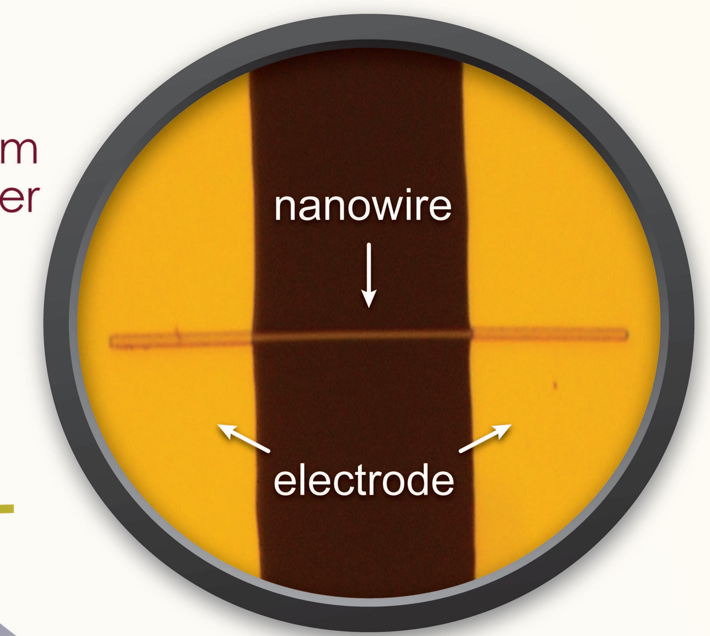
Chopping Frequency Dependent Photocurrent

At slow chopping rate, the photothermal effects contribute significantly to the photocurrent which, at high chopping frequency, is dominated by the photo-generated charge carriers.

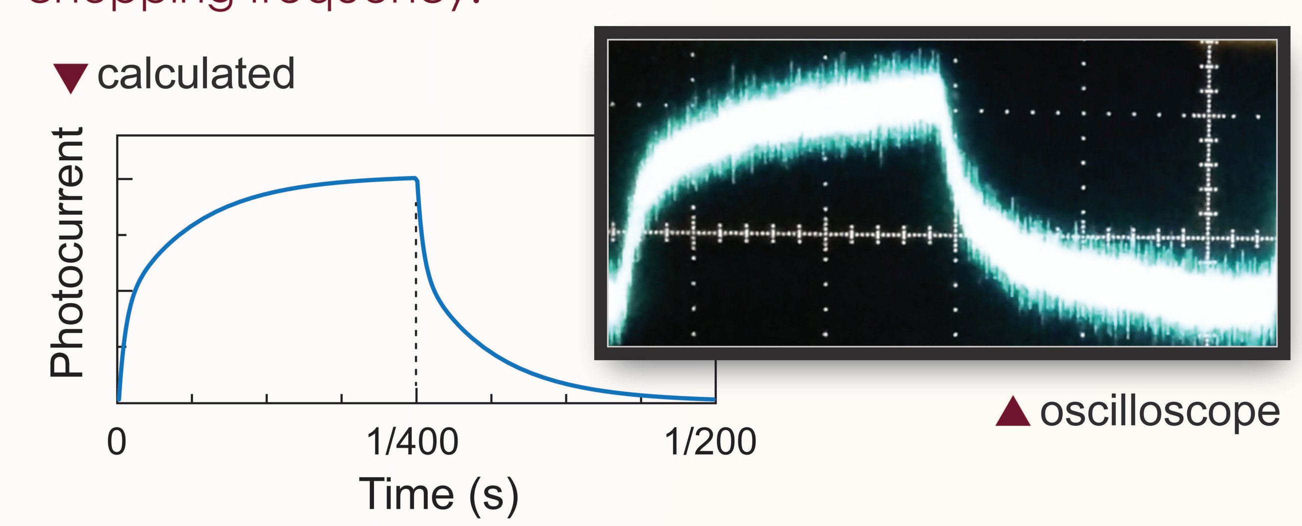


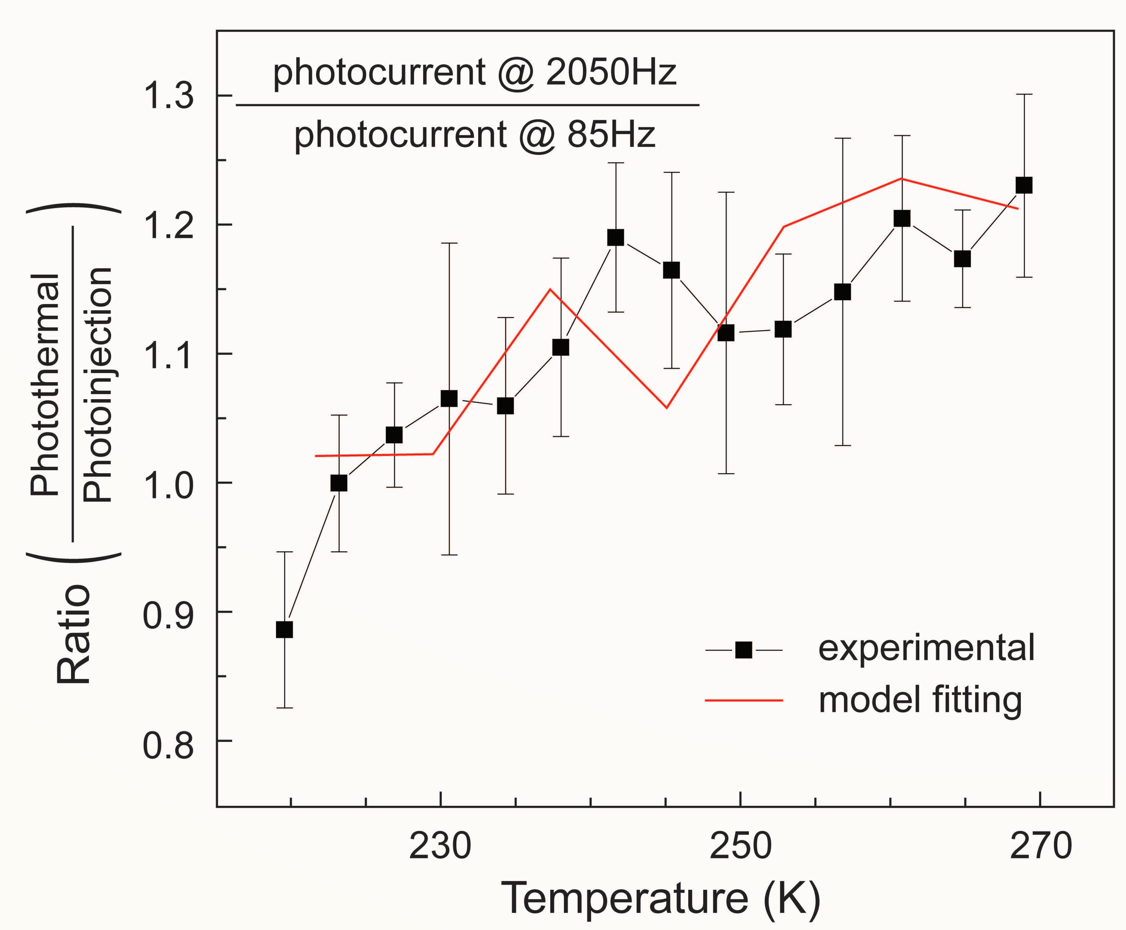
Photocurrent was measured from single-nanowire devices under chopped laser excitation.





The slow photothermal response can be observed obviously in the waveform of the AC photocurrent with 200-Hz chopping frequency.



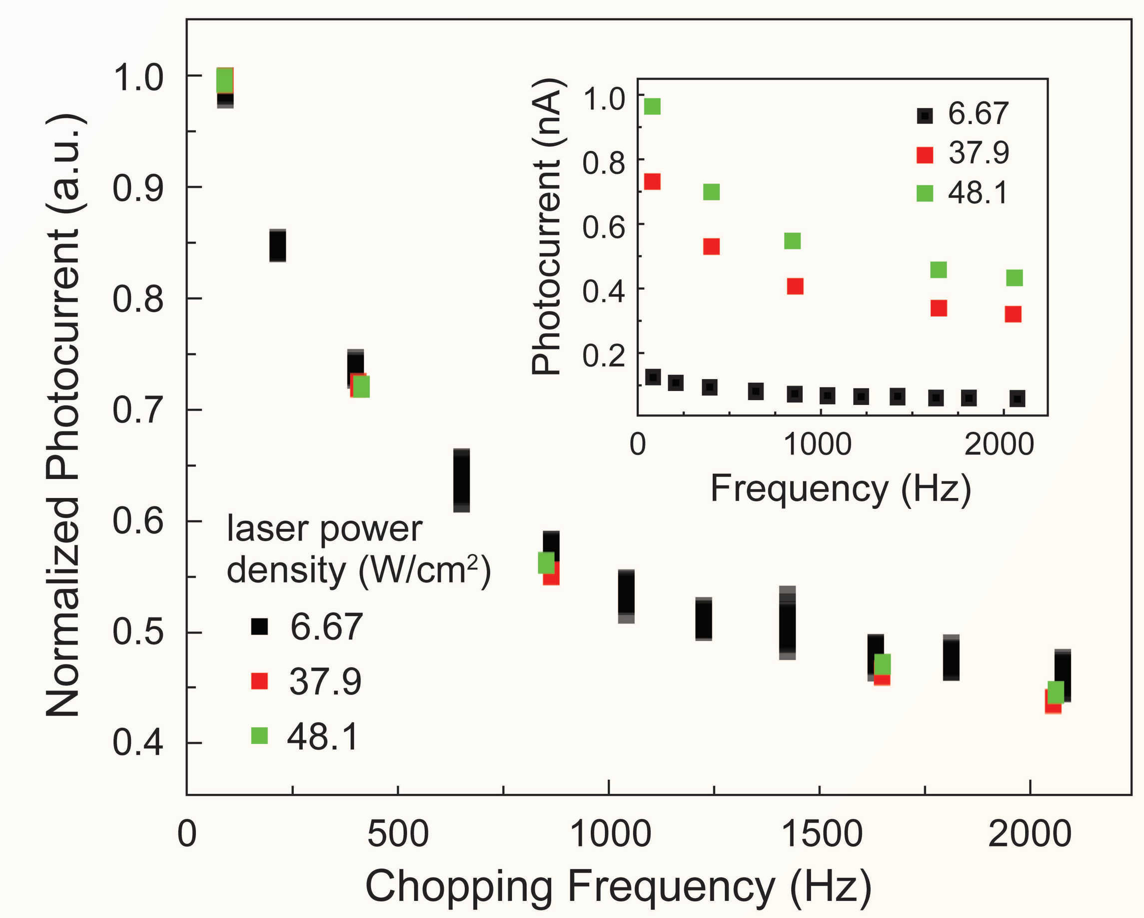


◀ The photocurrent at 2050 Hz and 85 Hz represent the contributions from photoinjection and photothermal effects, respectively. The ratio increases with increasing temperature, indicating a larger photothermal compoenent at higher temperature.

✔ **Predicted by model**

✔ **Observed in experiments**

Although the photocurrent scales linearly with the power of the excitation light, the exponent of the decay with respect of the chopping frequency remains the same, as shown by the normalized photocurrent. ▶



This work is supported by FSU start-up funds. H.G. thanks FSU Office of Research for the First Year Assistant Professor Award (FYAP).
Correspondence should be addressed to *hga3@fsu.edu*.