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Semiconductor-Metal Phase Transition Characteristic of VO_2 Film Investigated by Pump-Probe Terahertz Spectroscopy

Q. W. Shi,[1,2] W. X. Huang,[2] T. C. Lu,[1,a)] and F. Yue[2]

[1]*College of Physical Science and Technology, Sichuan University, Chengdu, People's Republic of China*
[2]*College of Materials Science and Engineering, Sichuan University, Chengdu, People's Republic of China*

Abstract:

Due to the ultrafast semiconductor-metal phase transition (SMT) with giant changes in electrical and optical properties, vanadium dioxide (VO_2) has been widely studied and attracted special attention on the application in terahertz (THz) range. It is suggested that the VO_2 film supports the giant and ultrafast phase transition and can be used to realize THz dynamic devices with higher efficiency and faster speed. However, previous study indicated quite different results for the SMT speed, which was varied from femtoseconds to microseconds.[1-4] And there is rare reports considering the fundamental reasons for the varied SMT speed of VO_2 films.

In this study, we investigated the SMT of VO_2 film using a pump-probe THz spectroscopy. The results demonstrated ultrafast phase transition in VO_2 film excited by laser. And this phase transition could be divided into two processes: a "fast process" occurred in a few picoseconds, and a "slow process" occurred in tens picoseconds or even longer. Particularly, the "fast process" was independent on the pump

fluence and film thickness, indicating an intrinsic nature of the SMT in VO_2. By contrast, the films with different thicknesses exhibited the same "fast process" but varied "slow process". We then proposed that the "fast process" could be attributed to the structural phase transition, but the "slow process" corresponded to an inhomogeneous phase evolution. Moreover, this inhomogeneous phase evolution would be affected significantly by the microstructure, stoichiometry, stress in the VO_2 film. And the varied phase evolution characteristics in different VO_2 films will result in different SMT speeds. This study could provide considerable insights into the explanation of SMT in VO_2 film.

References:

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