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LABORATOIRE INTERACTIONS, DYNAMIQUES ET LASERS

LIDYL-UMR 9222

CEA, CNRS, Université Paris-Saclay

SEMINAIRE LIDYL

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Attention Jour Inhabituel

**Le Mercredi 14 Juin 2017 à 10h30
- Bâtiment 522 - Salle 138**

"Studying Ultrafast Carrier Dynamics in Semiconductors using Attosecond Transient Absorption Spectroscopy"

Investigation of the ultrafast photoexcited electronic response in semiconductors has provided invaluable insights into carrier dynamics. Germanium and its alloys with Si have promise for creating multi-junction solar cells with higher efficiency and mid-infrared optoelectronics. However, the dynamics are complicated by multiple energetically similar valleys, rendering an understanding of carrier thermalization and population inversion following photoexcitation difficult. Attosecond transient absorption spectroscopy (ATAS) has recently been employed to probe ultrafast electron and hole dynamics in germanium at the $M_{4,5}$ -edge (~ 30 eV). In the experiment, a 5 fs VIS-NIR pump pulse excites carriers across the direct band gap and the dynamics are probed with a time-delayed broadband extreme ultraviolet pulse generated by high harmonic generation in xenon spanning ~ 20 -45 eV. The observed transient absorption signal contains the energetic distribution of both carriers, electrons and holes, due to state blocking as well as spectroscopic features induced by bandshifts (e.g. due to band gap renormalization) and broadening (e.g. due to many body effects). By iterative procedures the measured signal can be successfully decoupled into these contributions resolving the carrier and band dynamics with excellent time and energy resolution. Hot carrier relaxation on a 100-fs time scale and carrier recombination on a 1-ps time scale are observed in nanocrystalline Germanium. Oscillations observed in the retrieved bandshift signal, i.e. a modulation of the band gap, are associated with coherent phonon modes, and harmonic oscillations of the Transverse Optical phonon are clearly observed. The dynamics observed at the Ge M-edge are further utilized for studying carrier dynamics in Silicon-germanium alloy, where in addition carrier trapping in sub-band edge states is observed. Finally, prospects for transient studies of semiconductors using attosecond sources in transmission and reflection geometry will be discussed.

Formalités d'entrée :

Visiteur U.E. : Se faire connaître au moins 48 heures à l'avance pour l'établissement de votre autorisation d'entrée sur le Centre de Saclay.

Visiteur hors U.E. : Se faire connaître au moins 4 jours à l'avance pour les formalités d'entrée et se faire accompagner par un agent CEA.

Sans autorisation, vous ne pourrez entrer sur le Centre de Saclay. Tél. : 33.1.69.08.74.09- Fax : 33.1.69.08.76.39 - email : caroline.lebe@cea.fr ou veronique.gerecny@cea.fr
Dans TOUS LES CAS, se munir d'une pièce d'identité (passeport et carte d'identité - pas de permis de conduire)

References:

- [1] L. J. Borja, M. Zürich, C. D. Pemmaraju, M. Schultze, K. Ramasesha, A. Gandman, J. S. Prell, D. Prendergast, D. M. Neumark, and S. R. Leone, "Extreme ultraviolet transient absorption of solids from femtosecond to attosecond timescales," *J. Opt. Soc. Am. B* 33, 00C57 (2016).
- [2] H.-T. Chang, M. Zürich, P. M. Kraus, L. J. Borja, D. M. Neumark, and S. R. Leone, "Simultaneous generation of sub-5 femtosecond 400 nm and 800 nm pulses for attosecond extreme ultraviolet pump-probe spectroscopy," *Opt. Lett.* 41, 5365 (2016).
- [3] M. Zürich, H.-T. Chang, L. J. Borja, P. M. Kraus, S. K. Cushing, A. Gandman, C. J. Kaplan, M. Hwan Oh, J. S. Prell, D. Prendergast, C. D. Pemmaraju, D. M. Neumark, and S. R. Leone, "Direct and Simultaneous Observation of Ultrafast Electron and Hole Dynamics in Germanium," *Nat. Comm.* 8, 15734 (2017).
- [4] M. Zürich, H.-T. Chang, P. M. Kraus, S. K. Cushing, L. J. Borja, A. Gandman, C. J. Kaplan, M. Hwan Oh, J. S. Prell, D. Prendergast, C. D. Pemmaraju, D. M. Neumark and S. R. Leone, "Ultrafast Carrier Thermalization and Trapping in Silicon-Germanium Alloy Probed by Extreme Ultraviolet Transient Absorption Spectroscopy," *Struct. Dyn.* 4, in press (2017).
- [5] S. K. Cushing, M. Zürich, P. M. Kraus, L. M. Carneiro, A. Lee, H.-T. Chang, C. J. Kaplan, and S. R. Leone, "Valley-Specific Hot Phonon and Carrier Relaxation Pathways in Si(100) Determined by Transient Extreme Ultraviolet Spectroscopy," arXiv:1705.04393 (2017)

