Coherent control of injection current at surfaces and interfaces: Si(111) and GaAs(110), clean and with adsorbate

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Various coherent control experiments are based on the use of ultrafast optics. We demonstrate theoretically that the so-called one-beam coherent control effect (see, *e.g.* [1]) can be used as a new probe of surfaces and interfaces in cubic semiconductors with or without bulk inversion symmetry. The motivation is that surface sensitive non-invasive optical techniques as, *e.g.*, reflectance anisotropy spectroscopy (RAS) or second harmonic generation (SHG), crucial for understanding surfaces and interfaces, are not sensitive or cannot be applied to many important systems: RAS is not sensitive to, *e.g.*, optically isotropic Si(111), while SHG signal for III-V or II-VI cubic compounds is influenced by nonzero bulk contribution. The coherent control effect, which we propose, vanishes in the bulk of both homopolar and compound cubic semiconductors, but is allowed for most surfaces or interfaces due to their reduced symmetry. We calculated the injection current from the first principles for prototypical Si and GaAs surfaces, namely hydrogenated and clean Si(111)(2×1), and the clean and Sb-covered GaAs(110)(1×1). To get even more detailed access to the surface/interface properties, we applied a microscopic layer-by-layer formalism that separates the optical response from each subsurface atomic layer. The effect is shown to be sensitive to the surface or interface and its response can be explicitly interpreted in terms of the surface electronic structure. Calculated effect magnitudes indicate that the coherent control current should be easily observable experimentally and demonstrates distinctive photon energy dependence for all of the surfaces considered. This can be a very efficient surface sensitive technique since (i) the injection current originates only from the surface or interface of cubic systems, (ii) it can be easily extracted from any spurious photovoltaic backgrounds due to its dependence on the phase difference between two orthogonally polarized beams; (iii) the coherent control current response is essentially dependent on the microscopic atomic structure, surface symmetry, type of the bonding and adsorbate. Last but not least, this effect can be detected with terahertz radiation.

[1] N.Laman, A.I.Shkrebtii, H.M.van Driel, *et al*, Appl.Phys.L., **75** 2581 (1999).