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Effect of heavy noble gas ion irradiation on terahertz emission efficiency of InP (100) and (111) crystal planes

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Abstract

Emission of terahertz (THz) electromagnetic radiation from heavily-doped (5×10^{18} cm^{-3}) (100) and (111) InP bulk materials and nanoporous honeycomb membranes, irradiated with heavy noble gas (Kr and Xe) ions, is presented. Irradiating samples with Kr or Xe improves THz emission efficiency. For (111) samples, as for unirradiated samples, the irradiated porous structures generate more THz radiation than their bulk counterparts. On the other hand, in contrast to unirradiated (100) samples, the irradiated (100) samples show a decrease in THz emission with porosity. We attribute this behaviour to changes in the local electric field due to the combined effect of the irradiation and nanoporosity.

Keywords: terahertz, nanoporous, ion irradiation, optical rectification, transient current

(Some figures may appear in colour only in the online journal)

1. Introduction

Many semiconductor materials are capable of emitting THz radiation under excitation by ultrashort near-infrared (NIR) pulses. Such pulsed THz emission is guided by mechanisms which include the photoconductivity (PC) mechanism [1, 2], the transient current (TC) mechanism [3], and the optical rectification (OR) mechanism [4]. In the absence of any external bias, THz emission from bulk InP samples depends primarily on the doping type and doping level, with TC being the principal mechanism of THz generation [5]. The growth of pore structures on InP surfaces increases the nonlinear optical response and so THz generation, which may be attributed to strong local fields in the porous network [6]. THz conductivity measurements suggest that the nanoporosity considerably changes the dynamics of both extrinsic and photoexcited electrons [7]. A long carrier recombination lifetime and reduced electron mobility have been observed for nanoporous InP samples due to band bending at the pore surfaces [8]. Photoexcitation may reduce the density of surface states [9]. Improved THz emission has been reported for InP (100) and (111) nanoporous membranes [6, 10] and for ion-irradiated (111) InP nanoporous membranes [11]. In this paper, THz emission from bulk and nanoporous InP structures irradiated with Kr and Xe ions is presented. The comparison is made between bulk and nanoporous samples as well as between (100) and (111) InP samples with respect to different ion doses of Xe and Kr.

2. Experimental details

(100) and (111)-oriented n-InP substrates, 500 μm thick, with free electron concentrations of 5×10^{18} cm^{-3}, were used as the

