Chen, Liu, and Shen Reply: The authors of the Comment [1] mention that the bound phonon can be stable only under the condition that the impurity transition energy is higher than $\hbar\omega_{\mathrm{LO}}$, while this condition is not fulfilled at low fields used in Ref. [2]. They further argue that a n-GaAs layer at low temperature acts as a bolometer.

It is true that most experimental results of bound phonons were achieved under the condition that impurity transition energy is larger than $\hbar\omega_{\mathrm{LO}}$. This kind of bound phonon is indeed stable. But, nevertheless, the microscopic bound phonon theory generalized by Rashba [3] has demonstrated that the bound phonon can also be formed as a quasibound state when the impurity transition energy is smaller than $\hbar\omega_{\mathrm{LO}}$, this microscopic theory is, for now, the unique quantitative quantum model for bound phonons. Besides, there already is an experimental result indicating the existence of such a bound phonon [4], or the so-called quasilocalized mode [3]. Such a quasilocalized mode is known as metastable states, which would relax into extended states and have been observed in many different systems as different quasiparticles [5]. The observation of many metastable electronic states of impurities under magnetic fields [2,6] also supports our attribution of the photoconductivity (PC)structure near $\hbar\omega_{\mathrm{LO}}$ to the presence of the metastable bound phonons, the quasiparticles of impurities electron and phonon.

A bolometer is one type of thermal detector, whose PC mechanism is, up to now, ambiguous, but, nevertheless, it is generally believed that the PC mechanism of the bolometer is mainly due to phonon and free electron absorption. The line shape of the simulated peaks due to phonon absorption in Ref. [1] is not completely in agreement with the experimental results. In Fig. 2 of Ref. [2], note that the observed PC responses at either 290 or 350 cm^{-1} approximately correspond to zero (noise limitation). There are no observable PC responses below 293 cm^{-1} (within a reststrahlen band) [2], while the simulated results [1] show large power absorption tails below 293 cm^{-1}, which can also be expected from the experimental absorption and reflectivity spectra of GaAs [7]. This fact is strongly against the assumption of bolometric effect due to phonon absorption, as suggested in Ref. [1]. In addition, our measurement is the standard technology of photothermal ionization spectroscopy [8]. It is not likely that our GaAs sample acts as a bolometer due to free electron absorption. Otherwise, a remarkably wide PC response should appear in the lower energy region ($<\hbar\omega_{\mathrm{LO}}$) [8]. However, this is not the case in our experiment. Moreover, note that absorptivity is not always equivalent to the PC response. The variance in absorptivity near $\hbar\omega_{\mathrm{LO}}$ due to phonon absorption cannot induce the change of conductivity of n-GaAs at 4.2 K since our GaAs sample cannot act as a bolometer (as discussed above) and the transition probability from the $1S$ state to the conduction band landau levels is nearly zero at about $\hbar\omega_{\mathrm{LO}}$ in GaAs (as we observed).

Of course, dielectric artifacts can affect the PC structure. In a multilayer structure, strong phonon absorption within the reststrahlen band can remarkably distort the absorption line shape near the reststrahlen band [9], while such dielectric distortion in bulk semiconductor is not pronounced [10]. In bulk samples, the dielectric artifacts could influence the line shape of the PC structure near $\hbar\omega_{\mathrm{LO}}$. However, it does not really affect our assignment of the structure near $\hbar\omega_{\mathrm{LO}}$ as the presence of the bound phonons. At zero field, a pinning peak at about $\hbar\omega_{\mathrm{LO}}$ shows the nearly same line shape as that at 5.3 T (shown in Ref. [2]). Its intensity is of the order of α (Fröhlich coupling constant of GaAs 0.068) of the impurity transition responses lying at the low frequency region, though under a nonresonant condition. This cannot be explained by the dielectric artifacts; on the contrary, it is in good agreement with the prediction of the bound phonon theory considering multiphonon processes [3].

In conclusion, the PC spectroscopy of a high purity n-GaAs layer at 4.2 K [2] cannot be completely simulated as a bolometer. The dielectric artifacts might not correspond to the observed pinning PC structure near $\hbar\omega_{\mathrm{LO}}$ in the whole magnetic field range. The observed structure near $\hbar\omega_{\mathrm{LO}}$ under magnetic fields (including zero field) and their evolution can be understood as the presence of the metastable bound phonons, the quasilocalized modes [2].

Zhonghui Chen, Pulin Liu, and S. C. Shen
National Laboratory for Infrared Physics
Shanghai Institute of Technical Physics
Academia Sinica, Shanghai 200083, China

Received 1 October 1997 [S0031-9007(98)07228-7]
PACS numbers: 63.20.Mt, 71.38.+i, 78.20.Ls

[1] M. L. Sadowski *et al.*, preceding Comment, Phys. Rev. Lett. **81**, 2834 (1998).
[2] Zhonghui Chen *et al.*, Phys. Rev. Lett. **79**, 1078 (1997).
[3] È. I. Rashba, Pis'ma Zh. Eksp. Teor. Fiz. **15**, 577 (1972) [JETP Lett. **15**, 411 (1972)]; P J. Dean *et al.*, Phys. Rev. Lett. **25**, 1027 (1970); M. A. Kanehisa *et al.*, Phys. Rev. B **31**, 6469 (1985); Y. B. Levison *et al.*, Rep. Prog. Phys. **36**, 1499 (1973).
[4] C. H. Henry *et al.*, Phys. Rev. B **6**, 2233 (1972).
[5] S. C. Shen *et al.*, Phys. Rev. B **22**, 2913 (1980); S. C. Shen and M. Cardona, Solid State Commun. **36**, 327 (1980).
[6] Zhanghai Chen *et al.*, J. Appl. Phys. **81**, 6183 (1997); P. W. Barmby *et al.*, Phys. Rev. B **54**, 8566 (1996).
[7] A. Mooradian *et al.*, Solid State Commun. **4**, 431 (1966); E. S. Koteles *et al.*, Can. J. Phys. **54**, 1676 (1976).
[8] G. E. Stillman *et al.*, Semicond. Semimet. **12**, 169 (1977).
[9] J. P. Cheng *et al.*, Phys. Rev. Lett. **62**, 1925 (1989).
[10] J. P. Cheng *et al.*, Phys. Rev. B **48**, 7910 (1993); M. Grynberg *et al.*, *ibid.* **54**, 1467 (1996); R. Kaplan *et al.*, Phys. Rev. Lett. **20**, 1499 (1968).

