Comment on "Electron–Optical-Phonon Interaction in Semiconductor Multiple-Quantum-Well Structures"

In a recent Letter, Chang *et al.*[1] reported on a magneto-optical study of the $1s \rightarrow 2p^+$ transition for on-well-center shallow donors in GaAlAs-GaAs multiple quantum wells (MQW). The experiments have been done in a *frequency-sweep arrangement* using a Fourier-transform spectrometer (FTS) in order to investigate the electron–optical-phonon interaction. The authors claimed to observe a resonant polaron "pinning" behavior at an energy well below those of the zone-center longitudinal-optical (LO) and transverse-optical (TO) phonons. It is the purpose of this Comment to propose that this observation is not due to the electron-phonon interaction but to a dielectric artifact.

Recently, we have independently reported on a similar study.[2] Our experiments were done in a *magnetic-field-sweep* arrangement using a far-infrared laser (FIRL). A plot of our measured peak positions of the $1s \rightarrow 2p^+$ transitions for on-well-center donors is given in Fig. 1 together with the FTS results of Ref. 1. It can be seen that both sets of experimental data behave the same way below 25 meV: The data of Ref. 1 lie at slightly lower energies because of the wider wells. Above 25 meV, the FTS data quickly and strongly deviate from the FIRL data and give one the impression of a resonant polaron pinning well below the reststrahlen band of GaAs. This is direct proof for a dielectric artifact in the FTS experiment, as has been previously discussed in the case of the cyclotron resonance in thin (200 Å) InAs quantum wells sandwiched between GaSb layers[3] and GaInAs-based heterojunctions.[4]

In Ref. 1, a dielectric artifact was ruled out on the basis of the different behavior of "bulk" and confined impurities. This argument is, however, not correct. In the MQW the electronic transitions take place in repeated "Fabry-Perot" resonators formed by the GaAlAs barriers sandwiching the GaAs wells. In the vicinity of TO energies, the optical indexes become very high in both materials, but sufficiently different for the interfaces acting as semitransparent mirrors. Inside this Fabry-Perot structure, the intensity of the electromagnetic wave varies with the z component along the growth direction in a way which is also strongly frequency dependent in a FTS experiment. The electronic contribution to the optical response of the system is then strongly distorted by the resonant phonon contribution[3,4]: This is just what is observed in Ref. 1. This is no longer the case when the electronic transitions take place outside the Fabry-Perot structure, in the buffer layer for instance. Thus the dielectric artifact exists only in the MQW structure. We have shown that such a problem is considerably less critical in FIRL experiments.[4]

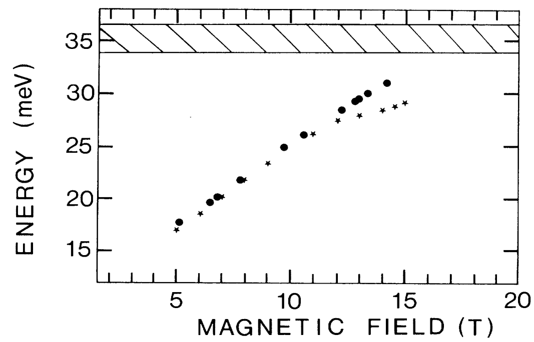

FIG. 1. Field positions of the $1s \rightarrow 2p^+$ transitions for on-well-center donors in the MQW structures. The stars are the FTS data (Ref. 1) (well width, 138 Å) and the circles are the FIRL data (Ref. 2) (well width, 100 Å). The hatched zone denotes the GaAs reststrahlen band; "GaAs-like" optical phonons in GaAlAs have energies slightly less (~1 meV) than in GaAs.

In conclusion, we suggest that bound resonant polarons in MQW have not been observed in Ref. 1 and that there is thus no need to invoke polaron coupling with zone-boundary LO phonons nor to suggest a reexamination of the Fröhlich model for MQW structures.[1] Indeed, we have observed bound resonant polarons in MQW and this model can explain our results.[2]

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[1] Y.-H. Chang *et al.*, Phys. Rev. Lett. **61**, 1408 (1988).
[2] S. Huant, W. Knap, G. Martinez, and B. Etienne, Europhys. Lett. **7**, 159 (1988).
[3] M. Ziesmann, D. Heitmann, and L. L. Chang, Phys. Rev. B **35**, 4541 (1987).
[4] K. Karrai, S. Huant, G. Martinez, and L. C. Brunel, Solid State Commun. **66**, 355 (1988).