Ourmazd and Cunningham Reply: According to Deveaud himself (Ref. 1, p. 1635), an essential consequence of the atomically smooth model is that, as a laser spot is moved over a sample with a single quantum well, the individual photoluminescence (PL) lines should remain fixed, retaining energy separations corresponding to discrete monolayer changes in the well width. In *all* the quantum wells we have studied (obtained from several sources), the PL and PL-excitation line splittings vary *substantially* as the laser spot is moved.[2] For example, the splitting between the PL lines in a "21 ML" quantum well[3] changes by nearly 40% over the area explored (Fig. 1).[2] (The error bars include the effect of composition changes in the barrier, measured at every point by PL.) According to Deveaud's own paper (Ref. 1, p. 1638) fluctuations in the mean island size affect the splitting only when the island size is comparable with the exciton diameter (~300 Å). We observe variations in the splitting even in samples where micron size islands have been claimed. Thus luminescence experiments themselves render the atomically smooth model untenable.

To determine the effect of radiation damage, we have irradiated with 400-keV electrons a variety of high-quality GaAs/AlGaAs interfaces (including those showing PL line splitting), and measured the composition profiles across the interfaces as a function of irradiation dose (Fig. 2). Even after a 15-min irradiation at 400000× magnification, no broadening occurs in the interfacial profile. (We typically record images within 5 min at 400000×.) The point here is not that radiation damage does not occur, but that *the imaging process does not cause radiation-induced interdiffusion in our samples.*

The references cited by Deveaud do not support his other contentions: (i) Figure 4 of the paper by Petroff *et al.*[4] characterizes tilted superlattices as AlAs-rich and GaAs-rich layers, rather than pure binary compounds; (ii) the x-ray references do not establish the absence of alloying effects in short-period superlattices. Indeed, every careful x-ray analysis has indicated the presence of an interfacial region of intermediate composition.[5] Deveaud can observe interfacial steps only when layers are grown on miscut substrates and the steps are parallel to the electron beam, because their chemically insensitive lattice images can detect a composition change only when an *entire* atomic column of Ga is replaced with Al. In our experiments, the replacement of a single Ga atom with Al produces ~2σ signal, and can be detected with ~80% confidence.[3] With this sensitivity a step can always be detected, whether parallel to the beam direction or not.

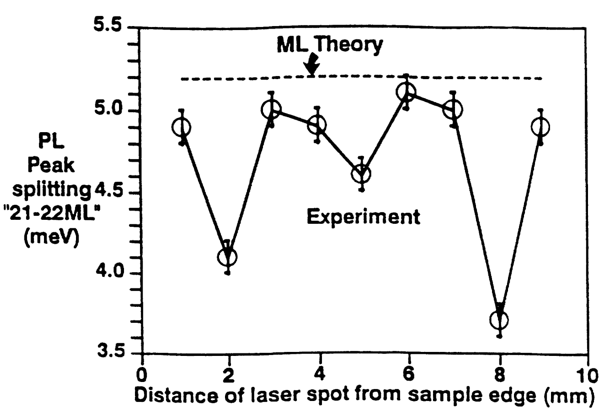

FIG. 1. Splitting between the "21 ML" and "22 ML" PL lines in a quantum well (Ref. 3), as a function of the position of the laser spot on the sample (Ref. 2).

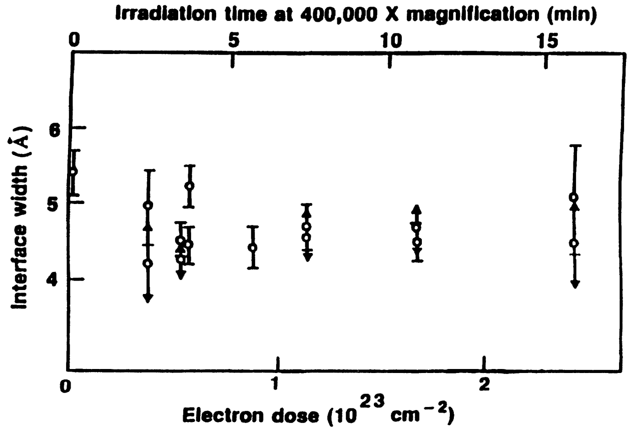

FIG. 2. Width of a GaAs/AlAs interface vs 400-keV electron dose. Different measurements at a given dose refer to different parts of the interface. Because of atomic roughness, the interface width varies from area to area. Note that the interface width does not change with electron dose.

In conclusion, the interpretation of PL data in terms of atomically smooth interfaces is in disagreement with optical *and* quantitative microscopic data, and thus untenable.

We are grateful to C. A. Warwick, M. Bode, A. Bourret, and J. Shah for valuable discussions.

A. Ourmazd and J. Cunningham
AT&T Bell Laboratories
Holmdel, New Jersey 07733

Received 28 December 1989
PACS numbers: 68.55.Nq, 61.16.Di, 68.35.Dv, 68.65.+g

[1]B. Deveaud *et al.*, J. Appl. Phys. **59**, 1633 (1986).
[2]C. A. Warwick *et al.*, Appl. Phys. Lett. **56**, 2666 (1990).
[3]A. Ourmazd *et al.*, Phys. Rev. Lett. **62**, 933 (1989); Science **246**, 1570 (1989).
[4]P. M. Petroff *et al.*, J. Cryst. Growth **95**, 260 (1989).
[5]R. M. Fleming *et al.*, J. Appl. Phys. **51**, 357 (1980); J. M. Vandenberg *et al.*, J. Appl. Phys. **62**, 1278 (1987).