Johnson, Herring, and Chadi Reply: We were already aware[1] that inhomogeneous doping influences the detailed quantitative interpretation of our experiment[2] and had performed calculations to assess the possibility that hydrogenation merely introduces compensating acceptors, without neutralizing the shallow donors. In this Reply we shall comment briefly on the physical plausibility of various compensation hypotheses and report new results, which were stimulated by our calculations and the recent discovery of H-induced defects in silicon[3] and which eliminate depth-inhomogeneity uncertainties.

Iyer and Kumar[4] (IK) consider two possible effects of hydrogenation: (1) introduction of charged acceptors at a fixed fraction of the donor density throughout the *n* region and (2) passivation of a large fraction of the original shallow acceptor dopants near the metallurgical junction. For the former effect, our calculations based on comparable assumptions are in general agreement with theirs: For conductance reductions in the range observed, this model of compensation predicts a slight *decrease* in $\mu_{\mathrm{H,eff}}$. This accords with our proposal[2] that the observed increase in Hall mobility after hydrogenation favors neutralization of donor dopants rather than compensation.

The second effect considered by IK we consider to be quite implausible in our experiment. Their calculations demonstrate that $\simeq 99\%$ of the boron near the *p-n* junction must be passivated to simulate our results quantitatively (for an erroneously assumed boron density of $7\times10^{16}\ \mathrm{cm}^{-3}$). Dopant profiles have been published[5] on identically doped and implanted silicon that was subjected to the same deuteration treatment as that of Ref. 2 but for an even longer time. Those results reveal that boron neutralization is suppressed within the depletion region, which extends from the metallurgical junction into the *p*-type substrate, and that the acceptor concentration immediately beyond the depletion layer is reduced by only $\simeq 30\%$ for zero bias (see Fig. 2 in Ref. 5). Thus, we conclude that compensation patterns of the type considered by IK cannot provide a physically plausible explanation of our experimental results.

We have examined additional compensation models based on an idea not considered by IK; namely, the degree of compensation introduced by hydrogenation may vary strongly with depth *within* the *n* region. Such models can indeed predict a modest increase in $\mu_{\mathrm{H,eff}}$ upon hydrogenation.

To test for possible inhomogeneity-compensation effects, we have performed transport measurements on new homogeneously doped *n*-type layers. The material consisted of arsenic-doped layers ($\simeq 0.75\ \mu$m thick) epitaxially grown on *p*-type (35–75 Ω cm) silicon. The measurements were performed at room temperature on square van der Pauw devices with corner Ohmic contacts. The effective areal electron density $n_{S,\mathrm{eff}}$ and the effective Hall mobility $\mu_{\mathrm{H,eff}}$ are listed in Table I for epitaxial layers before and after hydrogenation (H, 150 °C, 2 h). Also included are measurements performed after chemical removal of $\simeq 0.16\ \mu$m of the epilayer. The data were analyzed[6] to obtain the following values for the *removed* surface layer: $n_{S,\mathrm{eff}} = 1.4\times10^{12}\ \mathrm{cm}^{-2}$ and $\mu_{\mathrm{H,eff}} = 740\ \mathrm{cm}^2/\mathrm{V\text{-}s}$. The tabulated values have not been corrected for either electrode geometry or the Hall factor, which will change the absolute magnitudes but not the relative values. The results clearly demonstrate that hydrogenation reduces $n_{S,\mathrm{eff}}$ and increases $\mu_{\mathrm{H,eff}}$ in the epilayer and that these effects are particularly pronounced in the surface region of the epilayer. Thus, hydrogen passivation varies with depth within the uniformly doped epilayer, but the effect on carrier transport remains consistent with reduced ionized impurity scattering due to neutralization of donor dopants. A remaining recently identified issue[3] concerns the possible effect of H-induced three-dimensional inhomogeneities on carrier transport. However, the fundamental issue of hydrogen neutralization of shallow donors in silicon will be most convincingly resolved with spectroscopic techniques.

TABLE I. Hydrogenation of As-doped epilayers on Si.

Treatment	$n_{S,\mathrm{eff}}$ (cm^{-2})	$\mu_{\mathrm{H,eff}}$ ($\mathrm{cm}^2/\mathrm{V\text{-}sec}$)
Starting epilayer	4.38×10^{13}	410
Thinned epilayer	3.44×10^{13}	410
Hydrogenated epilayer	2.37×10^{13}	510
Epilayer thinned after hydrogenation	2.26×10^{13}	489

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