DISCUSSION

W. G. Johnston and J. H. Rosolowski[1] –Some of the predictions regarding void-free zone widths in heavy ion experiments are at variance on stainless steels bombarded with 5-MeV nickel ions [*14*]. We have on several occasions back-thinned all the way to a bombarded surface, and in each case we have seen voids quite close to that surface. For example, in Type 304 steel bombarded at 550 C (1022 F) there were voids within 500 Å of the surface, and in Type 321 steel bombarded at 625 C (1157 F), there were voids less than 600Å from the bombarded surface. The claim that the surface denuding would invalidate bombardments at 650 C (1202 F) with 3.5-MeV nickel ions thus seems somewhat extreme in view of our experience. Most of our 5-MeV nickel work has been at 625 C (1157 F) and below. However, a void-free zone of even 600 Å at 625 C, when multiplied by the factor of two (given by the authors as the extent of surface influence) and then scaled to 725 C (1337 F) with the temperature dependence they have shown, implies that the 5-MeV nickel bombardments could be slightly affected by surface proximity at the latter temperature.

It is apparent from comparison of HVE and heavy ion damage that voids are formed at much lower displacements per atom with HVE. This difference apparently arises because the total number of displacements are reported for each type of bombardment, and the HVE create mostly single-defect pairs while the heavy ions produce cascades in which only a fraction of the vacancies and interstitials survive to take part in void formation. Since damage by fast neutrons involves extensive cascade formation, heavy ion bombardments should provide a somewhat better simulation of reactor damage than HVE bombardments, in which there are no cascades. Is it possible that this difference of cascade formation by heavy ions but not by HVE can result in different widths of void-free zones in the two types of experiments?

F. A. Garner and L. E. Thomas (authors' closure)–The void-free zone widths quoted for the HVEM and ion studies are not as inconsistent as they first appear. Our correlation predicts zone widths of 0.30 and 0.56 μm at 550 and 625 C (1022 and 1157 F) for our calculated dose rate of 6 dpa/h. As mentioned in this paper, we anticipate an inverse square-root dependence of the zone width on

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dose rate and note that your ion experiments were run at one of the highest dose rates ever reported. If we recalculate the HVEM displacement rate on the same basis (that is, using a 33-eV displacement threshold), there is a factor of more than twenty difference in the peak dose rates for the two experiments. If we had used a comparable dose rate, we would expect denuded zones of 0.063 and 0.116 μm compared with your observations of 0.050 and 0.060 μm at the same temperatures.

This is rather fair agreement considering the uncertainties associated with the calculation of the dose rates of the two bombarding species, and the uncertainties associated with other experimental variables such as temperature. Note that the HVEM defect production rate is essentially constant with depth while the ion-produced profile varies strongly, and that 1-MeV electrons produce single Frenkel pairs while ions create defect cascades. Due to these and other differences it is difficult to extrapolate directly from HVEM results to make zone width predictions for ion bombardments. We are convinced, however, that experiments using 3.5-MeV ions at lower dose rates are influenced by surface effects, particularly for temperatures above 600 C (1112 F).