ions the volume of the cascade decreases by about an order of magnitude, and the maximum density of deposited energy increases by about the same factor.

The work of English *et al.*[9] and English (unpublished), has highlighted the difficulty of cascade collapse in another b.c.c. metal, molybdenum. It was found that the defect yield produced by heavy-ion bombardment was dependent on both the irradiation temperature and on the mass of the incident ions. For 60-keV Mo^+ ions the defect density decreased at irradiation temperatures >200 °C. This decrease cannot be explained on a vacancy-emission mechanism, where cascades are assumed to collapse athermally and then shrink by vacancy emission, nor by loop loss to the surface. The former mechanism had been successful in explaining the decrease in defect density in copper irradiated at high temperatures with 30-keV Cu^+ ions[10]. It seems that in self-ion irradiation of molybdenum the collapse process is itself temperature dependent. Further experiments with 60-keV Xe^+ and W^+ ions have, however, shown that the defect density in these cases remains unchanged at temperatures up to 425 °C, the highest irradiation temperature which could be achieved. It would seem, therefore, that in b.c.c. materials there is a sensitive balance between the collapse of vacancies in a cascade to a vacancy loop or their retaining an uncollapsed distribution and perhaps dispersing in the lattice.

Our results suggest that an important parameter in determining whether or not cascade collapse occurs in α Fe is the energy density or compactness of the cascades. The results from Mo irradiated with heavy ions at high temperatures provide further support for this concept and also suggest that an important and closely associated factor could be the rate at which vacancies diffuse out of the cascade centre into the surrounding crystal. There is considerable doubt regarding the temperature range for long range vacancy migration in α Fe and thus we are not able to separate this factor from the energy density factor in the present results. We plan to clarify this by irradiating iron specimens with ions of different masses at 77 K. The results from pure f.c.c. metals and alloys suggest that energy density in the cascade is a less critical factor governing cascade collapse than for b.c.c. metals. Nevertheless, there is a marked trend for higher cascade collapse efficiencies on going to heavy metals irradiated with self ions, $Cu/Cu^+ \rightarrow Ag/Ag^+ \rightarrow Au/Au^+$. Moreover, Häussermann[11] has shown that in ion-irradiated copper the efficiency of cascade collapse to vacancy loops is higher for Au^+ ions that for Cu^+ ions, while Ruault *et al.*[12] have shown that in ion-irradiated gold the nature of the collapsed defects is also a function of ion mass. It seems, therefore, that energy density and cascade compactness are important parameters governing the development of damage structures in irradiated metals and their influence needs to be better understood.

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Mechanical forces of electromagnetic origin

EXPERIMENTS have been reported which verified that at low frequencies a time-varying polarisation P in a dielectric, if taking place in a magnetic field H, results in a mechanical force of density $\dot{P} \times \mu_0 H$. This force is not predicted by the Minkowski energy momentum tensor, but the Abraham form of that tensor gives a force density in an homogeneous isotropic body of magnitude

$$[(\varepsilon_r \mu_r - 1)/c^2] \ \frac{\partial}{\partial_t}(E \times H)$$

usually called the 'Abraham Force'. In a dielectric this can be written $\dot{P} \times \mu_0 H + P \times \mu_0 \dot{H}$. It is not surprising that $\dot{P} \times \mu_0 H$ should give a mechanical force, since P corresponds to a movement of electric charge associated with polarisation, but it is difficult to understand why $P \times \mu_0 \dot{H}$ should give a force.

To try to obtain experimental evidence of this effect, the same equipment was used as previously[1,2], namely a disk of barium titanate suspended as a torsional pendulum between the poles of a powerful electromagnet, the only change from the previous experiment was to hold P fixed but to vary H with time at the same frequency as the oscillation of the disk. Great difficulties were caused by the magnet system. A considerable coupling of energy to the pendulum resulted from mechanical vibrations in the magnet coils and there may also have been electromagnetic coupling because of small geometrical imperfections in the system. To avoid such resonance effects, we devised the following procedure.

If E and H have the same frequency, then, irrespective of their phase relationship, the time average of the Abraham Force is always zero. Thus if E and H are in time quadrature and if in fact $P \times \mu_0 \dot{H}$ produces no mechanical force, there should be a time-averaged unidirectional force given by $\dot{P} \times \mu_0 H$. In the experiment, E and H were in time quadrature but at a frequency about 250 times the resonant frequency of the pendulum, thereby avoiding parasitic coupling from the magnet system. It was arranged that the direction of the electric field applied across the disk was reversed at the instants when the torsional pendulum reversed in its direction of motion, thereby ensuring that the applied force (if any) would always assist the oscillation of the pendulum. If no oscillation beyond the noise level resulted, the Abraham Force would be verified. In fact, a strong oscillation was observed which agreed closely (within 4%) with the amplitude predicted by the term $\dot{P} \times \mu_0 H$ acting alone.

Full details will be published elsewhere, but we conclude that neither the Minkowski tensor nor the Abraham tensor is consistent with the observed effects.

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High resolution image of copper phthalocyanine

WE report here the successful high resolution of organic material by electron microscopy, a technique extremely sensitive to electron irradiation. As is well known, an inevitable factor that limits such high resolution microscopy is severe radiation damage, and, therefore, the electron beam must be reduced very much below the critical dose to prevent higher order details from fading. As a result, one cannot get high contrast