

dimension. It might also be possible to obtain larger reductions for slow local decrease in K instead of the step-function (4).

At nucleation something similar to a domain wall is found in the case studied but this has not freedom of movement and therefore does not change the magneti-

zation. It seems that in the case (5) a wall nucleated might move more easily, but in that case the nucleation field is³ rather large for reasonable defect dimensions. A combination of (4) and (5) might therefore give an easy nucleation of movable wall and therefore a much higher decrease in the coercive force.

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Etch Pits on Dendritic Germanium. A Clarification

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Previous reports by Billig and Holmes of the orientations of etch pits on the main faces of germanium dendrites are not at first sight consistent with those recently reported by Bennett and Longini. It is shown that this discrepancy arose because the orientation of equilateral pits on $\{111\}$ surfaces depends on the etchant used. A check on the earlier work confirms that there is in fact no contradiction: ferricyanide and WAg etches produce pits which point upwards on "perfect" faces grown in a " G direction," while superoxol and similar etchants give pits pointing downwards.

A RECENT publication by Bennett and Longini¹ has brought to light some confusion, concerning the directions in which triangular pits point on etched dendritic germanium, in the reports originally published from this Laboratory.^{2,3} These contained an error which is attributable to the fact that, at the time, it was not appreciated that the direction is also dependent on the actual etchant employed. On $\{111\}$ surfaces, the WAg and ferricyanide etches form equilateral pits which appear, in plan, as if they were bounded by facets of $\{111\}$ form, although they are actually much shallower.⁴ The No. 2 (Superoxol) etch, and others with the same components, give equilateral pits which resemble, in plan, $\{100\}$ facets. The edges of these two types of pit are both $\langle 1\bar{1}0 \rangle$ lines, but their apices point in opposite directions (Fig. 1).

The structure diagram in reference 2 (p. 357) does, in fact, show clearly what the orientation of " $\{111\}$ " type pits should be on the "perfect" and "imperfect" faces: they should always point upwards and downwards, respectively. The directions illustrated are, however, correct for " $\{100\}$ " type pits. Likewise in reference 3, the drawings of x-ray diffraction patterns are correct for the faces illustrated (one $\{111\}$ point would be $70\frac{1}{2}^\circ$ above the center on the "perfect" face, indicating an upwards tilt of this plane), but the etch pit directions shown are only correct for " $\{100\}$ " pits. The results of Bennett and Longini, whose dendrites contain an odd number of twin planes and therefore have two faces grown in the orientation corresponding to our "perfect" faces, are thus in accordance with this scheme: the WAg

etch gives pits pointing upwards on both sides of the specimen.

Our use of the term "imperfect" to describe the development of faces of the opposite orientation is a relative one, and careful reading of reference 2 reveals no mention of asterism in x-ray photographs, which were all taken by the present author; no distortion of the

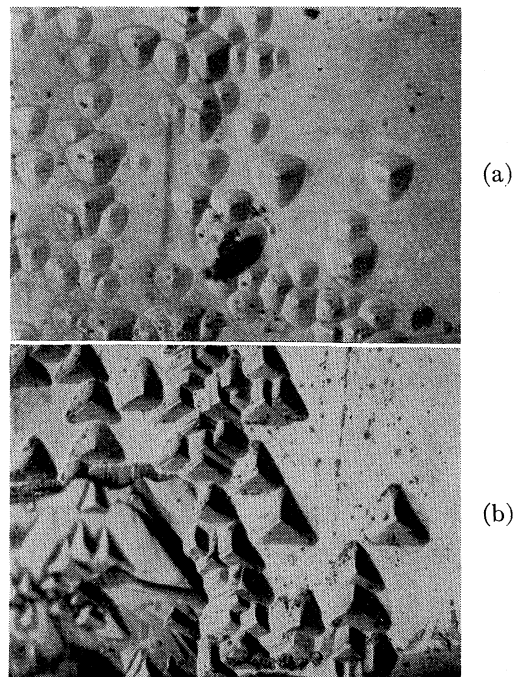


FIG. 1. (a) (above) Ge dendrite, "perfect" face, etched with 1 HF:1 H₂O₂:64 H₂O for 10 min. (b) (below) Same area, re-etched with ferricyanide etch for 1½ min. (×280).

¹ A. I. Bennett and R. L. Longini, *Phys. Rev.* **116**, 53 (1959).

² E. Billig, *Proc. Roy. Soc. (London)* **A229**, 346 (1955).

³ E. Billig and P. J. Holmes, *Acta Cryst.* **8**, 353 (1955).

⁴ P. J. Holmes, *Acta Met.* **7**, 283 (1959).

Laue spots was found, though a well-defined strip of reduced reflected intensity appeared on photographs of the region containing the center-line of hillocks. This region shows up on *both* faces of the dendrite after etching as a dense band of etch pits.

It seems to us that the experimental evidence published on dendrite growth directions and relative perfection of faces from both Laboratories can quite well be explained on a basis of a twin nucleation process as described by Bennett and Longini, followed by either extensive or limited overgrowth of further (111) planes according to Billig and Holmes's mechanism. Obviously, with two or more parallel twin planes, the easy directions of nucleation are doubled in number: if existing dendrites are used as seeds, those containing twin

lamellae are thus twice as likely to propagate downwards as those with only one twin plane.

It is hoped that this note will clarify the situation as regards the etch pits on dendritic germanium; there is in fact no difference between the two sets of experimental observations on this point. The need for emphasizing that not all etch pits have facets approximating to {111} form is borne out by the error into which we ourselves had fallen in preparing illustrations from, and describing a specimen which had been etched differently from the majority.

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Paramagnetic Resonance Spectrum of Manganese in Corundum*

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The paramagnetic resonance spectrum of Mn^{2+} in Al_2O_3 was measured at 3 cm. The spectrum can be expressed in a spin Hamiltonian with trigonal symmetry with the following parameters: $g_{||} = 2.0017 \pm 0.001$, $g_{\perp} = 2.000 \pm 0.002$, $D = +194.2 \pm 1$, $a - F = +21.9 \pm 0.6$, $A = -79.6 \pm 0.5$, $B = -78.8 \pm 0.8$ in units of 10^{-4} cm^{-1} .

INTRODUCTION

THE chromium and iron spectra have been investigated intensively in the trigonal crystal field of aluminum oxide.¹⁻⁴ Recently also the spectrum of trivalent vanadium has been investigated.^{5,6}

It was of interest to see whether divalent ions can be incorporated in the lattice of aluminum oxide and to what extent this may influence the point symmetry. Some investigations in this direction have been made by the Michigan group.⁷ These authors find that V^{3+} can be reduced to divalent V^{2+} in the lattice of Al_2O_3 upon irradiation. Geusic also investigated the spectrum

of divalent cobalt in this lattice.⁸ We wish to report results on divalent manganese in a single crystal of aluminum oxide.^{8a} These results are of interest since they permit a comparison of the magnitude of the initial splitting with that of trivalent iron.

RESULTS

We have investigated the paramagnetic resonance spectrum at 3-cm wavelength and at room temperature, on a single crystal of Al_2O_3 containing manganese.^{8a}

The paramagnetic resonance spectra can be expressed in a simple spin Hamiltonian having the same trigonal symmetry as trivalent iron. This Hamiltonian can conveniently be written as

$$\mathcal{H} = g\beta\mathbf{H} \cdot \mathbf{S} + B_2^0 O_2^0 + B_4^0 O_4^0 + B_4^{*0} O_4^{*0} + B_4^{*4} O_4^{*4} + A(\mathbf{S} \cdot \mathbf{I}), \quad (1)$$

where O_n^m are the following spin operators

$$\begin{aligned} O_2^0 &= 3S_z^2 - S(S+1), \\ O_4^0 &= 35S_z^4 - [30S(S+1) - 25]S_z^2 \\ &\quad - 6S(S+1) + 3S^2(S+1)^2, \\ O_4^4 &= (1/2)(S_+^4 + S_-^4). \end{aligned}$$

* J. E. Geusic, Bull. Am. Phys. Soc. 4, 1260 (1959).

^{8a} We are grateful to Dr. C. Pitha of Cambridge Air Force Research Center for providing us with this crystal.

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† On leave from the Atomic Energy Commission of Israel.

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⁷ J. Lambe, R. Ager, and C. Kikuchi, Bull. Am. Phys. Soc. 4, 1260 (1959).

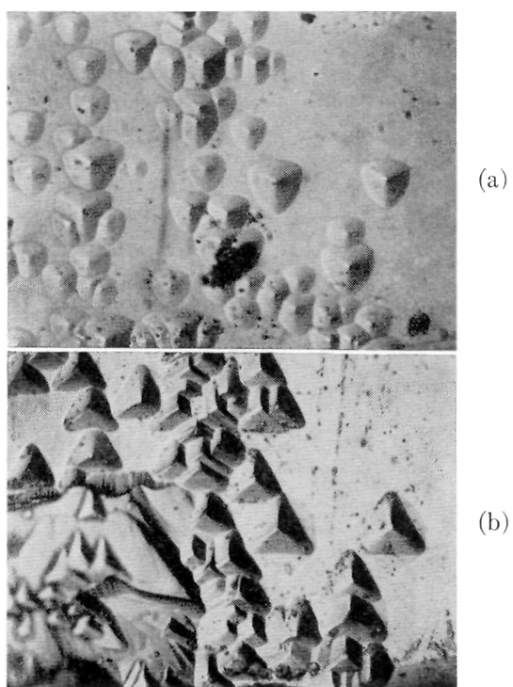


FIG. 1. (a) (above) Ge dendrite, "perfect" face, etched with 1 HF :1 H_2O_2 :64 H_2O for 10 min. (b) (below) Same area, re-etched with ferricyanide etch for $1\frac{1}{2}$ min. ($\times 280$).