When a collection of thin whiskers was thoroughly disintegrated in a few drops of water, poured onto a holder glass and dried, the X-ray diffraction diagram showed only one peak assigned to the (2 2 0) plane (Fig. 10c); therefore, the growth axis is supposed to be ⟨1 1 1⟩ or ⟨1 0 0⟩. Thick pillar-shaped crystals grown at a temperature above 1200° C showed the same diffraction profile as the thin whiskers, which had an appearance of square pillars with an average size of 0.5 μm edge length (Fig. 11). On the basis of these observations on crystal shape, the growth direction of the whiskers is considered to be ⟨1 0 0⟩, being in agreement with that reported by Miyoshi *et al.* [3].

Impurity metals such as platinum, iron and manganese form low eutectic binary alloys with zirconium or nitrogen as can be seen in Table I. Since zirconium nitride whiskers grew exclusively in the presence of impurity metals, their growth mechanism must be closely connected with the VLS mechanism. In Fig. 11, the tips of pillar-shaped crystals are shown on which a short-thin whisker with a droplet can be seen, and the growth procedure is supposed to be that of the VLS mechanism in the axial direction, followed by VS growth in the radial direction.

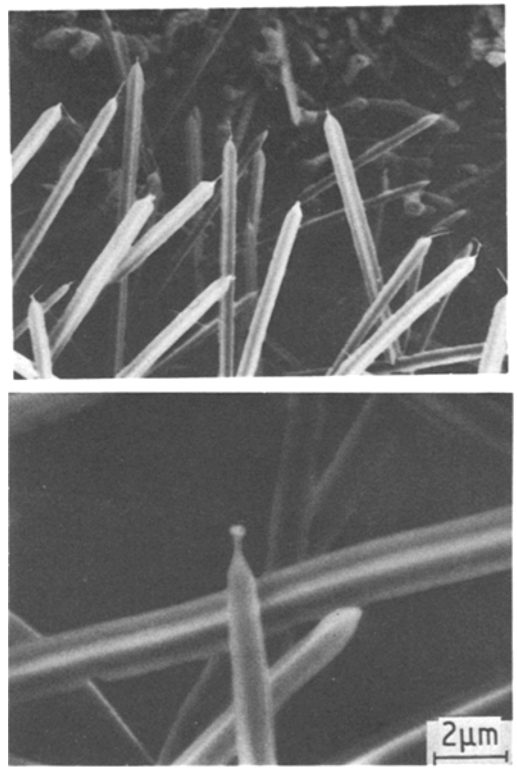

Figure 11 The tip of a whisker.

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On the thermal fracture of ice

Brittle materials are susceptible to catastrophic failure induced by thermal stresses. This is well known for ceramic materials in engineering applications which involve relatively high temperatures [1]. Thermal fracture, also occurs in ice, which can fail in a brittle manner even at temperatures close to its melting point. Thermal fracture of ice can be demonstrated experimentally by the immersion of ice-cubes in water or alcohol. The resulting thermal fracture frequently is accompanied by acoustic emission easily perceived by the human ear.

The low thermal stress resistance of ice can be demonstrated by a numerical example. Consider a piece of ice of spherical geometry initially at −20° C suddenly immersed in H_2O at a temperature of 25° C. For an estimate of the heat-transfer coefficient, it will be assumed that heat transfer to the ice occurs by laminar convection. The heat-transfer coefficient, h, can be expressed [2] as

$$h \simeq \frac{K}{D}(0.56)(N_{pr}\cdot N_{gr})^{1/4}, \quad (1)$$

where K is the thermal conductivity of the water, D is the diameter of the sphere, N_{pr} is the Prandtl number and N_{gr} is the Grasshoff number. From tabulations [3] of the properties of water the quantity $N_{pr}\cdot N_{gr}$ is approximately:

$$(2) \quad N_{pr}\cdot N_{gr} \simeq 2\times 10^4 D^3 \Delta T \, \mathrm{cm^{-3}\,{}^\circ C^{-1}}$$

where ΔT is the temperature difference between the ice surface and the mean temperature of the water. With $D = 2.5$ cm, $\Delta T = 45°$ C, $K_{H20} = 1.5\times 10^{-3}$ cal cm^{-1}° C^{-1} sec^{-1} [4], the heat transfer coefficient becomes,

$$h \simeq 1.98\times 10^{-2}\ \mathrm{cal\,cm^{-2}\,{}^\circ C^{-1}\,sec^{-1}}. \quad (3)$$

As shown by Crandall and Ging [5] the maximum value of tensile thermal stress (σ_m) is a spherical body heated in a convection heat-transfer environment can be expressed as:

$$\sigma_m \simeq [\alpha E \Delta T/(1-\mu)]\,[2\beta/5(\beta+2)], \quad (4)$$

where ΔT is the initial temperature difference between the ice and the water, α is the coefficient of thermal expansion, E is Young's modulus, μ is Poisson's ratio and β is the Biot number defined by $\beta = Rh/K$ where R is the sphere radius, h is the heat-transfer coefficient and K is the thermal conductivity of the ice. Substitution of the following literature data for ice, $\alpha \simeq 1.13\times 10^{-4}$° C^{-1} [4], $E \simeq 10^{10}$ Nm^{-2}, $\mu = 0.33$ and $K \simeq 5.4\times 10^{-3}$ cal cm^{-1}° C^{-1} sec^{-1} [6], with the above value of h (Equation 3) yields:

$$\sigma_m \simeq 1.82\times 10^7\ \mathrm{Nm^{-2}}. \quad (5)$$

This value can be compared with a reported [6] value of the tensile strength, σ_f, of ice with $\sigma_f \simeq 1.5\times 10^6$ Nm^{-2}, which clearly indicates that for thermal conditions and dimensions chosen for the present calculation, the thermal fracture of ice is unavoidable. A reduction in size of the ice to a diameter of approximately 0.1 cm reduces the stress to a value comparable to the fracture stress. By raising the initial temperature of the ice to its melting point, thermal fracture on heating can also be avoided, regardless of the nature of magnitude of the heat transfer involved.

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The angles of intersection of coarse shear bands in polystyrene

Shear bands are distinct microstructures developed during deformation of amorphous polymers such as polystyrene. They are localized regions of plastic flow and sources of shear fracture. Two different kinds of shear bands have been observed on polished surfaces after compressive deformation of atactic polystyrene [1, 2]. One appears as dark straight lines in the optical microscope and is called coarse shear bands. The other appears as diffuse zones not resolvable in the optical microscope but is revealed in the electron microscope to be thin short segments. They are called fine shear bands. While the fine bands seem to intersect at right angles, the coarse bands do not. This communication reports a set of more careful and