

Triboluminescence on "Explosive" crystallization of non-crystalline germanium films

Recently, the present authors described the "explosive" crystallization of sputtered non-crystalline germanium films [1, 2] when pricked with a sharp point. At the time when a germanium thick film (45µm) crystallizes and then peels off the substrate, triboluminescence was observed by using an infra-red film (Kodak High Speed Infra-red Film) as a sensor. A germanium thick film sputtered on a fused silica substrate was

pricked on the photofilm with its emulsion side up as shown in Fig. 1a in complete darkness. Fig. 1b and c show the resultant features of the crystallized germanium film and of the infra-red photofilm (developed and printed in line with the regular instructions), respectively. Since the nominal cut-off wavelength of Kodak High Speed Infra-red Film is about 0.95 µm, a considerable amount of near infra-red radiation (between the visible and 0.95 µm) must be generated. When the crystallization was very violent, it was possible to see the luminescence very slightly with the naked eye in complete darkness by very careful observation (but this "visible" light was not intense enough to be sensed by TRI-X Film through a similar procedure to that of Fig. 1).

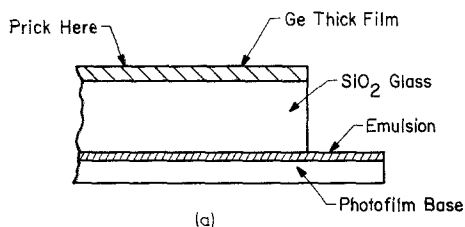
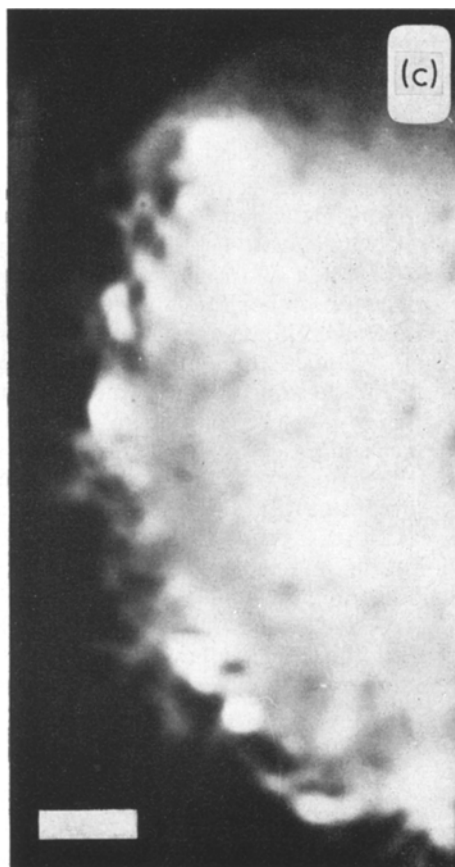


Figure 1 Triboluminescence on crystallization of non-crystalline germanium films. (a) Experimental arrangement, (b) crystallized germanium (within the light half circle) and (c) triboluminescence detected by infra-red photofilm (white bar = 5 mm).



Originally, this experiment was conducted to detect any possible instantaneous infra-red radiation accompanied by crystallization. The observation in Fig. 1c, however, clearly shows that the luminescence occurred only at the places where the germanium film peeled off. In the figure, portions of the crystallized film remained attached to the substrate, as seen by the dark areas along the circular perimeter, indicating that no measurable infra-red radiation of this wavelength region was emitted by the heating of crystallization. The "explosive" crystallization of the film proceeds by the rapid crystallization of the non-crystalline film followed by rapid peeling as has been demonstrated by a high speed motion picture [3]. Thus, immediately after the crystallization, the film is still remaining on the substrate. Instead of the expected infra-red heating, however, the present result indicated that even after the crystallization reaction there is an apparent strong bonding between the germanium film and the substrate, which can be broken a moment later by the internally

accumulated stress in the film through the crystallization.

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References

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2. *Ibid.*, *J. Mater. Sci.* **8** (1973) 1809.
3. The film was shown by the authors at the Glass Division Meeting of the American Ceramic Society, Bedford, Pa., 13 October 1971.

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On the excess volume of mixing of liquid alloys

In a recent article surveying density measurements in liquid metals and liquid binary alloy systems [1], the discussion of the alloy densities was based on plots of specific volume against atomic concentrations of the components. It is useful to remember, however, that, when specific and atomic volumes are plotted against composition, the former must be plotted against the composition in weight fraction and the latter against the composition in atomic fraction, otherwise deviations from a linear relationship will appear which are not meaningful and which can, in certain cases, be very misleading. This communication outlines analytically the reasons for this, illustrating the point with two examples, the Cd-Bi and Na-K systems. Thus, in the Cd-Bi system, the atomic volume plotted against atom fraction Bi will give a correct positive deviation while the specific volume plotted on the same atom fraction scale gives a meaningless negative deviation.

Let us first consider ideal mixing of a binary alloy system. The atomic volume $V_{id}^A(c_1)$ for a given composition is given by

$$V_{id}^A(c_1) = c_1 V_1 + c_2 V_2$$

where c_1, c_2 are the respective atom fractions and V_1, V_2 the respective atomic volumes of components 1 and 2; $V_{id}^A(c_1)$ is, therefore, linearly related to c_1 and c_2 .

The specific volume for a given composition $V^S(c_1)$ is given by

$$V^S(c_1) = \frac{V^A(c_1)}{A(c_1)} \quad (1)$$

where $A(c_1)$ is the atomic weight of the alloy which can be expressed by

$$A(c_1) = \frac{w_1 + w_2}{(w_1/A_1) + (w_2/A_2)},$$

where w_1 and w_2 are the respective weights and A_1, A_2 are the respective atomic weights of the components 1 and 2.

The weight fraction of component 1,

$$W(c_1) = \frac{w_1}{w_1 + w_2}$$

Hence, since $c_1 = \frac{w_1}{A_1} / \left(\frac{w_1}{A_1} + \frac{w_2}{A_2} \right)$,

$$W(c_1) = \frac{c_1 A_1}{A(c_1)} \quad (2)$$