

Zeitschrift: Helvetica Physica Acta
Band: 62 (1989)
Heft: 6-7

Artikel: Crystallization of rapidly quenched metal droplets with high melting point
Autor: Soares, V. / Meyer, E. / Rinderer, L.
DOI: <https://doi.org/10.5169/seals-116094>

Nutzungsbedingungen

Die ETH-Bibliothek ist die Anbieterin der digitalisierten Zeitschriften auf E-Periodica. Sie besitzt keine Urheberrechte an den Zeitschriften und ist nicht verantwortlich für deren Inhalte. Die Rechte liegen in der Regel bei den Herausgebern beziehungsweise den externen Rechteinhabern. Das Veröffentlichen von Bildern in Print- und Online-Publikationen sowie auf Social Media-Kanälen oder Webseiten ist nur mit vorheriger Genehmigung der Rechteinhaber erlaubt. [Mehr erfahren](#)

Conditions d'utilisation

L'ETH Library est le fournisseur des revues numérisées. Elle ne détient aucun droit d'auteur sur les revues et n'est pas responsable de leur contenu. En règle générale, les droits sont détenus par les éditeurs ou les détenteurs de droits externes. La reproduction d'images dans des publications imprimées ou en ligne ainsi que sur des canaux de médias sociaux ou des sites web n'est autorisée qu'avec l'accord préalable des détenteurs des droits. [En savoir plus](#)

Terms of use

The ETH Library is the provider of the digitised journals. It does not own any copyrights to the journals and is not responsible for their content. The rights usually lie with the publishers or the external rights holders. Publishing images in print and online publications, as well as on social media channels or websites, is only permitted with the prior consent of the rights holders. [Find out more](#)

Download PDF: 21.02.2026

ETH-Bibliothek Zürich, E-Periodica, <https://www.e-periodica.ch>

CRYSTALLIZATION OF RAPIDLY QUENCHED METAL DROPLETS WITH HIGH MELTING POINT

V. Soares, E. Meyer* and L. Rinderer

Institut de Physique Expérimentale, Université de Lausanne
CH-1015 Lausanne, Switzerland*Instituto de Física, Universidade Federal do Rio de Janeiro
RJ-21945 Rio de Janeiro, Brazil

Abstract: The crystallization process of rapidly quenched liquid metal droplets has been studied by using photographic techniques. Cooling rates of these droplets have been obtained and they have shown a appreciable supercooling before a sharply phase transition occurs which is contrary to classical nucleation theory. The instability of the liquid phase is investigated within the framework of an adiabatic nucleation model.

The mechanism by which a crystalline solid forms in the freezing of a pure liquid is controlled essentially by the nucleation rate of small crystallites in the supercooled liquid phase. However, the nucleus itself cannot be studied directly and this limits experimental information to the measuring of the limit temperature T_L to which the liquid can be supercooled before crystallizing.

Small droplets has been used in the study of the solidification mechanism to minimize the probability of nucleation due to the presence of foreign nuclei inside the liquid. By using this technique, this limit temperature T_L has been measured for a variety of liquid metals.

We have applied the technique of dendritic crystal growth to obtain dendritic crystals from rapidly quenched metal droplets with high melting point. This technique improved with an stereophotographic apparatus has permitted to obtain the cooling rate of these droplets and, then, to determine the amount of supercooling these metals can sustain.

This procedure was described previously. (1,2) A metal wire is overloaded by a high current inside a chamber and the sample is liquefied. Liquid metal droplets are produced and these radiating spheres are then fall down in the chamber, being cooled during the time of flight.

Calibrated curves of color density ratio on photographic film vs temperature and position of free falling droplet vs time enable us to plot the temperature of droplet at given position vs time as is represented in Figure 1. It should be noted that the limit temperature T_L to the supercooling the liquid droplet undergoes is just the minimum temperature before the sudden increase of temperature at which the solid phase appears.

This curve also has the following characteristics: (i) the temperature at which the solid appears is not a plateau-like but

immediately falls; (ii) the cooling rate after this limit temperature corresponds to a radiative cooling droplet; and (iii) the temperature attainable by the solid phase is lower than that predicted upon release of the latent heat during the nucleation process.

As is suggested by Nelson(3) the characteristic (iii) merely indicates that only a fraction of the mass of the supercooled droplet could crystallize rapidly, the remainder of the solidification being rate-limited by the process of heat loss from the outer surface of the droplet. However, this picture estimates that only after a time of the order of 30 msec or larger the Ta droplet of Figure 1 should present a radiative cooling behavior.

The present results suggest that nucleation phenomenon may not be regarded as an isothermal one as considered by the classical nucleation theory. It seems the solid can nucleate at higher temperature than the liquid phase but this temperature may be lower than the associated melting temperature, the resulting evolution towards equilibrium occurring very fast, as predicted from the adiabatic theory of nucleation. (4)

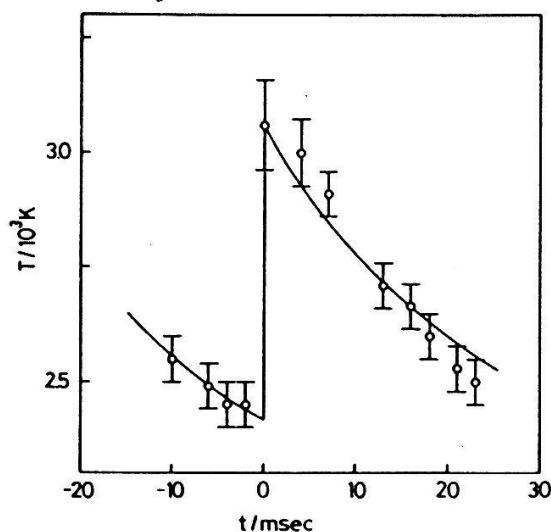


Fig. 1 Typical cooling rate to 400 μ m Ta droplets

Acknowledgements: We thanks Prof. N. Melamed the suggestion of this technique and the valuable support from the Fonds National de la Recherche Scientifique and Conselho Nacional de Desenvolvimento Científico e Technológico.

References:

- (1) V. Soares *et al.*, Helv. Phys. Acta, 61, 857 (1988)
- (2) E. Meyer and L. Rinderer, J. Crystal Growth, 28, (1975)
- (3) L. Nelson, 12th International Symposium on Combustion, Poitiers, France, 1968
- (4) E. Meyer, J. Crystal Growth, 74, 425 (1986); 76, 525 (1986)