

OPENING AND CLOSING OF CHANNELS DURING SECOND ORDER PHASE TRANSITIONS (CRITICAL PHENOMENON) IN Al-Mn THIN FILMS. José Reyes Gasga (1), Abraham Pita Larrañaga (1). (1) Instituto de Física de la Universidad Nacional Autónoma de México (IFUNAM), Apartado postal 20-364, 01000 México D. F., México. Emails: jreyes@fisica.unam.mx , abrapita@avantel.net .

During in situ heating of thin films of the Al-Mn system a phenomenon consisting of first opening and later closing of channels was observed (see the figures 1 and 2). The channels are aggregates of vacancies in amorphous film. The decagonal quasicrystalline phase was observed together of the channels. There is a small fringe of a lighter contrast always present around the channels. The decagonal quasicrystalline phase is in the fringe; is possible to have a relation between the quasicrystalline phases and the channels.

In order to elucidate the parameters of the driving force which produces the opening and closing of channels in thin films during phase transitions, we have to take into account thin film parameters such as internal and superficial energies, stresses, and some other mechanical properties which connect the interaction of the surface with the bulk of the film. Of course, the minimization of both the surface and interfacial energy has to be the driving force of this phenomenon.

First of all it has to be noted that the behaviour of the channels is very similar to that observed in a fluid state, because the superficial tension produces a gradient of pressure along the new phase structure. This movement goes together with an increase of density. It is worth noting that, since the opening of the channels occurs at a given temperature before which the channels do not appear and after which they disappear, the temperature is of the “edge” type very similar to a Dirac’s Delta behaviour around 550 °C and 600 °C.

From the fringe formed around the channel we can interpret this phenomenon on a transition phase basis. It is quite clear that this fringe represents the growth of this new phase. Therefore, the channels are the result of an excessive diffusion of one component of the alloy (Al in this case because it presents a higher diffusion than Mn at 600 °C), very similar to the famous Kirkendall effect [1]. All this agrees very well with the observed behaviour of the channels.

In the closing of the channels, at a higher temperature, the films have to show an internal dilatation together with a rising of the superficial tension along the channels. This tension is higher at the tip of the producing channels along their edges and, therefore, the closing of them occurs in the reverse direction.

Now, we propose an equation that connects the mechanical parameters (superficial tension) and diffusion parameters with geometrical and thermodynamics parameters. We suppose that the channels are aggregates or sets of vacancies, their proprieties are driving with “Mean Field Percolation”. This theory (Mean Field Percolation) is connected with Landau’s critical phenomenon theory. The connection is on the order parameter and the Helmholtz’s potential. The order parameter depends of the probabilities of occupation, of a vacancy, of some place in the mean field percolation lattice which is very similar to Penrose’s lattice. These theories, the percolation and the Landau model have critical parameters, ‘Pc probability’: if a vacancy has probability Pc of to be in the lattice then there is presence of channels on the film (infinitum aggregates). The Landau model connects to Pc with ‘Tc’; a critical temperature. Therefore we consider a relation between quasicrystals, critical phenomenon and channels because, if there are channels then there are decagonal quasicrystalline phases and crystals phases related with them (Al₃Mn and Al₄Mn; quasicrystalline approximants). However the observation of quasicrystalline phases does not necessarily imply the presence of channels [2 and 3].

References

- [1] A. Smigelskas and E. Kirkendall, *Trans. AIME*, 171 (1947) 130.
- [2] J. Reyes-Gasga, G. Mondragón-Galicia and M. José Yacaman, *Thin Solid films*, 230 (1993) 108.
- [3] P. Barna, A. Csanady, U. Timmer and K. Urban, *J. Mater. Res.*, 7 (1992) 1115.

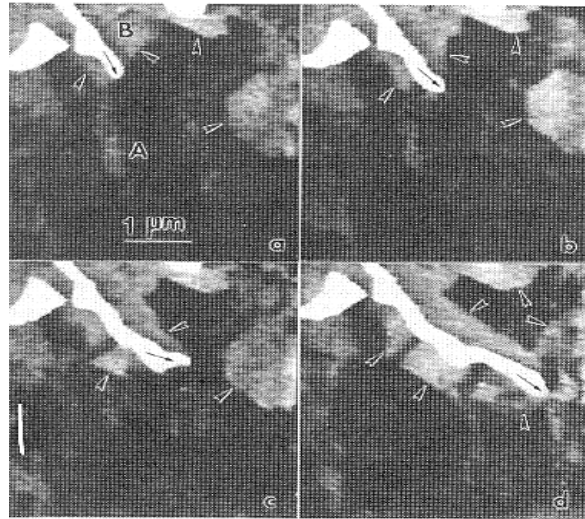


Figure 1: Behaviour of the fringe contrast around of the channels.
A) Time = 0, B) time = 0.99s, C) time = 3.84s and D) time = 7.02s.

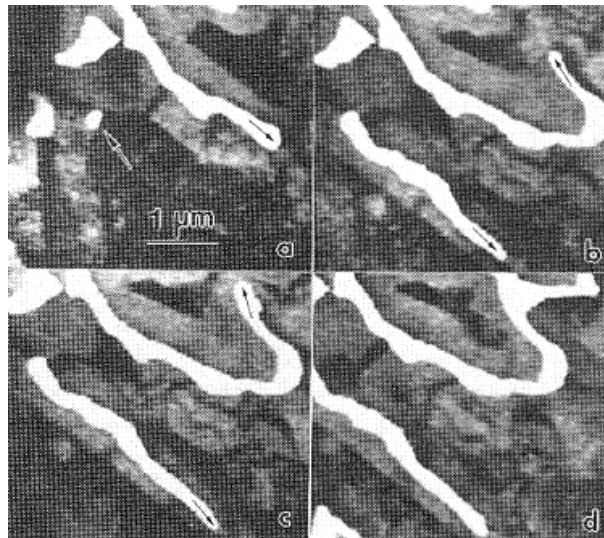


Figure 2: The channel grows continuously.
A) Time = 0, B) time = 11.95 s, C) 13.94 s and D) time = 17.83 s.