In-situ Observation of Coupled Growth Morphologies in Organic Peritectics

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1. Introduction

In the last years the solidification morphology of peritectic coupled growth (PCG) was investigated and discussed in [1-3]. For the first time, isothermal PCG was observed by systematic directional solidification experiments with TRIS-NPG organic peritectic alloys close to the limit of constitution undercooling. The experiments were carried out as in-situ observation in a horizontal micro Bridgman-furnace. The main findings for the selected phase diagram are: (i) a competition between nucleation and lateral growth during peritectic band formation, and (ii) a decrement of the implemented solidification velocity in situations were both phases grow as cells/dendrites side by side, lead to PCG.

2. Experimental set-up

The organic non-faceted/non-faceted peritectic system TRIS - NPG [4] is used as a model substance for peritectic solidification morphologies [5-7] which occur close to the constitutional undercooling limit. The in-situ observation of the different peritectic solidification morphologies was done with a micro Bridgman-furnace setup under a microscope, see Figure 1.

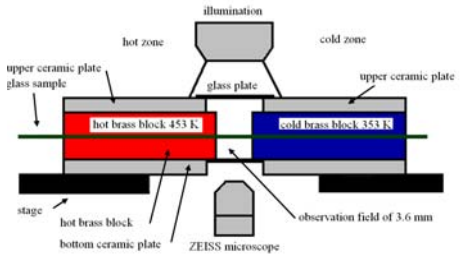

Figure 1: Sketch of the directional solidification apparatus (Bridgman furnace) used for the optical investigation of the organic peritectic alloys. The samples had an inner spacing of 100 µm.

3. Results and discussion

Figure 2 and Figure 4 show the growth of isothermal PCG at similar process conditions with different preceded pulling rates. The observed lamellar distances for different pulling rates and concentrations are shown in Figure 3.

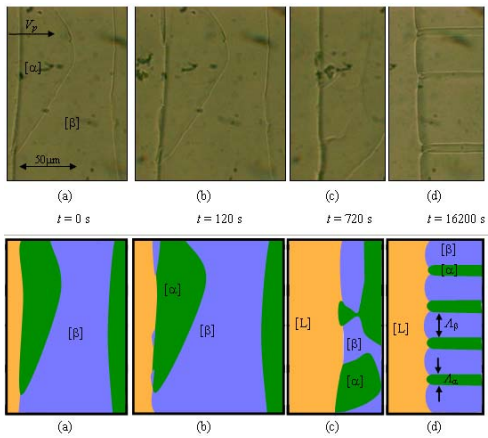

Figure 2: Sequence of planar bands of primary and peritectic phases leads via island banding to PCG for x = 0.51 mol fraction NPG and V = 0.19 µm/s: (a) growth of bands; (b) nucleation of the secondary phase ahead of the primary phase; (c) competition between lateral growth and solidification parallel to the pulling rate forms island bands; (d) finally a stable isothermal PCG occurs.

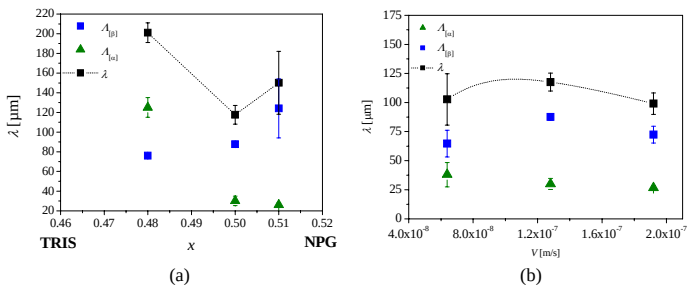

Figure 3: Estimated interphase spacing and lamellar spacing. (a) Lamella distances λ for different pulling rates V and a concentration x = 0.5 mol fraction NPG. (The ratio between lamella thickness and interphase spacing of the lamella follows the constraint from the phase diagram). (b) For different concentrations x at a pulling rate of V = 0.19 µm/s.

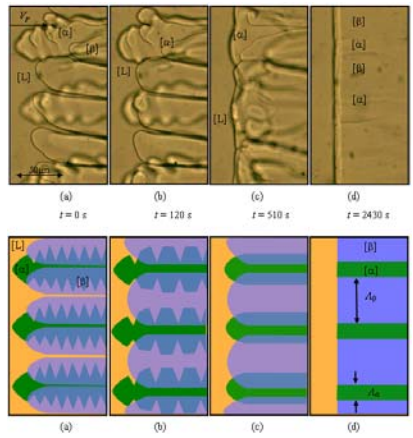

Figure 4: Development of coupled peritectic growth morphologies by reducing the pulling velocity from 0.64 µm/s down to 0.19 µm/s for x = 0.5. (a-b) The dendritic/cellular tip radius increases. (c) The dendritic structure of primary phase [α] transforms to a cellular morphology and starts to interact with [β]. (d) An isothermal PCG has been established.

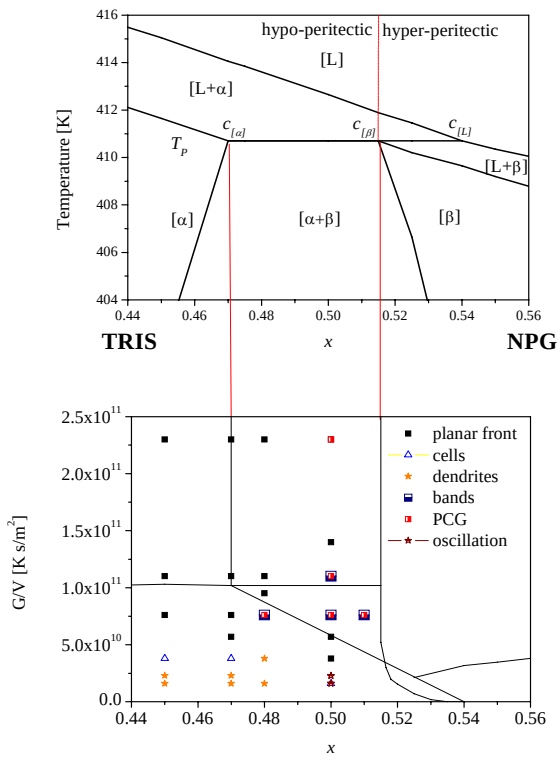

Figure 5: Peritectic region of the TRIS–NPG phase diagram and the observed microstructures in a microstructure map (G/V-x diagram). The black lines correspond to the criteria of limit of constitutional undercooling.

4. Conclusions

- The formation of isothermal PCG could be in-situ observed with the transparent organic peritectic TRIS–NPG system.
- Two different ways were found to obtain isothermal PCG: (i) reducing the growth velocity from above the critical value for morphological stability of both solid phases to a value below, and (ii) by long-time growing with a constant velocity below the critical value for morphological stability of both solid phases.

Reference

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