Conclusion

The growth of large volume crystals or large surface films with a limited number of defects, is achieved in favourable cases. Purity, concentration, temperature are controlled with the required accuracy.

However, the nucleation and, even, the growth mechanisms are still poorly understood from a fundamental point of view. The control of crystal size and habit is still limited (these aspects are of practical importance in magnetic applications, catalyse or pharmaceutics). Prediction of crystal morphology is even harder. The qualitative growth models need to be related to the microscopic scale. From this point of view, molecular dynamic simulations are helpful : diamond, metals, organic molecular crystals (urea...) are already investigated.

Difficulties arise from the determination of the species at the nucleation sites and/or in the mobile phase. It is known that these species depend on the presence of impurities and/or the thermal history of the sample. As an example, the crystallisation routes of a melt of $Y_3Al_5O_{12}$ differ, according to the maximum heating temperature of the liquid. When heated at T<2000 °C, the melt gives, on cooling (T=1925 °C), the expected cubic garnet. Surprisingly, the melt, heated above the critical temperature T=2000 °C, solidifies, on cooling, to give $YAlO_3$ perovskite and small amounts of $Y_3Al_5O_{12}$ and α-Al_2O_3. In this case, high temperature methods of in-situ investigation are needed (NMR, Raman ...) and are currently developped.

At the same time, new challenges for material characterisation appear with the emergence of original elaboration techniques : nanochemistry (plasma spraying ...), mechanical alloying or mechanical synthesis. They lead to small and/or stressed particles where surface effects, stacking faults or disorder play a major role in material properties.

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