



**Figure 1.2** Effect of shear and fluid micro-mixing on nucleation.

### 1.2.1.3 External Fields (Ultrasound, Laser, Electromagnetic)

The principal benefit of using external fields, such as ultrasound or laser, to control nucleation lies in avoiding the problems typically encountered with conventional seeding; inconsistent seed attributes and seed history, incomplete seed wetting and dispersion resulting in polycrystalline particle formation, seed dissolution due to delayed seed addition, *etc.* Well-controlled nucleation offers the possibility of exquisite control of product particle size. These aspects are particularly important in continuous crystallization where seeding is an essential element in the start-up process required to minimize the peak supersaturation attained and so to delay the onset of encrustation. The benefit of externally induced nucleation in starting up a continuous crystallization is that it can be initiated at supersaturation levels lower than the metastable zone limit for spontaneous nucleation and potentially at levels lower than would be considered robust for conventional seed addition.

In a classical continuous crystallization, following successful initiation *via* seed addition, the next major operational challenge is to manage the secondary nucleation rate such that the available surface area for crystal