Lattice Boltzmann Modeling of Foaming Processes

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Foams develop by agglomeration of gas bubbles in liquids and are omnipresent in nature as well as in technology. Typically, foams are produced by chemical or physical blowing agents. The gas released by the blowing agent is dissolved in the liquid and diffuses to a huge number of bubble nuclei. The increase of bubble pressure leads to bubble expansion and eventually, if there is some stabilizing mechanism present, to a meta stable foam or to collapse. The whole foaming process is dominated by the highly dynamical evolution of the huge internal gas-liquid interface and comprises a variety of interesting phenomena like drainage, avalanche-like topological changes, gas bubble coalescence, etc.

A 2D-LBM with free surfaces is used to model the whole foaming process starting from nucleation, bubble growth by diffusion, foam expansion including cell wall rupture and eventually foam collapse due to gas loss to the ambient atmosphere. The two phase system is reduced to a one phase system, where the dynamics of the gas is not explicitly taken into account but only couples via the pressure boundary conditions to the fluid. The hydrodynamical problem is solved using a D2Q9 model whereas gas diffusion within the fluid is described by a D2Q4 model. The decomposition of the blowing agent is modeled by the use of a volume gas source within the liquid. Foam stabilization is realized in a phenomenological way by a local acting disjoining pressure.

We present examples for foam evolution, stabilization, collapse and the influence of material parameters like viscosity and surface tension. The variety of different real foam structures is reproduced by our model. Collective phenomena, like avalanche-like cell coalescence, emerge from our model without further assumptions. First 3D-results are presented.