Determination of the contact angle based on the Casimir effect

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Abstract

In several crystal growth processed based on capillarity, a melt comes into contact with a crucible wall at an angle defined as the contact angle. For molten metals and semiconductors, this contact angle is dependent upon both the crucible and melt material and typical values fall in the range $80\text{-}170^0$. However, on a microscopic scale, there does not exist a precise and sharp contact angle but rather the melt and solid surfaces merge smoothly and continuously over a distance of up to several micrometers. Accurate modeling requires a more advanced treatment of this interaction. The interaction between the melt and solid surfaces can be calculated by considering two forces: a short-range repulsive force and a longer range (up to a few micrometers) Casimir force. The Casimir force between the two bodies of complex geometry is calculated using a retarded temperature Green's function (Matsubara type) for the photon in the medium. The governing equations are cast in the form of a set of boundary integral equations which are then solved numerically for the case of molten Ge on SiO_2. The shape of the molten surface approaching the flat solid body is determined, and the contact angle is defined as the angle between the two surfaces at the microscopically asymptotic distance of 1-2 micrometers. The formulation of this model and the results of the numerical calculations will be presented and discussed.