No touchdown at zero points of the permittivity profile for the MEMS problem

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(Joint work with Jong-Shenq Guo) We study the quenching behavior for a semilinear heat equation arising in models of micro-electro mechanical systems. The problem involves a source term with a spatially dependent potential, given by the dielectric permittivity profile, and quenching corresponds to a touchdown phenomenon. It is well known that quenching does occur. We prove that **touchdown cannot occur at zero points of the permittivity profile.** In particular, we remove the assumption of compactness of the touchdown set, made in all previous work on the subject and whose validity is unknown in most typical cases. This answers affirmatively a conjecture made in [Y. Guo, Z. Pan and M.J. Ward, SIAM J.Appl. Math 66 (2005), 309–338] on the basis of numerical evidence. The result crucially depends on a new type I estimate of the quenching rate, that we establish. In addition we obtain some sufficient conditions for compactness of the touchdown set, without convexity assumption on the domain. These results may be of some qualitative importance in applications to MEMS optimal design, especially for devices such as micro-valves.