Pyroelectric response of an Fe$_3$O$_4$/Nb:SiTiO$_3$ interface

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Magnetite (Fe$_3$O$_4$) is a prototype multiferroic material with both spontaneous magnetization and dielectric polarization. Below the Verwey transition at 120K, a regular arrangement of the B-site Fe$^{2+}$ and Fe$^{3+}$ ions in an inverse spinel structure results in a charge ordering pattern with an alternation of short and long Fe-Fe bonds. The coexistence of bond-centered and charge-centered charge ordering triggers an electronic polarization along the monoclinic b-axis [1]. Here, we have demonstrated by pyroelectric detection that spontaneous polarization persists in Fe$_3$O$_4$ films grown on Nb:SiTiO$_3$ substrates up to the Verwey transition temperature [2].

Fe$_3$O$_4$ films were grown on Nb-doped SrTiO$_3$(001) substrates (Nb: 0.05wt%) by pulsed laser deposition [3]. For dielectric measurements, 100-nm thick Pd top electrodes with 1mm diameter were deposited on the Fe$_3$O$_4$ surface by e-beam evaporation. During cooling, pyroelectric response was detected below the Verwey transition temperature at 120K, suggesting spontaneous dielectric polarization in Fe$_3$O$_4$ films. The pyroelectric response from Fe$_3$O$_4$ films was strongly dependent on the sample capacitance, which showed a relaxor-like transition below 50K. Moreover, a very large pyroelectric coefficient of 735nC/cm$^2$K was found at 60K. This value is comparable to the well-known pyroelectric coefficient of Pb(Sc,Ta)O$_3$ films, 600nC/cm$^2$K, and much larger than, e.g., for PbTiO$_3$/MgO films, 20nC/cm$^2$K.

