Optical Properties of $(SrMnO_3)_n/(LaMnO_3)_{2n}$ Superlattices: An Insulator-to-Metal Transition Observed in the Absence of Disorder

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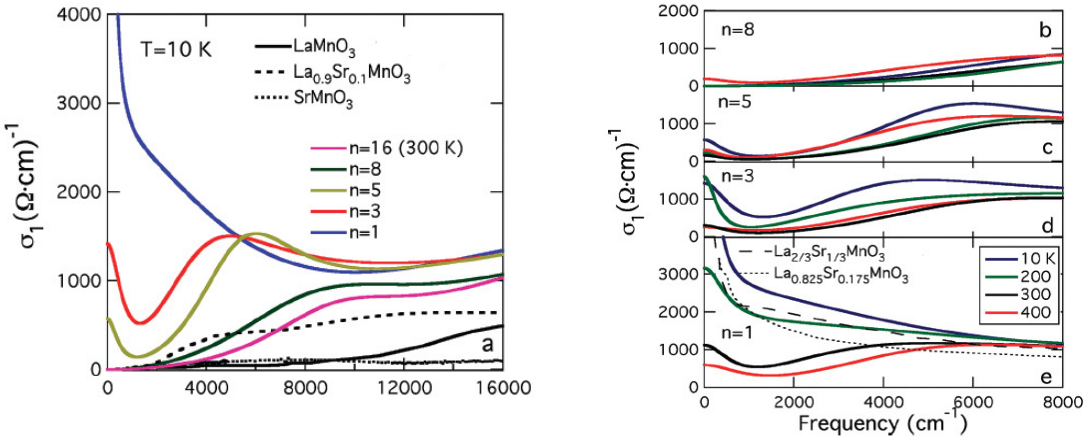
The insulator-to-metal transition (IMT) coupled to ferromagnetic ordering in hole-doping compuonds is understood through the double-exchange mechanism, once the localization tendency due to polaron formation has been taken into account. However, quenched disorder weakens long-range order and causes ferromagnetism to break up into clusters, an essential ingredient of the observed Colossal Magneto-Resistance effect. We measure the optical conductivity, $\sigma_1(\omega)$, of $(SrMnO_3)_n/(LaMnO_3)_{2n}$ superlattices (SL) for n= 1, 3, 5, and 8 and 10 <T < 400 K: these heterostructures offer the opportunity to observe the IMT in the absence of the disorder due to chemical doping.

Our data show a T-dependent insulator to metal transition for n < 3, where eventually the charge reaches a uniform distribution throughout the film; the transition is driven by the softening of a polaronic mid-infrared band, more evident in the n= 1 sample. At n = 5 the softening of the polaronic band is incomplete, while at the largest-period n = 8 compound the mid-infrared band is independent of T and the SL remains insulating, thus suggesting a strong localization of the charges at the interfaces. Unsuccessful reconstruction of the SL optical properties from those of the original bulk materials suggests that $(SrMnO_3)_n/(LaMnO_3)_{2n}$ heterostructures give rise to a novel electronic state.

In the present collaboration, the SPIN groups have provided and partly characterized the samples, and have participated both to the infrared data collection, and to the delicate phase of data analysis.



Panel (a): $\sigma_1(\omega)$ at T = 10 K for the n = 1, 3, 5, 8 compounds, showing the Mott transition induced by the proximity between the layers. $\sigma_1(\omega)$ at T = 300 K , for n = 16 is reported as well. Data on single crystals of $LaMnO_3$ and $La_{0.9}Sr_{0.1}MnO_3$ and on $SrMnO_3$ at 10 K are also shown for comparison. Panels (b-e): $\sigma_1(\omega)$ at different T for n = 8, 5, 3, and 1, respectively. Low-T conductivity of cleaved $La_{0.825}Sr_{0.175}MnO_3$ single crystals and $La_{2/3}Sr_{1/3}MnO_3$ films is also reported for comparison in panel e.