Sliding charge-density waves in manganites

To the Editor: Cox *et al.*[1] claim charge-density-wave (CDW) sliding in an untwinned epitaxial 80-nm-thick $La_{0.5}Ca_{0.5}MnO_3$ film in which superlattice transmission electron microscopy reflections confirm charge order. Their evidence consists of hysteresis in differential resistance, and broadband noise in the nonlinear conductivity (NLC) regime. However, the measurements were performed using an irregular contact geometry that could support inhomogeneous heating currents, and there is no report of narrow-band noise, which represents the most direct observation of sliding CDWs[2].

For classic CDW materials such as $NbSe_3$ and TaS_3, NLC occurs in electric fields that are orders of magnitude smaller than the ~10^2 V cm^{-1} used in ref. 1. It was recently shown[3] that polycrystalline charge-ordered manganites show NLC only under d.c. conditions owing to heating, which is avoided using pulsed measurements[2]. Here, we report the same conclusion for a charge-ordered film that is nominally identical to the film investigated in ref. 1. However, unlike in ref. 1, we employ parallel contacts to avoid inhomogeneous currents and thus heating.

Using the deposition chamber and target of ref. 1, our film was grown under comparable conditions on an equivalent $NdGaO_3$ (001) substrate also purchased from Crystal GmbH. High-resolution X-ray diffraction (Philips PW3050/65 X'Pert PRO, CuKα_1 radiation) was used to confirm film thickness (79 ± 4 nm), in-plane orientation, and crystallinity (~0.01° full-width at half-maximum for the (004) reflection). Part of the sample was prepared for transmission electron microscopy by mechanical polishing and argon-ion thinning using a Gatan Precision Ion Polishing System at 5 kV. Selected-area electron diffraction patterns from 200-nm regions were acquired at room temperature and 95 K using a Philips CM30 microscope. Another part of the sample (5×7 mm^2) was prepared for four-terminal electrical measurements carried out as described in ref. 4. Parallel silver-dag strips for *a*-axis measurements were removed with acetone and repainted for *c*-axis measurements. This procedure does not compromise electrical measurements[5].

Figure 1a,b confirms charge order in our film at 95 K. Several similar films show no charge order. Moreover, no film exhibits charge order at room temperature. There is no clear evidence for anisotropy or charge order in resistivity data (Fig. 1c). Measurements of current density (*J*) versus electric field (*E*) along *a* and *c* under d.c. and pulsed conditions (Fig. 1d,e) show a linear relationship beyond the fields used in ref. 1. NLC and hysteresis occur near our highest electric field in some *a*- and *c*-axis traces, but disappear in pulsed measurements, and are therefore due to Joule heating. There is thus no evidence for CDW sliding in thin-film $La_{0.5}Ca_{0.5}MnO_3$. This matches our findings[5] for the more strongly charge-ordered manganite, $Pr_{0.48}Ca_{0.52}MnO_3$. ❐

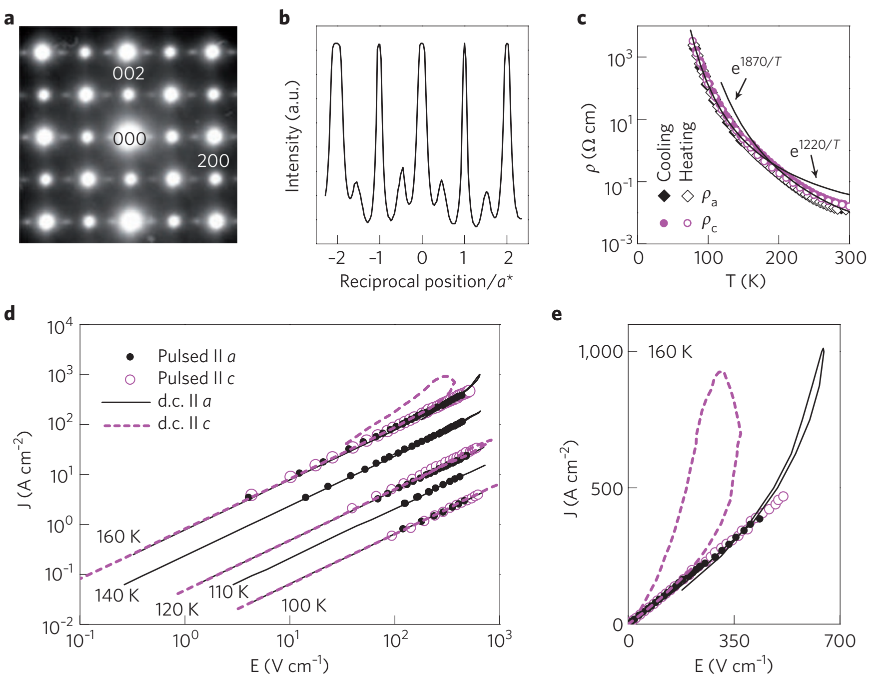

Figure 1 | TEM and electrical data for our $La_{0.5}Ca_{0.5}MnO_3$ film. **a**,**b**, 200 nm [010] selected-area electron diffraction pattern at 95 K (**a**) and the corresponding linescan (**b**). The *a*-axis superlattice reflections confirm charge order, and are substantially weaker than the parent-lattice reflections, as expected[1]. **c**–**e**, Four-terminal *a*-axis (black) and *c*-axis (pink) electrical measurements. Resistivity ρ versus temperature *T* on cooling (solid symbols) and heating (hollow symbols), with activated fits (black lines) as indicated (**c**). Panel **d** shows *J* versus *E* at selected temperatures, using d.c. (solid and dashed lines) or short voltage pulses of 1–20 ms duration (symbols). Panel **e** shows the data at 160 K from **d** replotted using linear axes. The pulsed data in **d** and **e** are highly linear at all fields.

References

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