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Electronic Supplementary Information (ESI)

Electron beam induced tunneling magnetoresistance in spatially confined manganite bridges

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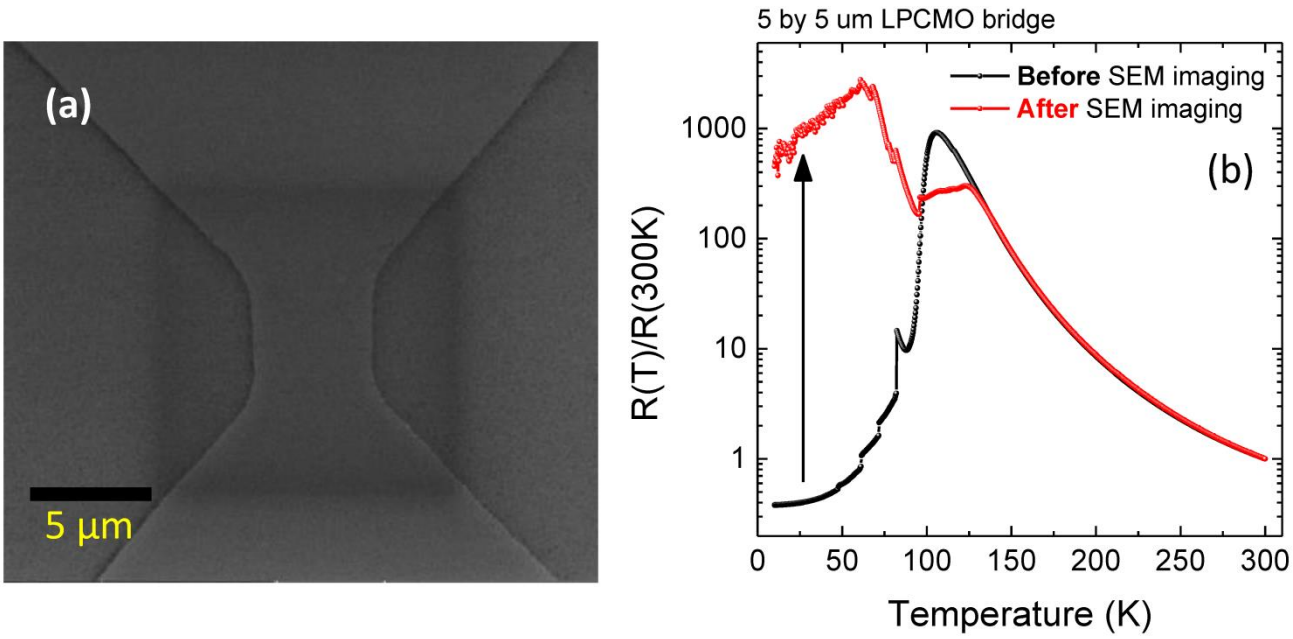

Figure S-1. SEM imaging dramatically changes the resistance of LPCMO microbridges. (a) The SEM image (SE mode; SEM mag x6.8k) of a 5 µm by 5 µm LPCMO bridge; the dark spot is where the higher magnification (SEM mag x10k) SEM image is taken. (b) The temperature dependences of the normalized resistance of the 5 µm by 5 µm microbridge before and after the SEM imaging is carried out.

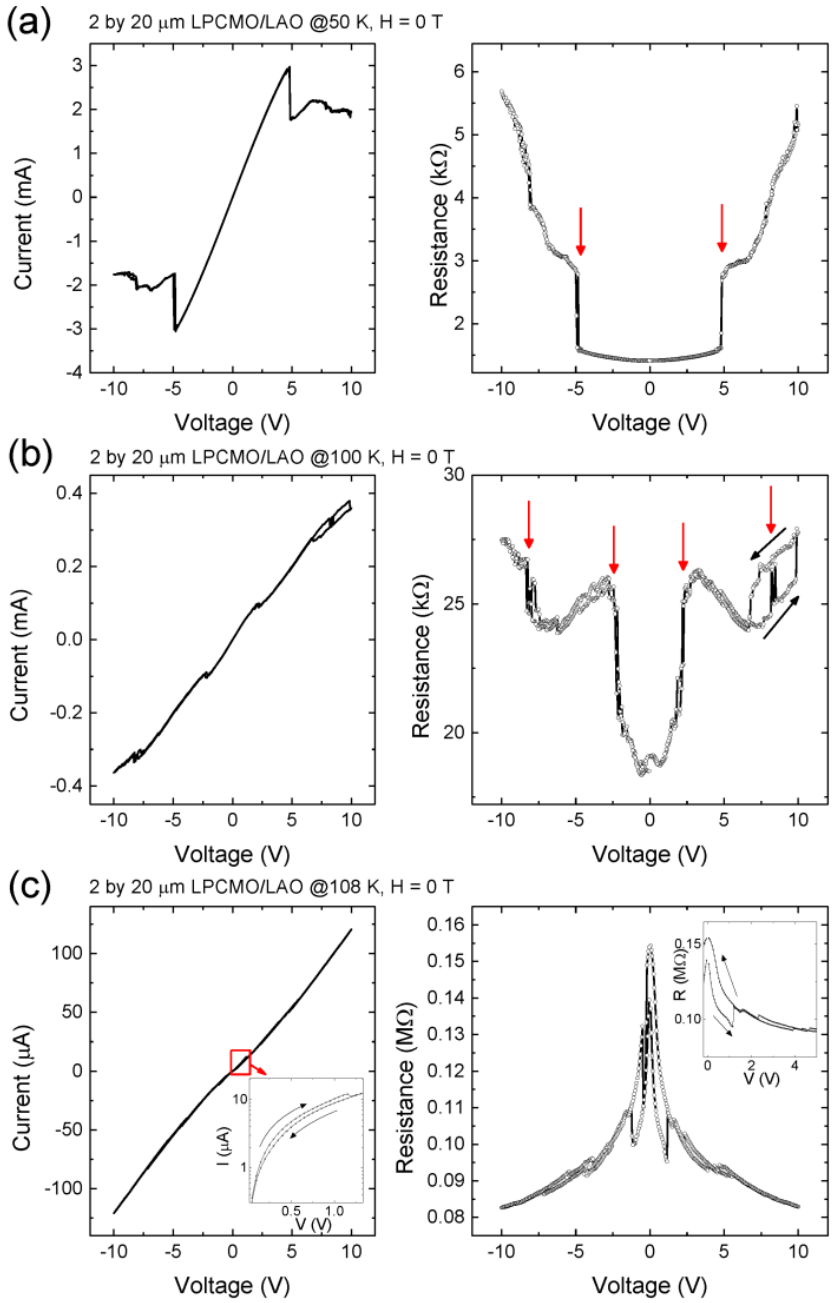

Figure S-2. I-V characteristics at (a) 50 K, (b) 100 K, and (c) 108 K. In the narrow LPCMO film, there exists small numbers of ferromagnetic domains which possess different initial sizes/shapes/magnetization directions in a certain temperature range. In this situation, the spin-torque effect could be involved when conduction electrons are traveling among the ferromagnetic domains.[35] At (c) 108 K, we observe hysteric and symmetric I-V characteristics which might be due to the spin-torque effect when the conduction electrons are traveling through a larger number of ferromagnetic domains along the current path(s). On the other hand, hysteresis and asymmetric I-V characteristics were observed at (b) 100 K, possibly due to the spin-torque effect in a smaller number of domains. This seems reasonable since the ferromagnetic domains grow and percolate with each other as the temperature decreases.[22-25] At low temperature ((a) and (b); $T \leq 100$ K), the current induced Joule heating is also important, marked in red arrows (a) and (b).[R1]

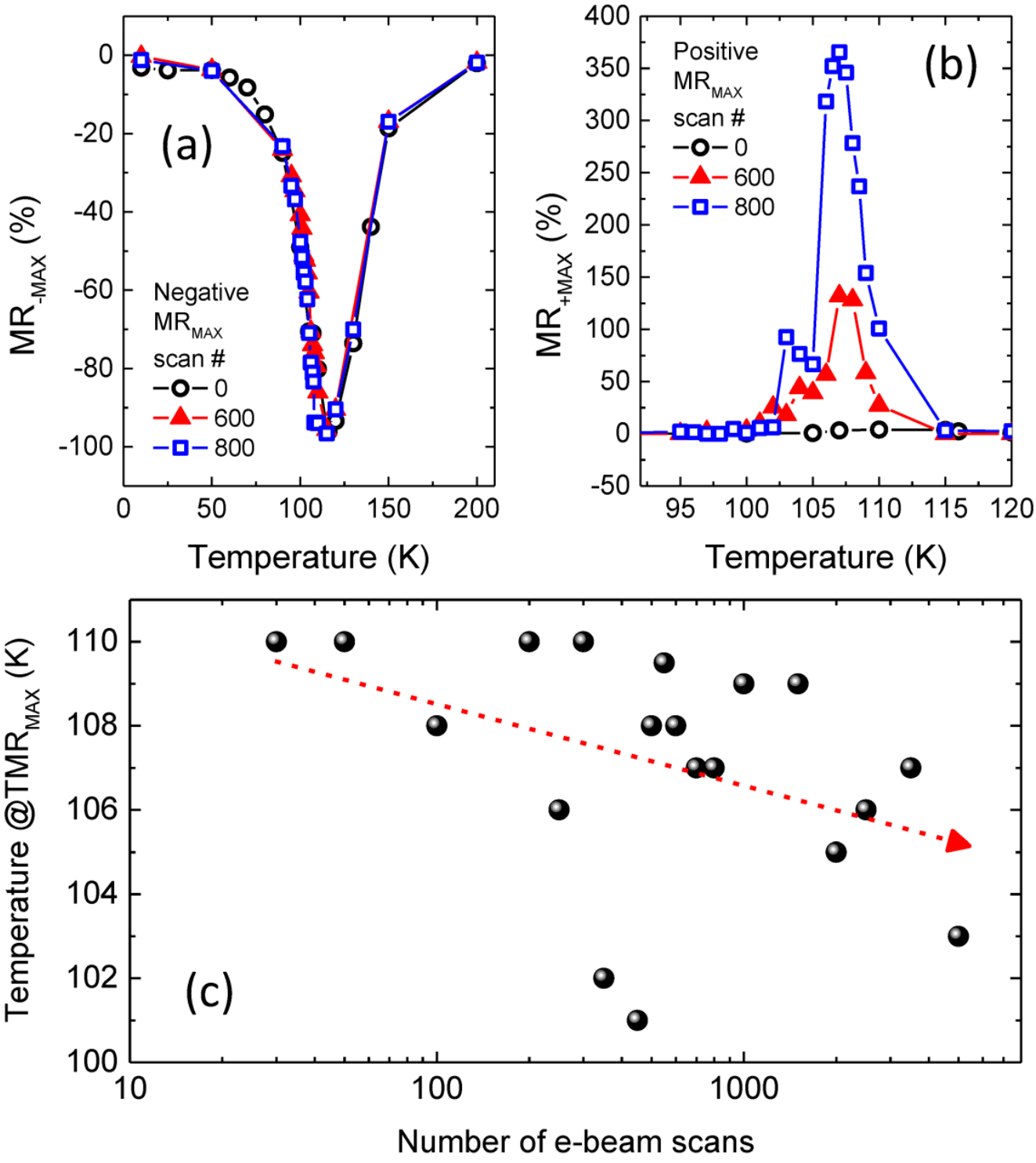

Figure S-3. The evolution of the temperature dependence of the (a) negative MR_{MAX} and the (b) positive MR_{MAX} as the number of e-beam scans varies. Notice that the negative MR is very similar before and after e-beam scanning while there is a clear difference for the positive MR. The increase in the positive MR with e-beam scanning is attributed to the creation of the TMR effect in the sample. (c) The number of e-beam scans modifies the temperature at which the TMR_{max} occurs. As the e-beam dose increases the TMR_{MAX} tends to occur at slightly lower temperature (indicated with the red arrow).

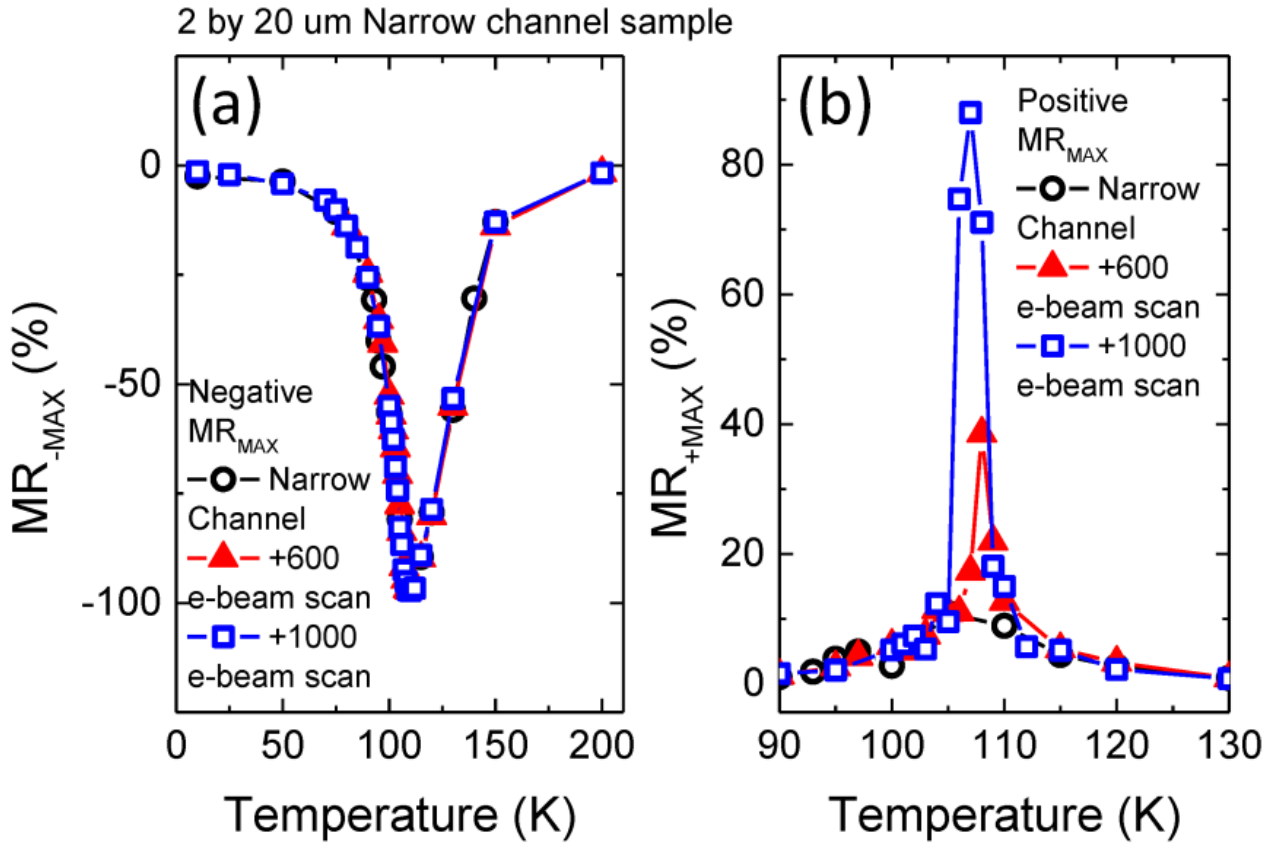

Figure S-4. The temperature dependence of the (a) negative MR_{MAX} and the (b) positive MR_{MAX} of the narrow channel microbridge (2 by 20 μm). The positive MR values near 107 K show a dramatic increase when the e-beam is scanned across the sample whereas the negative MR values do not show noticeable changes at any temperature.

References

[R1] J.-C. Wu, H. Sun, H.-X. Da, and Z.-Y. Li, *Appl. Phys. Lett*. 2007, **81**, 103501.