$Gd_{0.6}Ca_{0.4}MnO_3$ and $Sm_{0.6}Ca_{0.4}MnO_3$ thin films as potential materials for memristor-like applications

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Introduction

- Memristor-like components are needed for neuromorphic computers
- Current memristors are based on formation of filaments in oxides or oxidation of metal/oxide interface [1, 2]
- Would it be possible to use Mott insulator to metal transition?

- Low bandwidth manganites have charge- and orbital ordered state (CO/OO) at high temperature
- CO/OO can be destroyed by external stimuli
- Transition temperature, T_{co}, increases with decreasing rare earth radius
- $(Pr,Ca)MnO_3$ thin film properties depend greatly on deposition parameters [3]
- $Pr_{0.6}Ca_{0.4}MnO$ has most interesting properties [4]

⇒ **$Gd_{0.6}Ca_{0.4}MnO_3$ and $Sm_{0.6}Ca_{0.4}MnO_3$ thin films as memristors?**

Experimental details

Film deposition

- Solid state synthesized targets
- Pulsed laser deposition at T_d= 500 °C or 700 °C on $SrTiO_3$ (100) substrates
- λ = 308 nm, E = 2.0 J/cm^2, f = 5 Hz
- Oxygen annealing at T_a= 500 °C or 700 °C
- Films with T_d/T_a500/500, 500/700 and 700/700

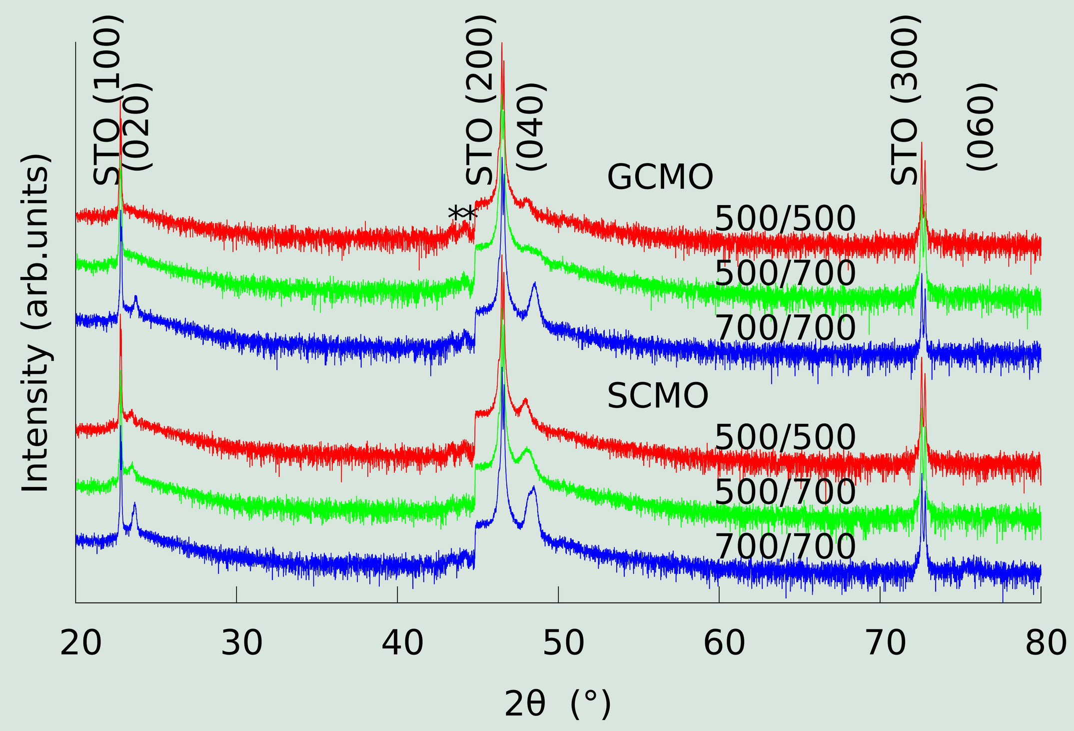
Structure & thickness

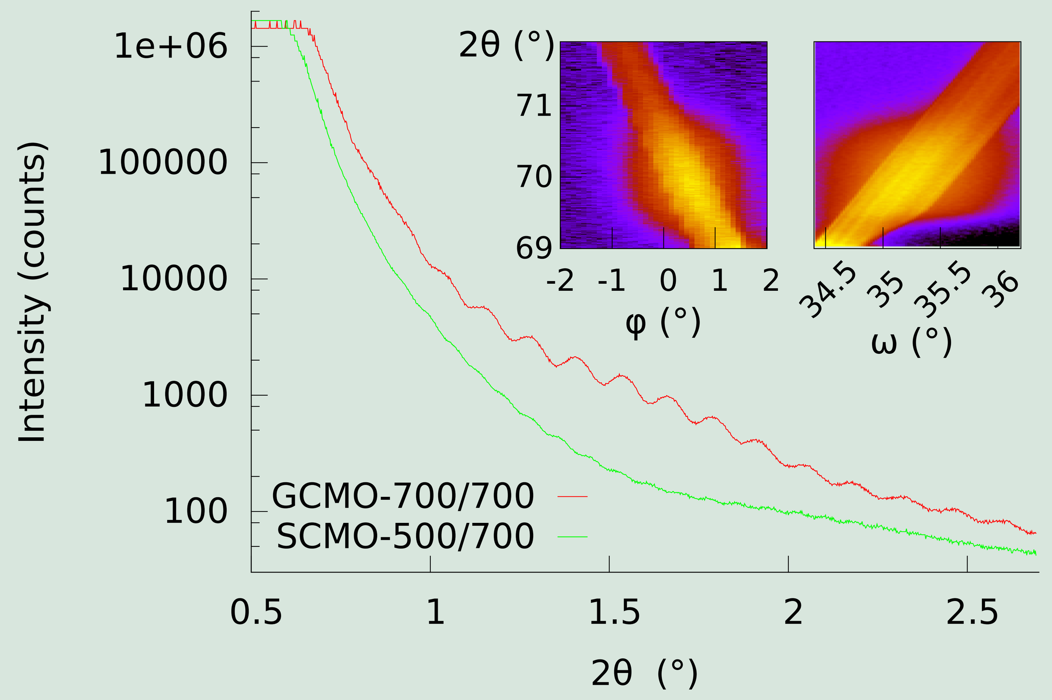
- X-ray diffraction (XRD) Philips X'pert PRO with PixCel and Schulz texture goniometer
- Lattice parameters from scans over (00l), (0kk) and (h,2h,h) with STO as internal standard
- Crystallinity from 2D-scans over (242) in $2\theta-\phi$ and $2\theta-\omega$
- Thicknesses (d)) with X-ray reflectivity (XRR)

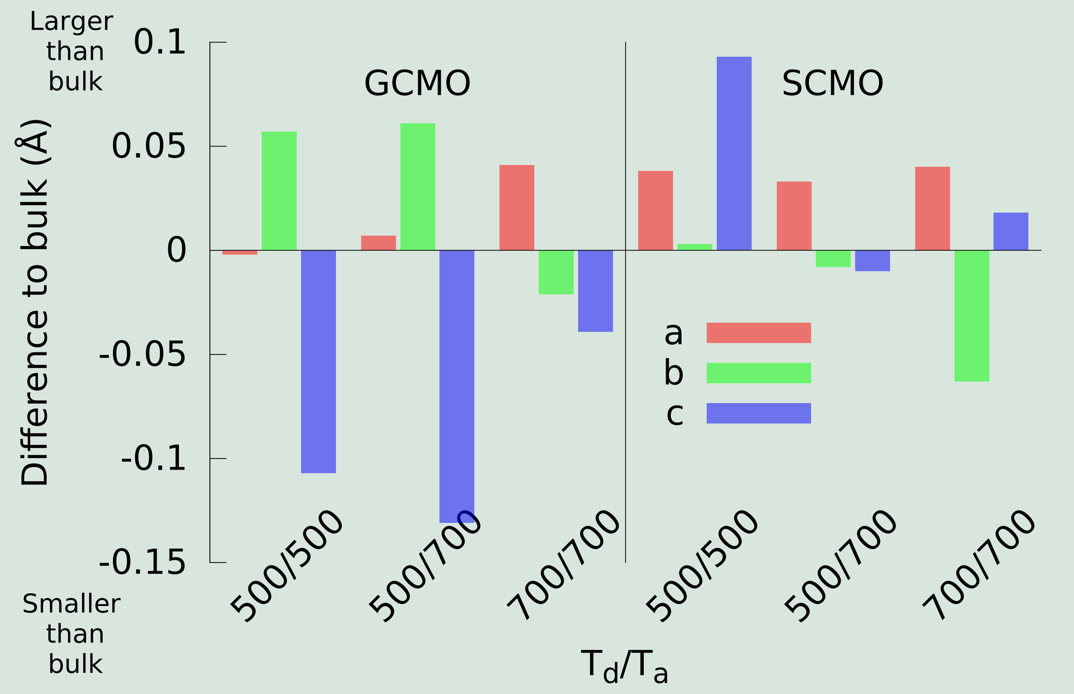
Magnetic and IV

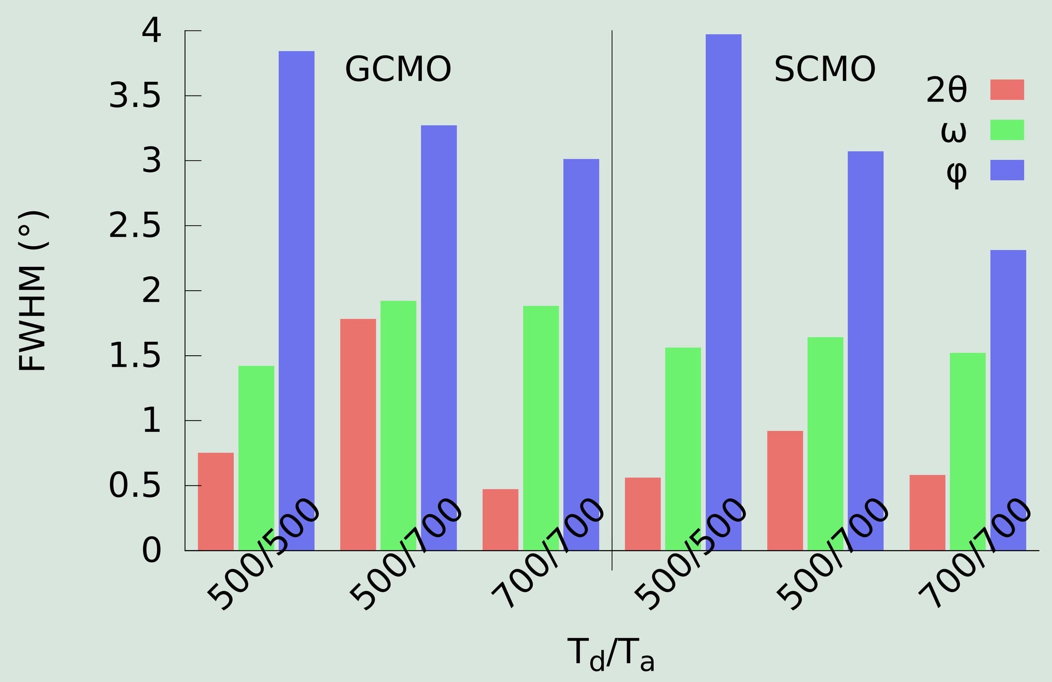
- Quantum Design MPMS SQUID
- FC and ZFC $M(T)$ at 50 mT
- Hysteresis loops at 10, 50, 300 and 400 K
- $I(V)$ at room temperature with Keithley 220 current source and HP 34401A multimeter

Structure



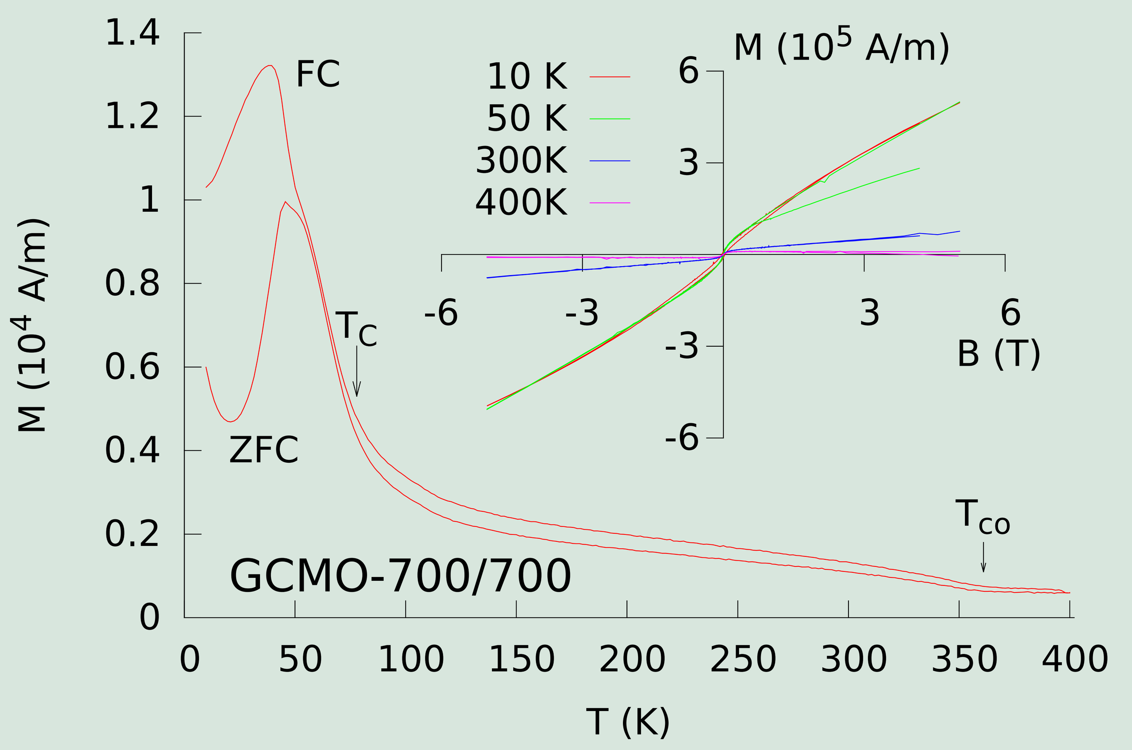


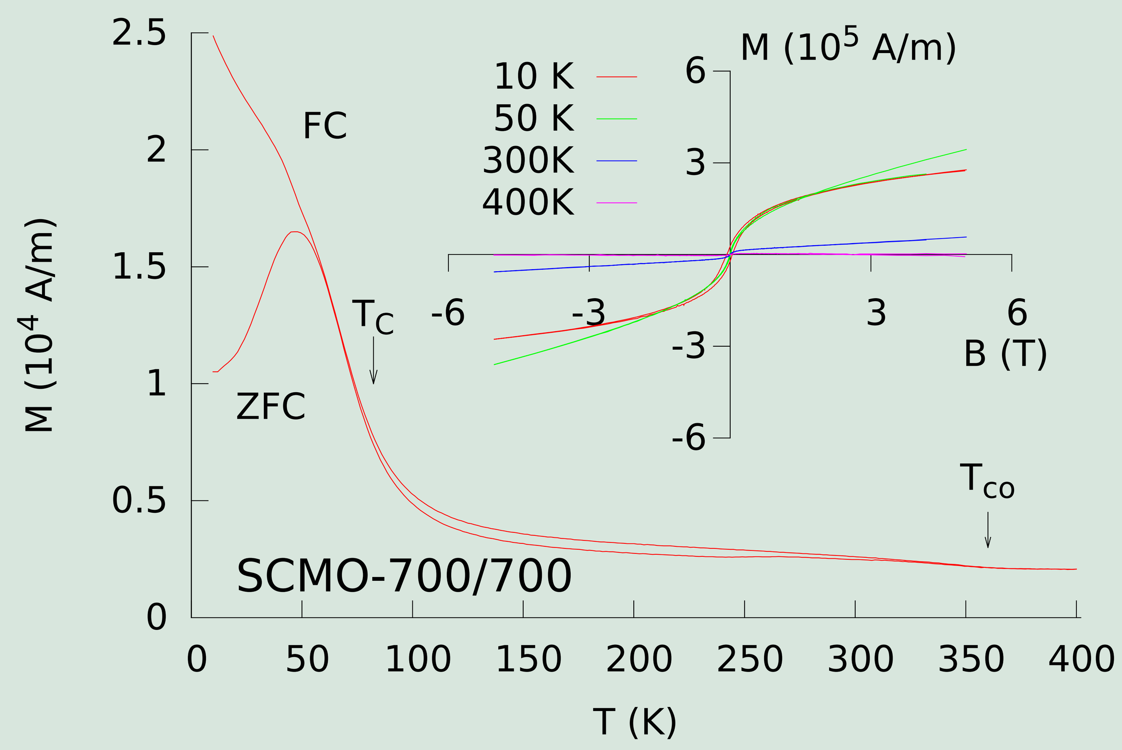




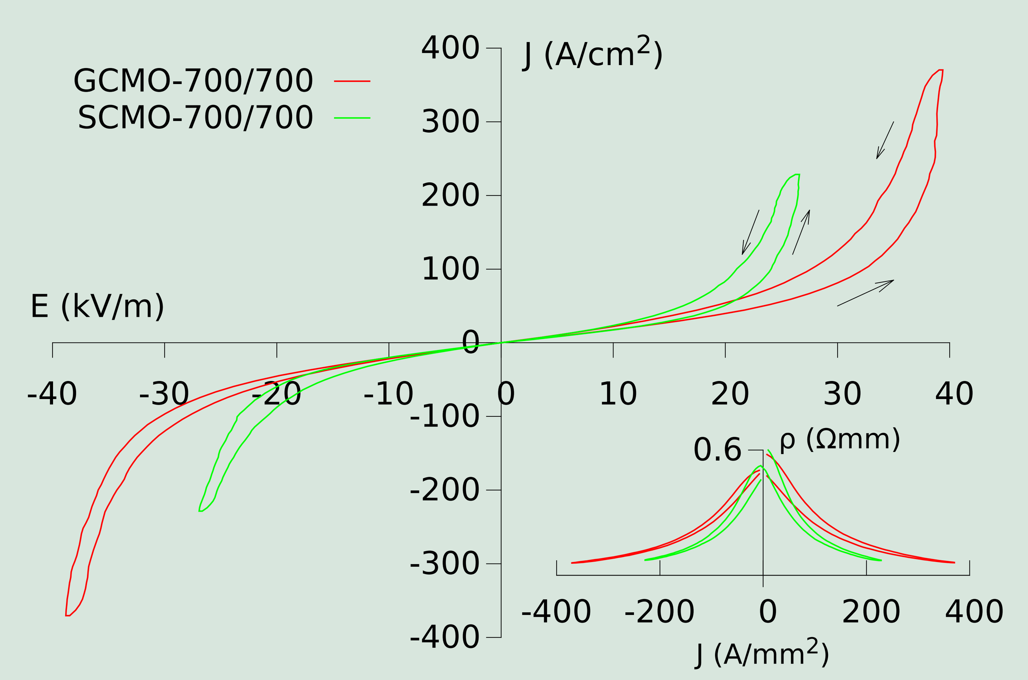
Magnetic properties

Material	T_d/T_a	T_C (K)	T_{co} (K)	M(5 T) (kA/m)	B_c (mT)	d (nm)
GCMO	500/500	70	362	470	8.5	59
GCMO	500/700	73	363	500	23.5	43
GCMO	700/700	78	361	510	49.2	54
SCMO	500/500	74	362	120	56.2	90
SCMO	500/700	78	366	300	78.2	83
SCMO	700/700	82	360	280	61.7	70





$I(V)$



Discussion

- All films show ferrimagnetic ordering with $T_C \approx$ 70 K
- All films have CO/OO-transition ≈ 360 K
- 700/700 films have the best crystallographic properties – narrowest peaks in all directions
- GCMO films are compressively strained, SCMO tensile strained
- SCMO films are clearly thicker than GCMO
- Hysteretic $I(V)$ at room temperature
- Strong electroresistance in all samples

Conclusions

CGMO and SCMO thin films have potential as Mott memristors

Best properties at T_d/ T_a= 700/700

References

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[2] Herpers A, Lenser C, Park C, Offi F, Borgatti F, Panaccione G, Menzel S, Waser R and Dittmann R *Advanced Materials* **26** 2730 (2014)
[3] Elovaara T, Huhtinen H, Majumdar S and Paturi P *EPJ Web of Conferences* **40** 15011 (2015)
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Acknowledgements

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Materials are also available at
`users.utu.fi/peetu/papers/`