

Electronic Supplementary Information (ESI) for

Atypical multiferroicity of HoCrO_3 in bulk and film geometry

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I. SURFACE CHARACTERIZATION

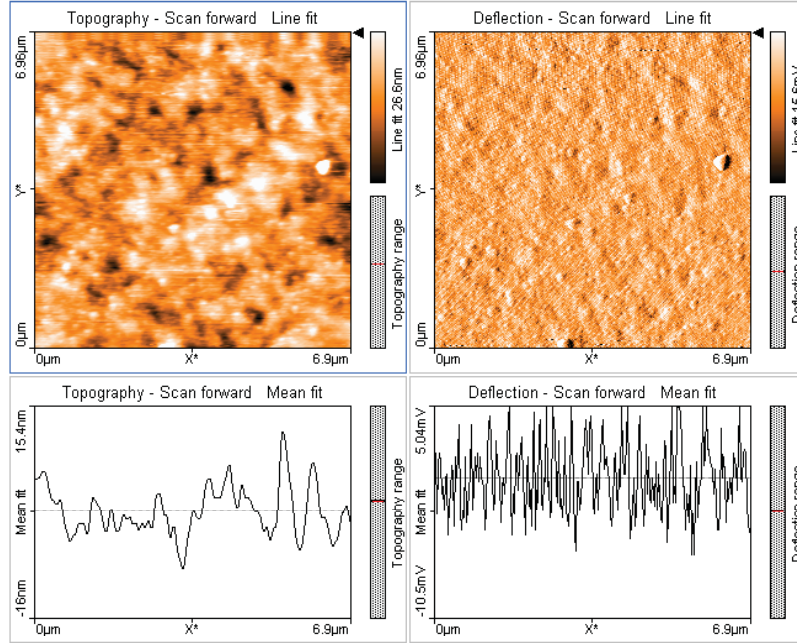


Figure S1: AFM image and depth profile of HoCrO_3 film.

AFM image shows nearly homogeneous surface topography as depicted in Fig. S1. The color bar indicates the Z-range or the depth profile.

II. ELECTRICAL CONNECTION FOR ELECTRIC POLARIZATION MEASUREMENT IN FILM

For $P - E$ loop measurements in film, initially gold is coated on the Si substrate using a gold coater (Eiko IB-2 Ion coater, Japan) on which HoCrO_3 film is deposited. Schematic representation of the electrical connection is shown in Fig. S2.

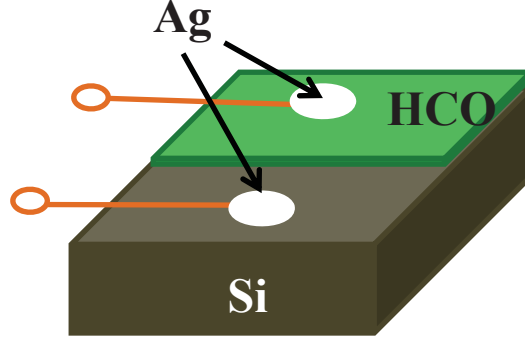


Figure S2: Schematic representation of the electrical connection for $P - E$ loop measurement in film.

III. LOW TEMPERATURE STRUCTURE

Low temperature structure has been evaluated using Rietveld refinement of x-ray diffraction pattern. Fig. S3 shows satisfactory fit using Rietveld refinement of the diffraction pattern of HoCrO_3 measured at 80 K. The details of the structural parameters as obtained from the refinement are given in Table S1.

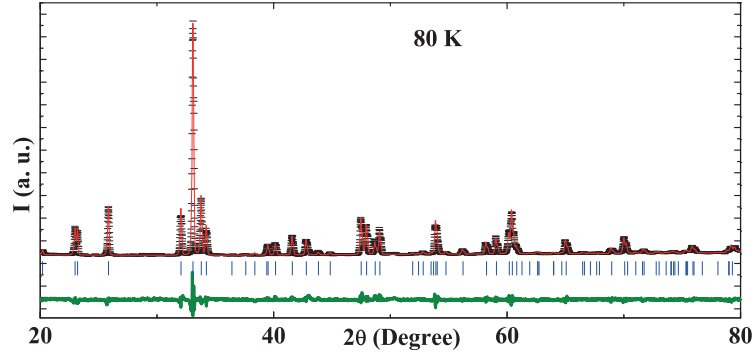


Figure S3: Rietveld refinement pattern of HoCrO_3 . X-ray diffraction pattern recorded at 80 K temperature.

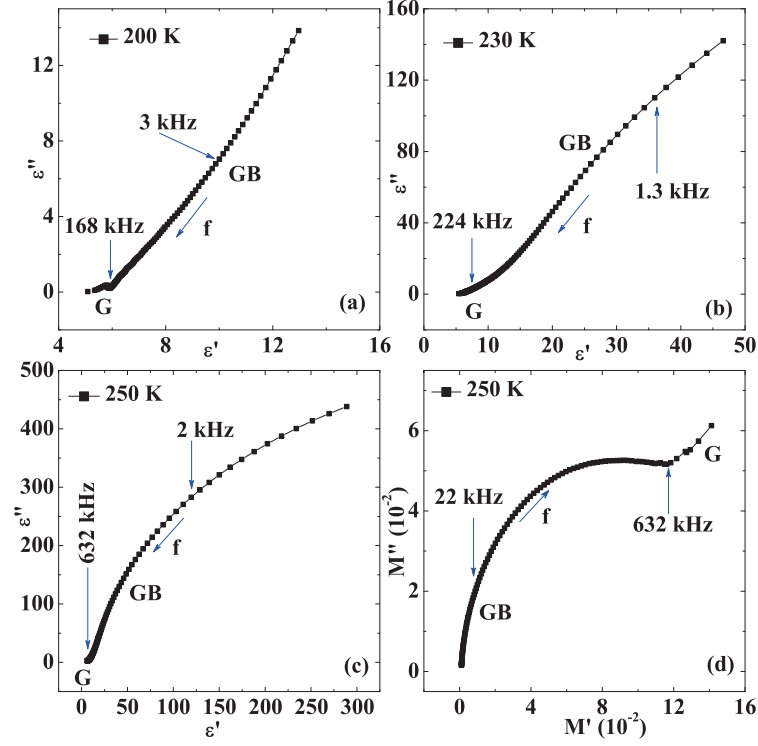


Figure S4: Cole-Cole plot at temperatures (a) 200 K, (b) 230 K, (c) 250 K and (d) complex-modulus plot at 250 K for bulk HoCrO_3 .

IV. COLE-COLE PLOT

Rapid increase of dielectric permittivity in bulk HoCrO_3 is due to the different conduction mechanism involved in grain (G) and grain-boundary (GB). It is clear from the Fig. S4 a that $f=1$ kHz is at the tail of the grain-boundary arc of the complex- ϵ plot. This indicates the low frequency lines at temperatures greater than 200 K corresponds to extrinsic grain-boundary effect. Also it is clear from Figs. S4 b and c that with increase in temperature G arc decreases and GB arc increases. The high frequency components remains within G arc even at high temperature. This provides a conclusive proof of presence of grain-boundary led extrinsic effect at high temperatures for bulk HoCrO_3 . As electric modulus shows real dielectric relaxation mechanism Fig. S4 d shows small G effect at high frequency range and large GB effect at low frequency range. So, the rapid increase in dielectric permittivity is

due to extrinsic grain-boundary effect.

V. RIETVELD REFINEMENT PARAMETERS

TABLE I: Rietveld refinement parameters obtained from x-ray diffraction data of HoCrO_3 using MAUD software package. The numbers in the parenthesis are the statistical errors in the last significant digits.

Lattice parameters			
T (K)	80 K	160 K	300K
a (Å)	5.5060(1)	5.5089(2)	5.2517 (2)
b (Å)	5.2359(2)	5.2410 (1)	5.5207 (1)
c (Å)	7.5218(1)	7.5310 (2)	7.5468 (1)
Space group	Pna ₂₁	Pna ₂₁	Pbnm
Atomic positions			
Ho (X)	0.0656 (1)	0.0646(1)	-0.0192(1)
Ho (Y)	0.0175 (2)	-0.0170(1)	0.0639(2)
Ho (Z)	0.1788(2)	0.4727(2)	0.25 (0)
Cr (X)	0.0104 (2)	0.0023 (1)	0.5 (0)
Cr (Y)	0.4830 (2)	0.4892(2)	0 (0)
Cr (Z)	-0.0831 (2)	-0.2802(1)	0 (0)
O1 (X)	0.4499 (1)	-0.0861(1)	0.0899(2)
O1 (Y)	-0.1144(2)	0.4155 (2)	0.4599 (2)
O1 (Z)	0.1634 (2)	0.2278 (2)	0.25 (0)
O2 (X)	0.0573 (1)	0.0499 (2)	0.3265 (2)
O2 (Y)	0.4569 (1)	0.6003 (1)	0.1722 (1)
O2 (Z)	0.4169 (2)	0.0119 (2)	0.0004(3)
O3 (X)	0.7028 (1)	0.2011 (1)	-
O3 (Y)	0.6977 (1)	0.1938 (2)	-
O3 (Z)	0.4818 (2)	-0.2144 (2)	-
Reliability factors			
R_w (%)	5.9350	7.7348	5.7941
R_{wnb} (%)	6.1372	8.2315	8.2655
R_b (%)	4.5496	5.7376	4.0158
R_{exp} (%)	4.2661	3.5464	1.3623