Rutile based novel spintronics devices

Xueyu Zhang, Manjit Pathak, Patrick LeClair, Arunava Gupta

MINT Center, University of Alabama, Tuscaloosa AL 35487

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Motivation:

- Fabrication of spintronics devices for their high performance
- Investigate the magneto-electric properties of rutile thin films.
- Relaxed growth of (110) CrO$_2$ on (110) TiO$_2$
- Out of plane magnetization in (001) CrO$_2$

Rutiles:

A rutile unit cell has body centered tetragonal structure with $a=b>c$. Examples: CrO$_2$, TiO$_2$, RuO$_2$, SnO$_2$, VO$_2$. Metal cations occupy the corner and the central sites while the oxygen anions occupy the octahedral site around the central metal ion. CrO$_2$: ferromagnetic half-metal VO$_2$: shows metal-insulator transition RuO$_2$: very good conductor

CrO$_2$ as half-metal:

CrO$_2$ has a band gap of about 1eV around Fermi level for its minority density of states. Because of this gap, it is called half-metal. CrO$_2$ shows spin polarization of $\sim 98\%$ at low temperatures. This high spin polarization makes it ideal for spin–electronic devices such as giant or tunnel magnetoresistance (GMR/TMR) devices.

GMR and TMR effect:

- parallel magnetization: low resistance
- antiparallel magnetization: high resistance

Fabrication steps for our (proof of principle) device:

1. Fabrication of rutile based GMR/TMR devices of (100), (110) and (001) orientations and measure their transport properties.
2. Modelling of these devices using COMSOL.
3. To study the magneto-electric properties of these rutile thin films – MR, resistivity, effect of strain on magnetization etc.

Sample preparation:

Epitaxial CrO$_2$ samples of (100), (110) and (001) orientations are prepared using atmospheric pressure chemical vapor deposition (APCVD) technique on TiO$_2$ substrates of respective orientations in a two zone furnace. Other rutile films can also be epitaxially grown using the same technique.

Future work:

1. Fabrication of rutile based GMR/TMR devices of (100), (110) and (001) orientations and measure their transport properties.
2. Modelling of these devices using COMSOL.
3. To study the magneto-electric properties of these rutile thin films – MR, resistivity, effect of strain on magnetization etc.

X-ray diffraction (XRD) studies show epitaxial (100), (110) and (001) CrO$_2$ films on TiO$_2$ substrates of respective orientations.