

List of publications

1. Ather Mahmood, Jamie L. Weaver, Syed Qamar Abbas Shah, Will Echtenkamp, Jeffrey W. Lynn, Peter A. Dowben, and Christian Binek, Adv. Physics Res., 2300061 (2023)
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Entropy Change at a Demagnetization Broadened First Order Transition
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<https://doi.org/10.1016/B978-0-12-819728-8.00084-X>
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Graphene on Chromia: A System for Beyond-Room-Temperature Spintronics

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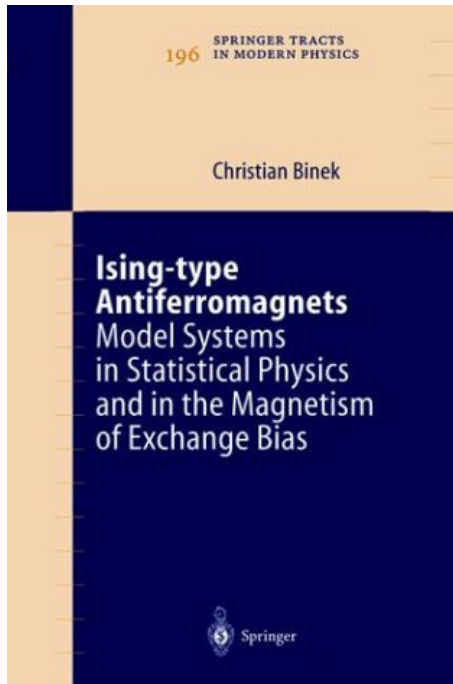
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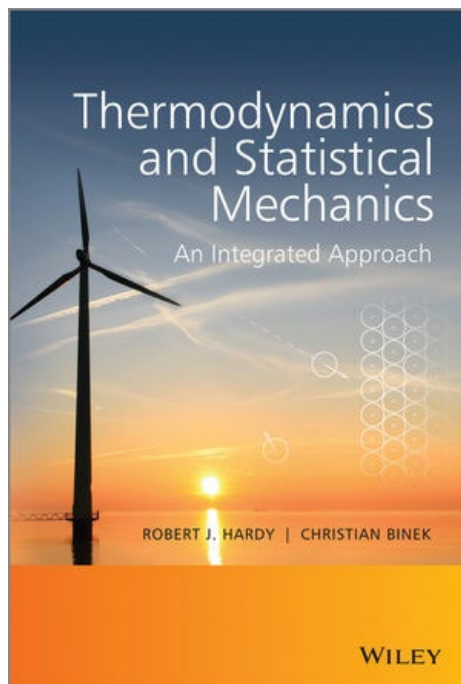
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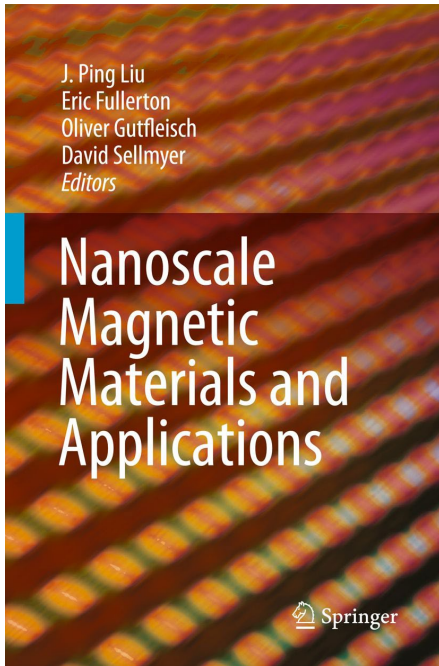
*Ising-type antiferromagnets:
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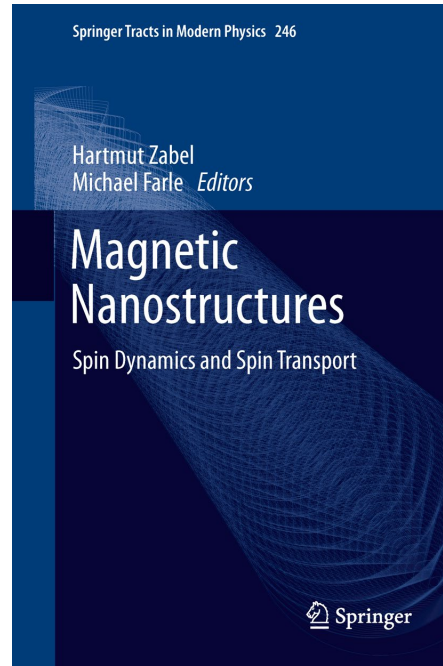


ISBN: 978-1-118-50100-9, 510 pages, May 2014

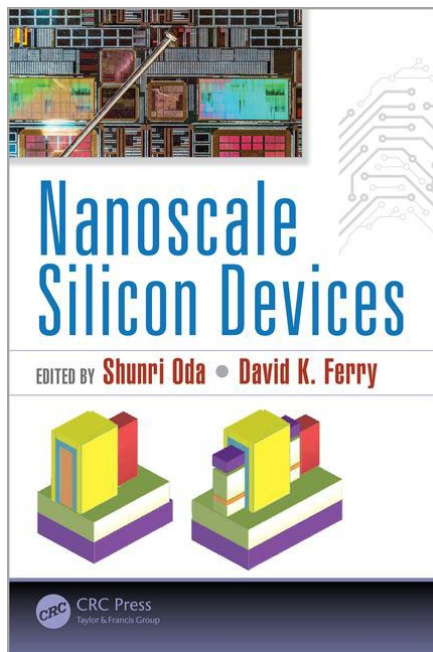
Book chapters



“Tunable Exchange Bias Effects”,
Chapter 6, page 159-179.



“Multiferroic and magnetoelectric materials”,
Chapter 5, page 163-187.



“Potential of Nonvolatile Magnetoelectric Devices for
Spintronic Applications”
Chapter 11, page 255 - 278

Patents

Method for refrigeration through voltage-controlled entropy change, involves generating change in temperature of ferromagnetic materials, in response to generating strain in ferromagnetic materials attached to piezoelectric materials

Patent Number(s): US2014007592-A1
 Inventor(s): BINEK C
 Patent Assignee Name(s) and Code(s): BINEK C(BINE-Individual)
 Derwent Primary Accession Number: 2014-A74862 [06]



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ART UNIT	PAPER NUMBER
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/161,888	05/23/2016	Christian Binek	24742-0065002	1737

TITLE OF INVENTION: REFRIGERATION THROUGH VOLTAGE-CONTROLLED ENTROPY CHANGE

Magneto-electric spin field effect transistor used for non-volatile memory device, consists of layer of magneto-electric gate dielectric, thin film of channel material, and source and drain disposed in electrical contact with thin film

Patent Number(s): US2014231888-A1
 Inventor(s): KELBER J A, BINEK C, BOWDEN P A, BELASHCHENKO K
 Patent Assignee Name(s) and Code(s): QUANTUM DEVICES LLC (QUAN-Non-standard)



(12) **United States Patent**
 Kelber et al.

(10) **Patent No.:** US 9,379,232 B2
 (45) **Date of Patent:** Jun. 28, 2016

(54) **MAGNETO-ELECTRIC VOLTAGE CONTROLLED SPIN TRANSISTORS**

(71) Applicants: **University of North Texas**, Denton, TX (US); **Quantum Devices, LLC**, Potomac, MD (US)

(72) Inventors: **Jeffrey A. Kelber**, Plano, TX (US); **Christian Binek**, Lincoln, NE (US); **Peter Arnold Bowden**, Crete, NE (US); **Kirill Belashchenko**, Lincoln, NE (US)

(73) Assignee: **QUANTUM DEVICES, LLC**, Rockville, MD (US)

(52) **U.S. CL**
 CPC **H01L 29/78** (2013.01); **G11C 11/161** (2013.01); **G11C 11/5607** (2013.01); **H01F 10/002** (2013.01); **H01L 29/517** (2013.01); **H01L 29/66984** (2013.01); **B82Y 10/00** (2013.01); **H01F 10/3268** (2013.01); **H01L 29/1606** (2013.01)

(58) **Field of Classification Search**
 USPC 257/4, 24, 194, 213, 295
 See application file for complete search history.

(56) **References Cited**
 U.S. PATENT DOCUMENTS

Magnetic Spin Valve With a Magnetolectric Element

Patent Inventorship Correction US patent 7,358,846



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Patent No. 7358846
Issued Date: 15 April, 2008
Appl. No: 11/444,675
Filed.: 01 June 2006

PART (A) RESPONSE FOR CERTIFICATES OF CORRECTION

This is a decision on the Certificate of Correction request filed 04 August 2015.

The request for issuance of Certificate of Correction for the above-identified correction(s) under the provisions of 37 CFR 1.322 and/or 1.323 is hereby:

(Check one)
 Approved Approved in Part Denied

Comments:

PART (B) PETITION UNDER 37 CFR 1.324 OR 37 CFR 1.48

This is a decision on the petition filed 15 June 2009 to correct inventorship under 37 CFR 1.324.

This is a decision on the request under 37 CFR 1.48, petition filed In view of the fact that the patent has already issued, the request under 37 CFR 1.48 has been treated as a petition to correct inventorship under 37 CFR 1.324.

The petition is hereby: Granted Dismissed

The patented filed is being forwarded to Certificate of Corrections Branch for issuance of a certificate naming only the actual inventor or inventors.

/Amy Cohen Johnson/
Supervisory Patent Examiner, Art Unit 2833
Technology Center 2800
Phone: (571) 272-1850

Certificates of Correction Branch email: CustomerServiceCxC@uspto.gov CxC Central Phone Number: (703) 756-1814

Magnetolectric chromia having increased critical temperature

Inventor(s): BINEK C, BOWDEN P A, BELASHCHENKO K, STREET MIKE

Patent Number : US 9,718,700 B2

Date of Patent: August 2017



(12) United States Patent		(10) Patent No.: US 9,718,700 B2
Binek et al.		(45) Date of Patent: *Aug. 1, 2017
(54) MAGNETOELECTRIC CHROMIA HAVING INCREASED CRITICAL TEMPERATURE	(52) U.S. CL	CPC ——— <i>C01G 37/027</i> (2013.01); <i>H01F 10/009</i> (2013.01); <i>H01F 10/002</i> (2013.01); <i>H01L 43/08</i> (2013.01); <i>H01L 43/12</i> (2013.01); <i>C01P 2002/50</i> (2013.01); <i>C01P 2002/72</i> (2013.01); <i>H01F 10/3268</i> (2013.01)
(71) Applicant: Board of Regents of the University of Nebraska, Lincoln, NE (US)	(58) Field of Classification Search	CPC ——— <i>H01L 20/82</i> ; <i>H01L 45/02</i> ; <i>H01L 45/08</i> ; <i>H01L 27/228</i> ; <i>H03K 19/173</i> ; <i>H03K 19/16</i> See application file for complete search history.
(72) Inventors: Christian Binek, Lincoln, NE (US); Peter Bowden, Crete, NE (US); Kirill Belashchenko, Lincoln, NE (US); Aleksander Wysocki, Ames, IA (US); Sal Mu, Lincoln, NE (US); Mike Street, Lincoln, NE (US)	(56) References Cited	U.S. PATENT DOCUMENTS 4,957,273 A 9/1990 Spencer et al. 9,276,040 B1 * 3/2016 Marshall ——— <i>H01L 43/08</i>
(73) Assignee: Board of Regents of the University of Nebraska, Lincoln, NE (US)	(*) Notice:	OTHER PUBLICATIONS "Increasing the Néel temperature of magnetolectric chromia for voltage-controlled spintronic" by M. Street, et al., in Applied Physics Letters, No. 104, Jun. 2, 2014, 4 pages. "Effect of substitutional doping on the Néel temperature of Cr ₂ O ₃ " by Sal Mu, et al., in American Physical Society, Physical Review B 87, Feb. 28, 2013, 11 pages.
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 108 days. This patent is subject to a terminal disclaimer.	(65) Prior Publication Data	* cited by examiner Primary Examiner — Carol M Koslow (74) Attorney, Agent, or Firm — Islem IP Law, L.L.P.
(21) Appl. No.: 14/629,178	(66) Related U.S. Application Data	(57) ABSTRACT
(22) Filed: Feb. 23, 2015	Provisional application No. 61/943,528, filed on Feb. 24, 2014.	A magnetolectric composition of boron and chromia is provided. The boron and chromia alloy can contain boron doping of 1%-10% in place of the oxygen in the chromia. The boron-doped chromia exhibits an increased critical temperature while maintaining magnetolectric characteristics. The composition can be fabricated by depositing chromia in the presence of borane. The boron substitutes oxygen in the chromia, enhancing the exchange energy and thereby increasing Néel temperature.
(51) Int. Cl.		15 Claims, 11 Drawing Sheets
<i>C01G 37/027</i> (2006.01) <i>H01F 10/00</i> (2006.01) <i>H01L 43/08</i> (2006.01) <i>H01L 43/12</i> (2006.01) <i>H01F 10/00</i> (2006.01) <i>H01F 10/32</i> (2006.01)		

Magnetoelectric Logic Devices using Semiconductor Channel with Large Spin-Orbit Coupling

Inventor(s):

Dr. Dmitri Nikonov, Intel

Prof. Christian Binck, University of Nebraska at Lincoln

Prof. Xia Hong, University of Nebraska at Lincoln

Prof. Jonathan P. Bird, University at Buffalo

Prof. Kang Wang, University of California – Los Angeles

Prof. Peter A. Dowben, University of Nebraska at Lincoln

Patent Number: US 10,361,292 B2

Date of Patent: July 23, 2019



US010361292B2

(12) **United States Patent**
Nikonov et al.

(10) **Patent No.:** **US 10,361,292 B2**

(45) **Date of Patent:** **Jul. 23, 2019**

(54) **MAGNETO-ELECTRIC LOGIC DEVICES USING SEMICONDUCTOR CHANNEL WITH LARGE SPIN-ORBIT COUPLING**

(51) **Int. Cl.**
G11C 11/00 (2006.01)
H01L 29/66 (2006.01)
(Continued)

(71) Applicant: **Board of Regents of the University of Nebraska, Lincoln, NE (US)**

(52) **U.S. Cl.**
CPC **H01L 29/66984** (2013.01); **B82Y 10/00** (2013.01); **G11C 11/14** (2013.01);
(Continued)

(72) Inventors: **Dmitri E. Nikonov, Beaverton, OR (US); Christian Binck, Lincoln, NE (US); Xia Hong, Lincoln, NE (US); Jonathan P. Bird, Buffalo, NY (US); Kang L. Wang, Los Angeles, CA (US); Peter A. Dowben, Crete, NE (US)**

(58) **Field of Classification Search**
CPC ... H01L 29/66984; H01L 29/08; H01L 29/24; H01L 29/423; G11C 11/14;
(Continued)

(73) Assignees: **INTEL CORPORATION, Santa Clara, CA (US); THE RESEARCH FOUNDATION FOR THE STATE UNIVERSITY OF NEW YORK, Amherst, NY (US); BOARD OF REGENTS OF THE UNIVERSITY OF NEBRASKA, Lincoln, NE (US); THE REGENTS OF THE UNIVERSITY OF CALIFORNIA, Oakland, CA (US)**

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2011/0233524 A1 * 9/2011 Wang B82Y 10/00
257/39

(Continued)

Primary Examiner — Toan K Le

(74) *Attorney, Agent, or Firm* — Talem IP Law, LLP

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(57) **ABSTRACT**

Antiferromagnetic magneto-electric spin-orbit read (AF-SOR) logic devices are presented. The devices include a voltage-controlled magnetoelectric (ME) layer that switches polarization in response to an electric field from the applied voltage and a narrow channel conductor of a spin-orbit coupling (SOC) material on the ME layer. One or more sources and one or more drains, each optionally formed of ferromagnetic material, are provided on the SOC material.

(21) Appl. No.: **15/898,457**

(22) Filed: **Feb. 17, 2018**

(65) **Prior Publication Data**

US 2018/0240896 A1 Aug. 23, 2018

Related U.S. Application Data

(60) Provisional application No. 62/460,164, filed on Feb. 17, 2017.

20 Claims, 9 Drawing Sheets

Hall Bar Device for Memory and Logic Applications

Inventor(s):
Christian Binek
Ather Mahmood
Will Echtenkamp



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LE, TOAN K

ART UNIT PAPER NUMBER

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DATE MAILED: 09/24/2021

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16/988,085	08/07/2020	Christian BINEK	MAR-UNL-105	1253

TITLE OF INVENTION: HALL BAR DEVICE FOR MEMORY AND LOGIC APPLICATIONS

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	\$1200	\$0.00	\$0.00	\$1200	12/24/2021