Curriculum Vitae

(Amol Karandikar)

Contact Information

Earth and Planets Laboratory
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Education

Goethe University, Frankfurt am Main, Germany
Ph.D., Natural Sciences, Sept. 2016
- *Magna cum Laude*
- Thesis Title: 'Development of the Flash-heating Method for measuring Melting Temperatures in the Diamond Anvil Cell'
- Advisor: Prof. Dr. Björn Winkler, Supervisor: Dr. Reinhard Boehler

University of Pune, Pune, India
M.Sc., Quantum Physics, Sept. 2000
- Project topic: Study of Quantum Gates in Quantum computing
- Advisor: Dr. P. S. Joag

University of Mumbai, Mumbai, India
B. Sc., Physics, June 1997

Acedemic Positions

Research Scientist Feb. 2019 - present
Geophysical Laboratory ('Earth and Planets Laboratory' since 2020)
Carnegie Institution for Science, Washington DC, USA
Supervisor: Dr. Michael Walter

Postdoctoral Research Associate Feb. 2017 – Jan. 2019
Geophysical Laboratory
Carnegie Institution for Science, Washington DC, USA
Supervisor: Dr. Reinhard Boehler, Dr. Timothy Strobel

Doctoral Research Associate March 2010 – Sept. 2014
Geophysical Laboratory
Carnegie Institution for Science, Washington DC, USA
Supervisor: Dr. Reinhard Boehler

Doctoral student Aug. 2009 – Sept. 2016
Department of Geoscience
Goethe University, Frankfurt am Main, Germany
Advisor: Prof. Dr. Björn Winkler

Doctoral student, research employee March 2009 - Nov. 2009
High pressure Mineral physics department
Max Planck Institute for Chemistry, Mainz, Germany
Supervisor: Dr. Reinhard Boehler

Scientific Officer Sept. 2002 - Nov. 2008
High Pressure Physics Division
Bhabha Atomic Research Centre, Mumbai, India

Trainee Scientific Officer Aug. 2001 - Aug. 2002
Raja Ramanna Centre for Advanced Technology, Indore, India

Work Experience/ Technical Expertise

Studies of phase transitions, melting, and synthesis of materials under high pressure using Toroidal anvil apparatus (6 GPa-1200K), Bridgman anvil apparatus (8 GPa), and laser-heated diamond anvil cell (LHDAC) apparatus (1 Mbar-5000K).

Experienced in probing electronic / ionic conductivity properties of materials using Toroid and Bridgman anvil apparatus. Handled various DAC types: Boehler-Almax, Mao-Bell, and membrane DAC.

Conversant with preparing and assembling DACs for 4-probe electrical measurements, and resistive heating.

Expertise in design and set up of near/far IR LHDAC facility. Probes used: Raman, Brillouin, and IR-absorption spectroscopy. Synchrotron methods - X-ray diffraction (XRD), absorption spectroscopy (XAS), and inelastic scattering (IXS) for the DAC research. Involved in optical alignment and calibration for optimizing temperature measurement at 16 ID-B beamline dedicated to LHDAC research at APS (USA).

Experienced user of the XRD beamlines at synchrotron facilities - Elettra (Italy), ESRF (France), PETRA (Germany), and APS (USA).

Experienced in developing Graphic User Interface (GUI) in Labview for instrument control at the XRD1 beamline Elettra (Italy), and at the Earth and Planets Laboratory (USA).

Experienced in Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Spectroscopy (EDX), and Focused Ion Beam Milling (FIBM) to prepare/characterize/analyze samples.

Software capability

Labview for developing GUI for instrument control; *Autocad* for machine drawing; *Origin*, *Veusz*, *Igor-Pro* for plotting; *Dioptas*, *GSAS, fit 2d* for XRD analysis; *LaTeX* for text edit. Currently learning *Python*.

Selective Research

- **Tunable thermal expansion materials**

Low/Negative thermal expansion (LTE/NTE) materials have potent use in synthesizing tunable thermal expansion materials. Under pressure, most of these materials (ZrW_3O_{12}, $NbOPO_4$, $HfMo_2O_8$, $ZrMo_2O_8$) amorphize, losing their NTE property. Using XRD, and Raman spectroscopy, I studied their compression-path through phase transitions to amorphization, and heating thereafter. The amorphization was attributred to kinetic hindrance to a phase transition/decomposition, in contrast to LTE ceramics having energetically favored amorphized state.

- **Development of flash-melting method**

Measuring melting temperatures (T_{melt}) in LHDAC is challenging due to difficulties like chemical reactions, sample instability, and thermal

runaway. Using rectangular shaped laser-pulses of milliseconds duration, with analysis using optical images, SEM, EDX, and FIBM techniques to characterize the melt texture, I developed 'flash-melting' method that circumvents these problems. Melting curves of Re, Mo, and Ta have been measured using this method. The method is robust, accurate within ±100 K, with reproducible results.

• **Development of a novel encapsulation for melting experiments**
The ultimate method to measure T_{melt} at extreme pressures is to be able to contain the material in liquid state inertly and probe the structure. Using FIBM technique, I developed novel insulating, inert encapsulations for synchrotron XAS to measure T_{melt} of iron at Megabar pressures in LHDAC. These encapsulations maintain uniform sample thickness within the X-ray beam - a crucial requirement for XAS - during compression and heating, allowing very first of this kind of measurement.

Recent Research

Using XRD to detect onset of melting from diffuse scattering signal and measure T_{melt} in a LHDAC is challenging due to sample dispersion and stringent alignment of X-ray, heating laser, and optical probe. I am using flash-melting synchronized with 0.1-10 ms XRD of samples (8-10 μm dia, 5-6 μm thin) contained in inert encapsulation to detect the melting onset. Beamlines used : 16 IDB and 13 IDD at APS (USA).

Current Research

• Melting diamond at high pressure is challenging due its high thermal conductivity and predicted high T_{melt}. It is fundamentally interesting due to a maximum in its melting curve, and yet to be observed BC8 phase. The only available data is above 600 GPa from shock experiments. Using Re as a coupler and flash-melting method with SEM, EDS analysis using FIB, I have attempted to measure T_{melt} in 20-50 GPa range using LHDAC.
• As a research scientist, I am setting up a user friendly, double sided LHDAC facility at the Earth and Planets Laboratory, DC, USA. It will facilitate CW and modulated laser heating, with 1 μm and 10 μm laser wavelengths. The temperature will be measured by specrtoradiometry and 2-d temperature maps will be created by 4-color method.

Research Grants

Postdoctoral Research Associate — Feb. 2018 – Jan. 2019
Washington Diamond® grant. Carnegie Institution for Science, DC, USA

Postdoctoral Research Associate — Feb. 2017 – Jan. 2018
U.S. Department of Energy, Office of Science under Award Number DE-SC0001057 EFree(I), Carnegie Institution for Science, DC, USA

Doctoral Associate — July 2014 – Sept. 2014
NSF grant (Dr. R. Boehler). Carnegie Institution for Science, DC, USA

Doctoral Associate — April 2014 – June 2014
Carnegie-DOE Alliance Center, Grant DE-NA0002006

Doctoral Associate Oct. 2010 – March 2014
U.S. Department of Energy, Office of Science under Award Number DE-SC0001057 EFree(I), Carnegie Institution for Science, DC, USA

Doctoral candidate fellowship March 2009 – Sept. 2010
Max Planck Institut für Chemie, Mainz, Germany

Posters presented

1. Tantalum Melting at High Pressure
   A. Karandikar, J. Riuz Fuertes, R. Boehler
   [2010 Sept 24-25, EFree Annual Meeting, Washington D.C., USA]

2. Melting of Refractory Metals in Extreme Environment
   A. Karandikar, R. Boehler
   [2011 May 25-27, Energy Frontier Research Centers – Summit and Forum, Washington D.C., USA]

3. Melting of Refractory Metals (Re, Mo) in Extreme Conditions
   L. Yang, A. Karandikar, R. Boehler
   [2011 Sept 16-17, EFree Annual Meeting, Washington D.C., USA]

4. Flash heating in diamond cell : *Melting curves of rhenium and molybdenum*
   A. Karandikar, L. Yang, R. Boehler
   [2012 June 24-29, Gordon Research Conference, Biddeford, New England, USA]

5. Synchronizing flash melting in diamond cell with synchrotron XRD
   Amol Karandikar, Reinhard Boehler, Yue Meng, Guoyin Shen, Eric Rod
   [2012 Oct 10-12, Advanced Photon Source workshop, Argonne National Lab, Chicago, USA]

Talks given

1. Methods for detecting metal melting in Diamond Anvil Cell
   [2011 Jan 07, Geophysical Laboratory, Carnegie Institution of Science, Washington D.C., USA]

2. Phonon Dispersion Curves of Gadolinium at High Pressures from Single Crystal Inelastic Xray Scattering in Diamond Anvil Cell
   [2011 Sept 28, AIRAPT – 23 International Conference, Mumbai, India]

3. Limits of material stability: melting of refractory materials
   [2012 Apr 3, EFree mid-term review, Baltimore, USA]

4. Flash heating in diamond cell: *Melting curves of rhenium and molybdenum*
   [2012 June 24-29, Gordon Research Conference, Biddeford, New England, USA]

5. Flash heating in diamond cells: Melting of refractory metals
   [2014 Sept 24, EFree Highlight Talk, Carnegie Institution of Science, Washington D.C., USA]

6. Bonds to Bands
   [2017 Dec 01, Geophysical Laboratory, Carnegie Institution of Science, Washington D.C., USA]

Publications

08. *Flash melting of tantalum in the diamond cell to 85 GPa.*
[Physical Review B 93 (2016) 054107]
A. Karandikar, R. Boehler

07. *Melting of iron determined by X-ray absorption spectroscopy to 100 GPa.*
[Proceedings of National Academy of Sciences 112 (2015) 12042]
G. Aquilanti, A. Trapananti, **A. Karandikar**, I. Cantor, C. Marini, O. Mathon, S. Pascarelli, R. Boehler

06. *High P-T Brillouin scattering study of H_2O melting to 26 GPa.*
[High Pressure Research 34 (2014) 327]
M. Ahart, **A. Karandikar**, S. Gramsch, R. Boehler, R. J. Hemley

05. *Flash Heating in the Diamond Cell: Melting Curve of Rhenium.*
[Review of Scientific Instruments 83 (2012) 63905]
L. Yang, **A. Karandikar**, R. Boehler.

04. *Microscopic evidence of a flat melting curve of tantalum.*
[Physics of Earth and Planetary Interiors 181 (2010) 69]
J. Ruiz-Fuertes, **A. Karandikar**, R. Boehler, D. Errandonea

03. *Amorphization and structural evolution of α-$HfMo_2O_8$ and its high density polymorph β-$HfMo_2O_8$ at high pressures.*
[Journal of Physics and Chemistry of Solids 69 (2008) 35]
G. D. Mukherjee, **A. Karandikar**, V. Vijayakumar, B. K. Godwal, S. N. Achary, A. K. Tyagi, A. Lausi, E. Busetto.

02. *Pressure evolution of resistance in framework structured materials α-$ZrMo_2O_8$ and α-$HfMo_2O_8$.*
[Journal of Applied Physics, 100 (2006) 13517]
A. Karandikar, G.D. Mukherjee, V. Vijayakumar, B.K. Godwal, S.N. Achary, A.K. Tyagi.

01. *Compressibility anomaly and amorphization in anisotropic negative thermal expansion material $NbOPO_4$ under pressure.*
[J. Solid State Chemistry, 178 (2005) 8]
G.D. Mukherjee, V. Vijaykumar, **A. Karandikar**, B.K. Godwal, S.N. Achary, A.K.Tyagi, A. Lausi, E. Busetto.

… Diamond melting to 50 GPa using flash heating in the diamond cell
[In preparation]
L. Yang, **A. Karandikar**, T. Shiell, S. Wong, B. Cook, D. McCulloch, J. Bradby, B. Haberl, R. Boehler