**Annual report (2015.9) for COMPTECH officer Jin Zhang**

**Name:** Jin Zhang

**Length of time at current position:** 11 months (2014.11 to 2015.10)

**Brief job description:**

The main mission of COMPTECH includes three aspects: First, create new technical capabilities for COMPRES users; second, establish preferential access to state-of-the art facilities at existing beamlines; and then finally, help to bring up new and important discoveries in deep Earth interior.

**Activities:**

1. COMPTECH major project: X-ray thermal diffuse scattering (TDS) (63%)

X-ray thermal diffuse scattering (TDS) has been used to determine elastic properties of solids since 1940s. However, its application in high-pressure mineral physics has not been widely recognized. Sound velocities of Earth materials at relevant high pressure (P) and temperature (T) conditions are essential for interpreting seismic data, which provides by now the most accurate image of the Earth interior. Comparing with other commonly used techniques for measuring sound velocities in the high-pressure mineral physics community, for example, Brillouin scattering, stimulated light scattering, inelastic X-ray scattering (IXS), nuclear resonance inelastic X-ray scattering (NRIXS) or MHz/GHz ultrasonics, it has significant advantages and disadvantages. Firstly, it could be used for measuring any single crystals at extreme P-T conditions using diamond anvil cell (DAC), not limited to transparent samples or nuclear resonant isotopes; Secondly, single-crystal elastic properties, not only aggregate elastic properties, could be obtained through TDS, and hence directional dependences of sound velocities are available; Finally, experimental setup for TDS measurement is very easy, no special optical components are needed. However, TDS is much less straightforward in data interpretation, which usually involves micro force constant modeling (Born-von Karman model) between the neighboring atoms.

I prepared the samples for high-pressure experiment, and developed experimental strategies of performing TDS experiments at different beamlines (including 13BMC, 13IDC and 34IDE) using different experimental setups (Mar CCD detector, Pilatus detector, flight path, energy scan) with the project PI Dr. Przemyslaw Dera, Sector 34 beamline scientist Dr. Ruqing Xu, GSECARS beamline scientist Dr. Dongzhou Zhang, Dr. Joanne Stubbs and Dr. Peter Eng. We successfully measured TDS up to 40GPa for foresterite and 1.4GPa for Si. I also developed Python fitting code based on continuum elastic wave model, the final fitted single crystal elasticity tensor of Si is identical to what’s obtained through the traditional approach using Born-von Karman model. The TDS signal is proved to be very sensitive to single crystal elasticity.

1. COMPTECH side project (25%):
2. PX2 instrumentation (6%):

I participated in the initial instrumentation and pre-alignment of the optical system in 13BMC before the appointment of the PX2 beam line scientist started in January 2015; I also helped PX2 users (e.g. Dr. Gang Liu and Liping Kong from HPSync) when the beamline scientist Dr. Dongzhou Zhang is not around; I worked on membrane pressure control system in 13BMC, including ordering tubing, connection parts and GE pressure controller, and the installation of stainless steel tubing inside 13BMC with the help from GSECARS Beamline Mechanical Technician Mike Proskey. The GE Drucker pressure controllers arrived at GSECARS early October, connection parts have been ordered, I hope to finish the installation before 2016-1 run.

1. Multigrain analysis (3%):

I prepared sample chambers and participated in the beam time for multigrain analysis in 2015-1 and 2015-2 in HPCAT on laser heating wollastonite and ferrosilite to gain experience on the synthesis process of materials inside of diamond anvil cell.

1. Website development (8%):

I rearranged and rewrote the original COMPTECH website created by Dr. Bin Chen in 2013, added techniques sections to introduce the new progress of the COMPTECH technical development, and advisory board section to include the information related to technology advisory committee (TAB). All TAB meeting schedules, notes and slides are uploaded onto the COMPTECH website. The tools section which include most frequently used soft wares in the high-pressure mineral physics field, is updated with developer’s emails and related publications.

1. Universal membrane cap (4%):

I designed a new type of membrane cap for changing the traditional screw-driven diamond anvil cell to a membrane cell, which allows remote control of pressure. The cap is designed to fit as many different types of diamond anvil cells as possible, and ensure no loss of diamond anvil cell opening, which is critical for single-crystal experiments. The membrane cap bulk parts are received and the membranes were sent back to the machine shop for revision.

1. Standard DAC Heaters (4%):

The commercial W-Al2O3 heaters are ready-to-use, well-calibrated, reusable, cheap (~$10) comparing with traditional Pt heaters (~$200). I introduced and calibrated the heaters in air and in the diamond anvil cell. Dr. Kurt Leinenweber and Dr. Dan Shim in Arizona State University ordered 20 pcs from us for the initial test, and Dr. Zhenxian Liu from NSLSII also ordered 4 pcs from us.

1. Personal research (7%):

I finished up writing part of my PhD thesis for developing a CO2 laser heating Brillouin spectroscopy system for sound velocity measurements at high-pressure high-temperature conditions. I published a new possible mechanism for generating deep earthquakes with Dr. Lijun Liu, the majority of the work has been finished when I was a PhD student. I also performed some offline laser heating experiment on hydrous ringwoodite during the APS shut down time, the quenched products are waiting for analysis.

1. Meetings and workshops (5%):

I attended several meetings and workshops during the past 1 year, advertised the PX2 beam line and present part of the results we obtained in COMPTECH project. The meetings and workshops include:

2014 AGU fall meeting (presenting my personal research on olivine);

2015 COMPRES annual meeting (report of the COMPTECH project progress);

HIGP seminar at University of Hawaii (advertisement on COMPTECH project);

COMPRES site visit at APS (update with presidents & Executive committee chair);

2015 MS&T conference (advertisement of PX2 beam line for single crystal XRD experimental opportunities to the material science community);

IEDA Alliance Kickoff Workshop (discussion about possible opportunities of developing mineral physics data base with IEDA at Lamont-Doherty Earth Observatory)

**COMPTECH time line:**

2014.11 join COMPTECH

2014.12 13BMC PX2 commissioning

Ambient TDS measurement: sample suitable for DAC, Si (15um thick)

AGU fall meeting at San Francisco, CA

2015.1 design of the first version universal membrane cap

1st test on W-Al2O3 heaters

Website major revision: Tools

2015.2 received the 1st set of modified W-Al2O3 heaters

Rearrange COMPTECH website

Preparation for TDS beam time

2015.3 1st TDS measurement with flight-path setup at 13BMC

1st high pressure (HP) TDS measurement on Si at 13BMC

2015.4 1st Python code for Si single-crystal elasticity tensor inversion (BVK model)

TDS sensitivity test

2015.5 1st Python code for single-crystal elasticity tensor (any symmetry)

Website revision: Facilities

2015.6 Received the 1st version of universal membrane cap

Website revision: Techniques

Preparation for TDS beam time

2015.7 1st HP TDS on foresterite at 34ID

1st HP TDS on foresterite at 13IDC

COMPRES 2015 annual meeting at Colorado Springs, CO

Membrane tubing installed in 13BMC

2015.8 HP TDS measurement on foresterite up to 40GPa at13BMC

1st W-Al2O3 heater test in DAC

University of Hawaii, HIGP seminar

2015.9 Testing new inversion algorism for TDS data analysis

1st heater user: U of Arizona

Budget approved for adding optical system for 34ID

COMPRES site visit to high-pressure facilities at APS

2015.10 GE Druck pressure controller received, connection parts ordered

MS&T 2015 conference at Columbus, OH

2nd HP TDS on foresterite at 34ID

IEDA Alliance Kickoff Workshop at Lamont-Doherty Earth Observatory, NY

**Publications:**

Zhang, J. S., Bass, J.D. and G. Zhu (2015), Single-crystal Brillouin spectroscopy with laser-heating and variable q, Rev. Sci. Instrum. 86, 063905. doi: 10.1063/1.4922634

Liu, L. and J. S. Zhang (2015), Differential contraction of subducted lithosphere layers generates deep earthquake generation, Earth Planet. Sci. Lett. 421, 98. doi:10.1016/j.epsl.2015.03.053