Synthesis, preparation and transport analysis of topological insulators $BiSbTeSe_2$ and $BiSbTe_2S$

[1]Bruno Gudac, [1]Mario Novak, [1]Filip Orbanić, [2]Petar Popčević, [1]Ivan Kokanović

[1]Department of physics, Faculty of Science, University of Zagreb, Zagreb, Croatia
[2]Institute of physics, Zagreb, Croatia

E-mail: bgudac@phy.hr

Topological insulator

Conductive surface or edge states

Semiconductor on the inside

Bi_2Te_2Se (BTS)

- Large inner resistance
- Te-Bi-Se-Bi-Te arrangment good for decreasing defects

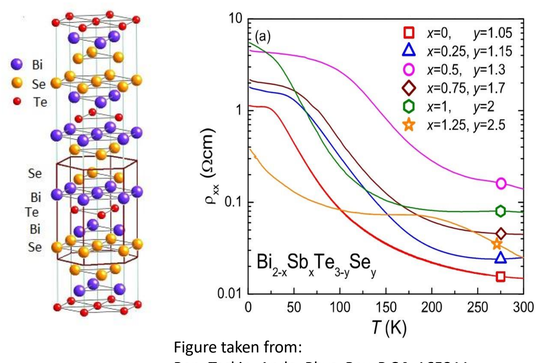
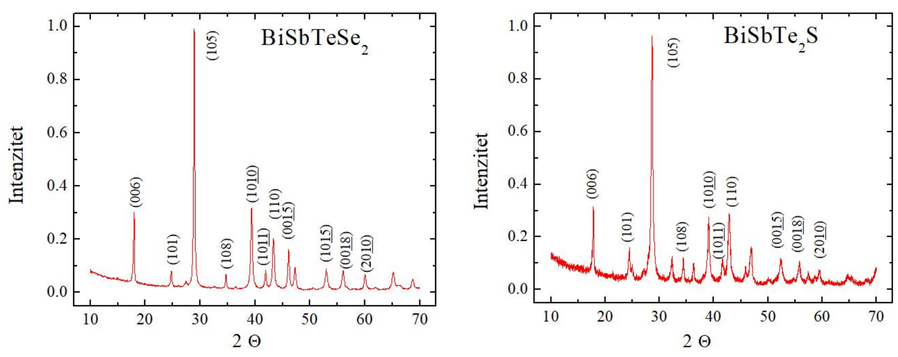


Figure taken from:
Ren, Taskin, Ando, Phys. Rev. B **84**, 165311

$Bi_{2-x}Sb_xTe_{3-y}Se_y$ (BSTS)

- Rhomboedric crystaline structure
- (Bi,Sb)/Te place swap and Se vaccancy are dominating defects
- Composition optimizing with goal of making bigger inner resistance

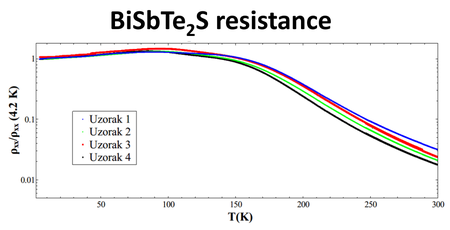
XRD analysis



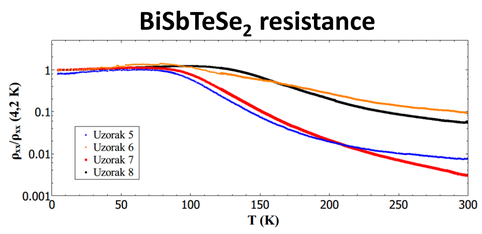
Both materials crystalize in rhomboedric structure with cell parameters a= 4.16 Å, c=29.41 Å in **$BiSbTeSe_2$** and a=4.21 Å, c=29.55 Å in **$BiSbTe_2S$**

Characterization outside magnetic field

$BiSbTe_2S$ resistance

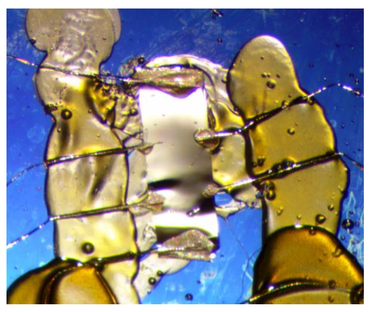


$BiSbTeSe_2$ resistance



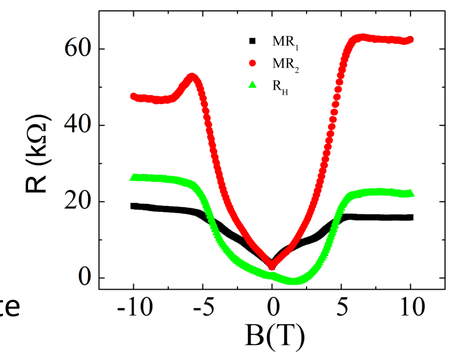
- At higher temperatures resistance grows with temperature decrease -> semiconductor
- At lower temepratures resistance starts decreasing with temperature -> conductive surface

Setup for measurement



- Contacts: Conductive silver paste and platinum wires (ϕ=25μm)

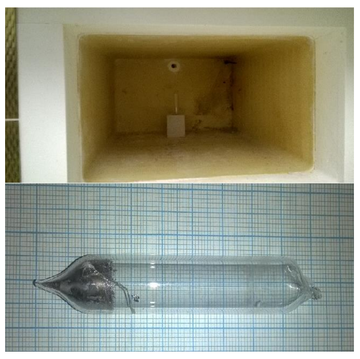
Recorded magnetization



Synthesis and sample preparation

Preparing ampoules with materials

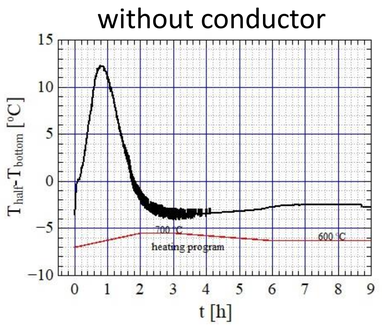
- Quartz ampoule
- Mixing pure elements in glovebox
- Sealing ampoule



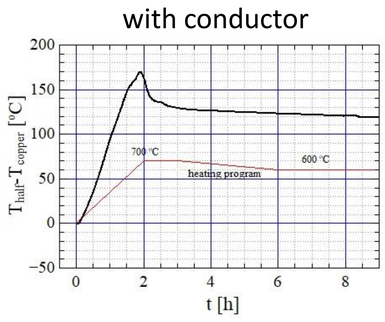
- **Heating**
  - From room temperature to 800°C in 24 hours
  - 800°C kept for 4 days (homogenization)
- **Cooling ->** Modified Bridgeman method
  - 800°C to 700°C in 12 hours
  - 700°C to 450°C in 3 days
  - 450°C kept for 3 days (annealing)

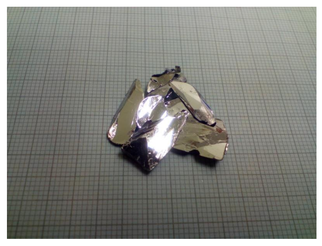
Modified Bridgeman method – temperature gradient achieved using copper heat conductor

without conductor



with conductor



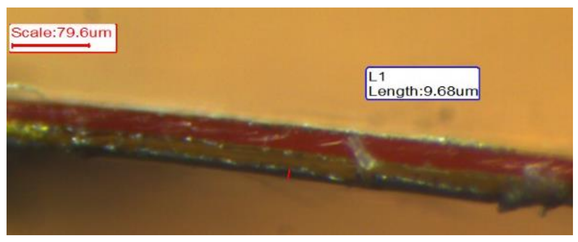


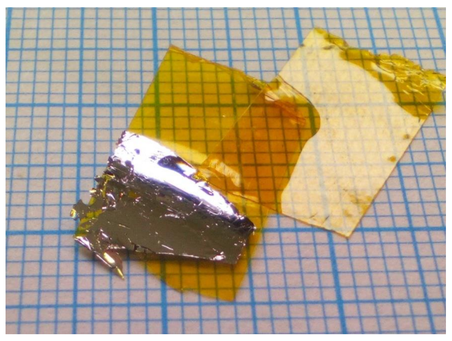
Synthesis results

- $BiSbTeSe_2$ monocrystal (right)
- $BiSbTe_2S$ monocrystal (left)

Characterization preparation

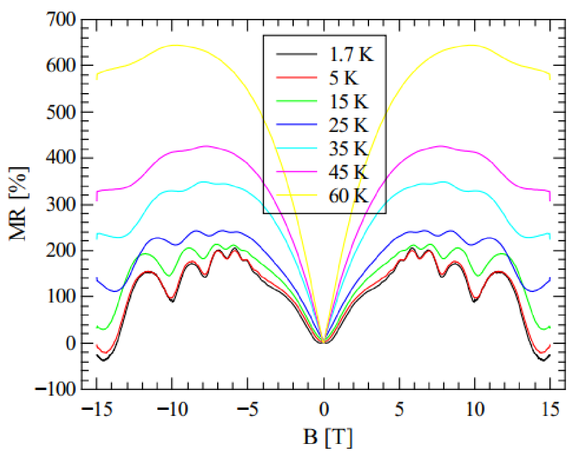
- Razor cutting
- *Capton* tape -> thickness ≈10 μm

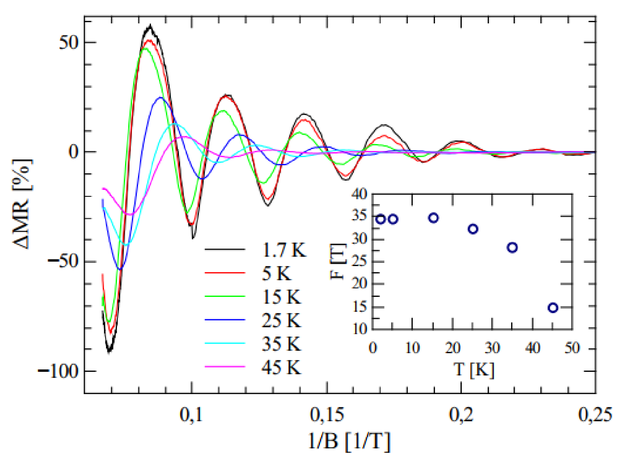


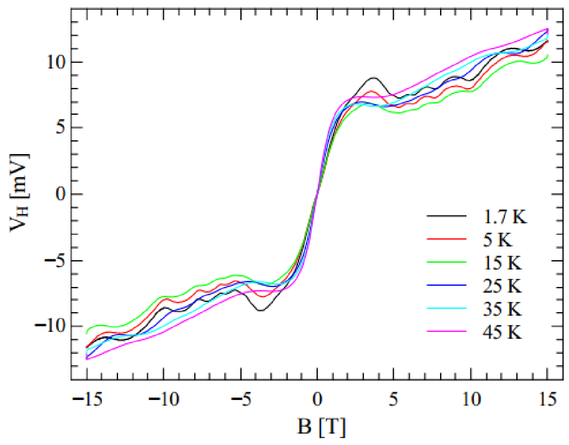


Characterization inside magnetic field

$BiSbTe_2S$







- Interesting temperature dependence of magnetoresistance
- Shubnikov-de-Haas oscilations
- Cyclotron frequency of charge carriers has temperature dependance (inset)

This research was completely funded by HRZZ projects 6216 and IP-2018-1-8912.

European CMetAC