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Scientific report

In the period of: October 2009 – May 2010

Purpose of the visit: investigations of the ferroelectric semiconductors of $\text{Sn}_2\text{P}_2(\text{Se}_x\text{S}_{1-x})_6$ group at different temperature and pressure conditions

Description of the work:

During the visit of Cavendish Laboratory the following issues were carried out:

- samples of $\text{Sn}_2\text{P}_2(\text{Se}_x\text{S}_{1-x})_6$ group with Se concentrations $x = 0\%$, 5% , 10% , 28% and 100% were cut and polished according to the measuring method requirements and the Au electrodes were applied on their surfaces by magnetron sputtering for future investigations. For pressure investigations prepared crystals were connected to the measuring board using Ag thin wires glued by silver paste on their surfaces on the one end and soldered to the measuring board on the other end. Thereafter, each sample was tested for the signal response by measuring the capacity at room temperature following which some of them had to be remade because of the lost contact caused either by electrodes or sample crack. These crystals are very fragile, which made the sample preparation process more complicated and slow, since the small shapes and sizes were required.
- After obtained corresponding signal quality at normal conditions, the samples were put into the pressure cell. The process of putting the sample into the cell and pressurizing it is very delicate. By the time the required signal response was obtained we had to go back to crystal preparation and electrode issues several times, since during the manipulations with the pressure cell some of them got

damaged. As soon as the proper signal was obtained samples were tested by measuring the resistance at room temperature and ambient pressure.

- During the testing in the pressure cell we discovered that the connection of the sample to measuring system using pin terminal with thin long copper wires is not sufficient, since it greatly affects the results and causes a lot of noise and uncertain quality of measured values. This led us to the further modification of the sample connection and measuring wires coming out of the cell.
- Several samples were also prepared for low temperature measurements at ambient pressure board.
- Temperature dependent impedance measurements in cooling mode (down to 350mK) and heating mode (up to room temperature) were realized for $x = 0\%$, 5% , 10% , 28% and 100% of $\text{Sn}_2\text{P}_2(\text{Se}_x\text{S}_{1-x})_6$ samples. Measurements were carried out at different frequencies 5 kHz, 10 kHz, 25 kHz, 50 kHz, 75 kHz and 100 kHz.

Description of the main results obtained:

- Temperature measurements of the resistance at cooling and heating mode for $\text{Sn}_2\text{P}_2\text{Se}_6$ were realized in the piston pressure cell at pressure 5kbar. From experimental results of resistance the phase transition was seen, but due to high resistance of measured samples and measurement error, obtained results did not meet our expectations qualitatively. Therefore, measurements of high resistance samples under pressure require further investigations, different measurement methods and high range equipment.
- During the low temperature studies of $\text{Sn}_2\text{P}_2(\text{Se}_x\text{S}_{1-x})_6$ samples with different concentrations of Se the following results were obtained:
 - ✓ Phase transition in the low temperature region for $\text{Sn}_2\text{P}_2\text{Se}_6$ samples was observed. The behavior of the dielectric properties within the ferroelectric, incommensurate and paraelectric phases were examined.

- ✓ For pure $\text{Sn}_2\text{P}_2\text{S}_6$ the frequency dispersion of dielectric values was observed in the interval below 100 K. The behavior of dielectric properties was examined in low temperature region.
- ✓ For $x = 28\%$ sample the phase transition was obtained just below the room temperature region. And further investigations of dielectric properties were made in the low temperature region.
- ✓ For samples $x = 5\%$ and $x = 10\%$ the low temperature behavior of dielectric properties was examined. Some frequency dispersions were obtained at low temperature region.

Future collaboration with host institution

Possible future collaboration in investigations of high resistance samples under pressure.

In Liberec 27th May, 2010