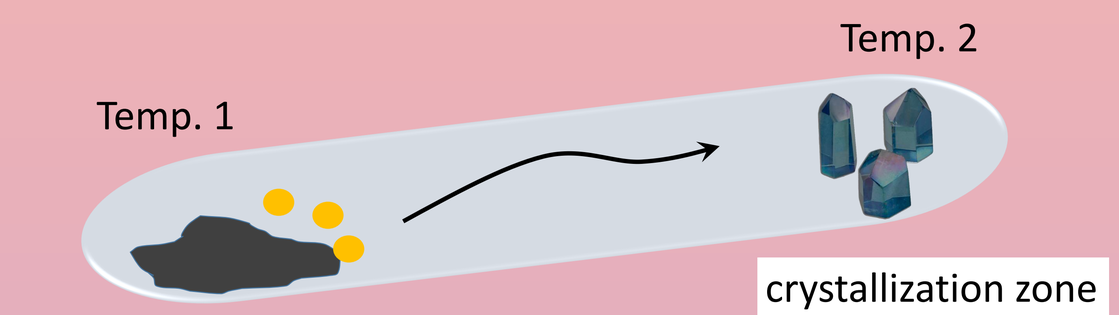
Growth and characterization of Weyl semimetal single crystals and single crystals of oxides for optoelectronic applications

P. Iwanowski, A. Hruban, **J. Fink-Finowicki**, K. Cieślak, D. Jastrzębski, A. Wadge, R. Diduszko, M. Czech, T. Wojciechowski, A. Wiśniewski, M. Berkowski

Chemical Vapor transport (CVT)



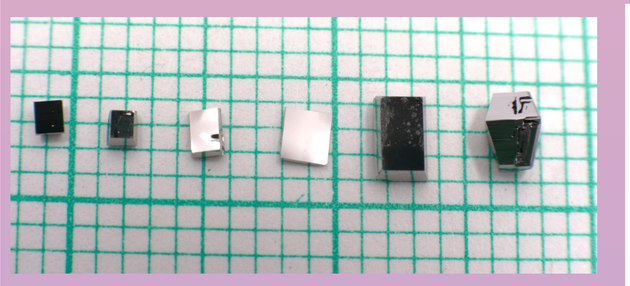
The chemical vapor transport (CVT) method is a technique used to grow single crystals of materials such as NbP. It involves the use of a chemical transport agent, typically a volatile liquid or gas, which transports the material from a source region to a growth region, where the crystal forms.

Czochralski method

The Czochralski method is a widely used technique for growing single crystals of materials such as semiconductors, metals, and ceramics. It involves the use of a seed crystal, which is dipped into a container of molten material and slowly pulled out while being rotated. The heat and rotation cause the molten material to solidify and form a single crystal as it is pulled out.

The seed crystal is typically made of the same material as the single crystal being grown, and it is carefully selected to have a specific orientation and surface morphology. The seed crystal is placed on the end of a rod or arm, which is then dipped into a container of molten material and slowly pulled out while being rotated. The heat from the molten material causes the seed crystal to melt and form a small droplet, which then solidifies and forms a single crystal as it is pulled out.

Weyl semimetal, NbP



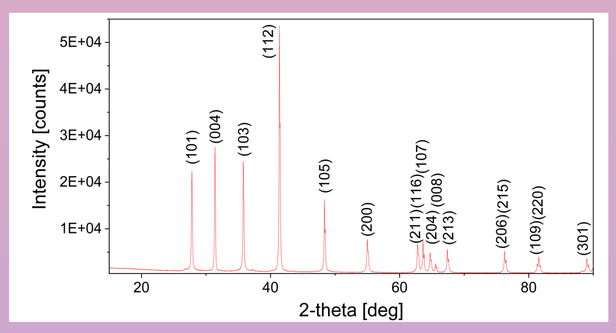


Figure 1. shows single crystals of NbP (b) X-ray diffraction of NbP

In the case of NbP, a common transport agent used is iodine. The source region contains a mixture of the precursor compounds for NbP (typically niobium and phosphorus) and iodine, while the growth region contains only iodine. The transport agent is heated, causing the precursor compounds to vaporize and react with the iodine to form NbP, which then condenses and crystallizes in the growth region.

$(Gd_{1-x}Lu_x)_2SiO_5$

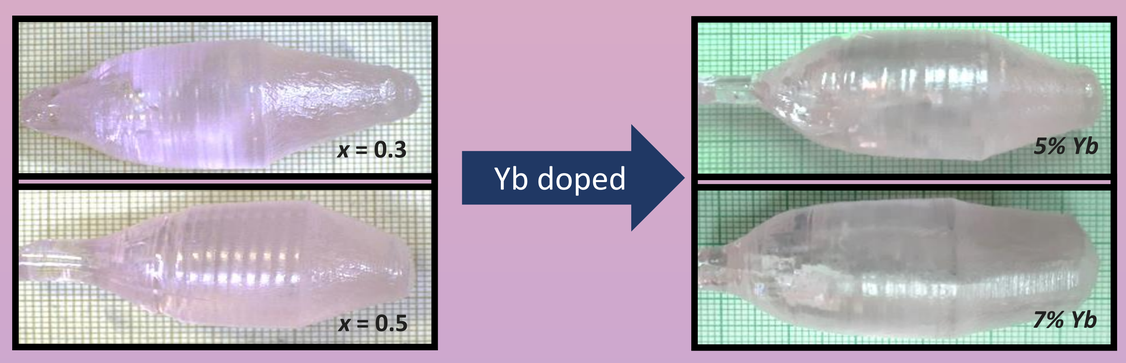


Figure 4. Single crystals grow $(Gd_{1-x}Lu_x)_2SiO_5$ with *x*= 0.3 doped 0.5% at Er, 2%at Yb and 0.5% at Er i 2% at Yb, 5% at Yb and 7% at Yb were fabricated by the Czochralski technique.

$LiNbO_3$Crystalization

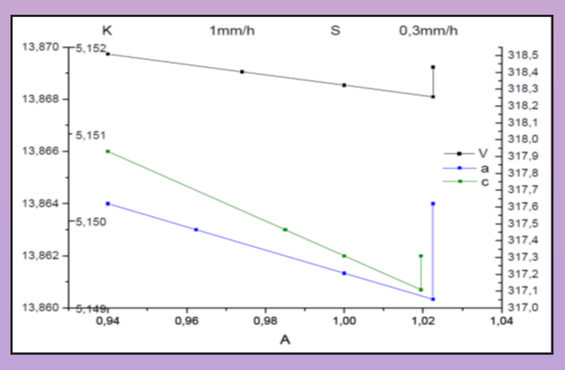


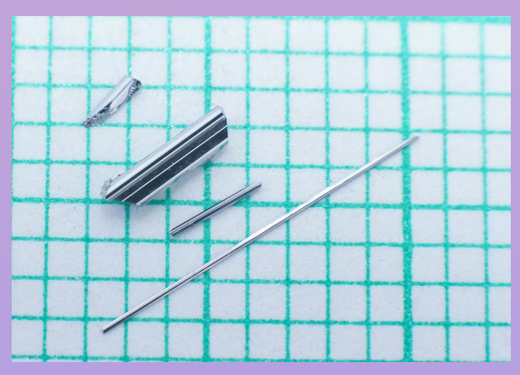
Figure 5. LiNbO crystal with and withauot 0.5% at Pr dopping

After every process lattice constants were defined and showed below. Li/Nb ratio in crystal is placed at „A" axis, „K" and „S" mean stoichiometric composition and congruent composition respectively (from the database); „a", „c" i „V" are lattice constants and the volume of the unit cell.

In doped crystal „a" increases to c.a. 0.96 (Li/Nb), „c" increases to stoichiometric value and the volume of the unit cell coresponds to 0.97 (Li/Nb).

The dopant introduced into the matrix is optically active in the visible range, therefore the obtained crystals may prove to be promising as laser sources. Cubes were cut and polished from the obtained crystals and sent for optical tests (Prof. A. Suchocki).

Nodal line semimetal, $ZrAs_2$



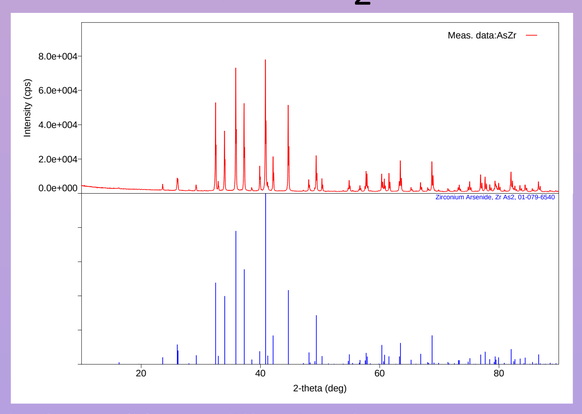
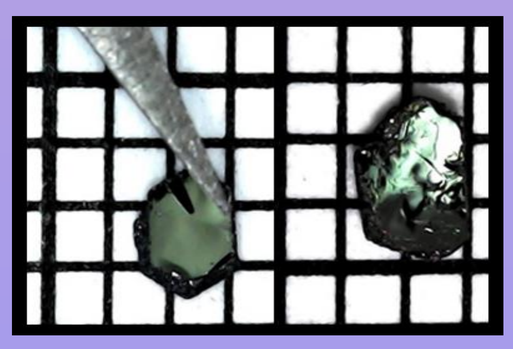


Figure 2. shows single crystals of $ZrAs_2$,(b) X-ray diffraction of $ZrAs_2$

$NbSe_2$



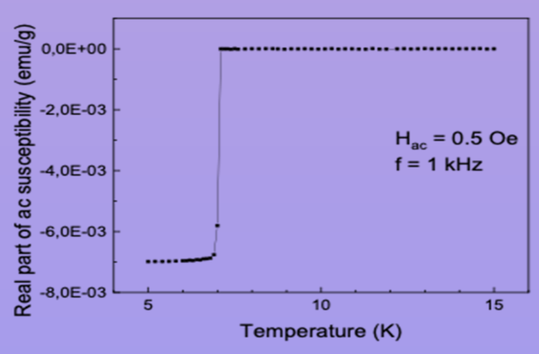


Figure 3. shows single crystals of $NbSe_2$,(b) SQUID measurements of $NbSe_2$

Single crystals (susceptible to exfoliation) with a diameter of up to 3 mm were obtained. The quality of the crystals was confirmed by XRD tests and in cooperation with Dr. J. Piętosa preliminary SQUID magnetic testing were done. Sharp transition to superconductivity in 7 K was confirmed.

$Y_{1-x}Gd_xAlO_3$: Mn, Hf

Figure 6. Single crystals grown in an optical furnace by zone melting

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Presenter: Dr. Jan Fink-Finowicki (Email: finow@ifpan.edu.pl)