50 years of the Institute of High Pressure Physics Polish Academy of Sciences

Highlights in III-V semiconductors, THz physics and nanomaterials

Anniversary Symposium „Unipress 50"

High pressure synthesis of superconducting wires

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Single Crystals & thin films growth under high pressure

High pressure (using Hot Isostatic Pressing (HIP) process) often allows to grow large single crystals [1] necessary for investigation of basic physical properties.

High pressure also allows to obtain new phases and physical properties, like increased critical temperature T_c, thanks to:

- Reduction of evaporation of substrates
- Introduction of additional strain in crystal structure

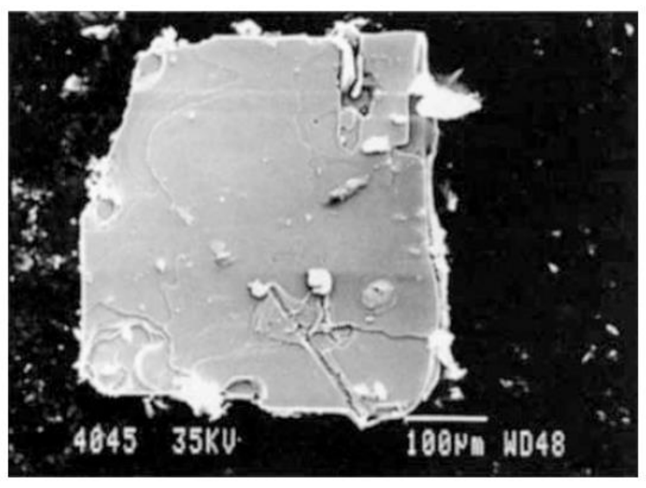
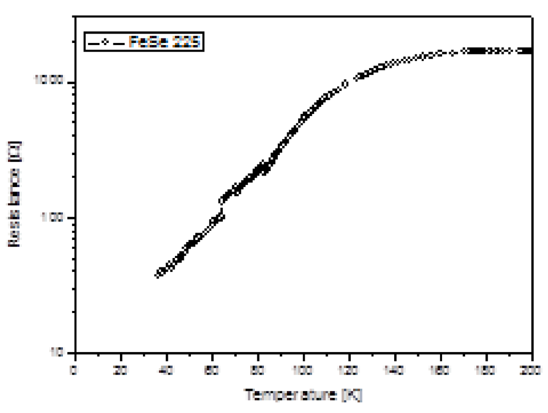
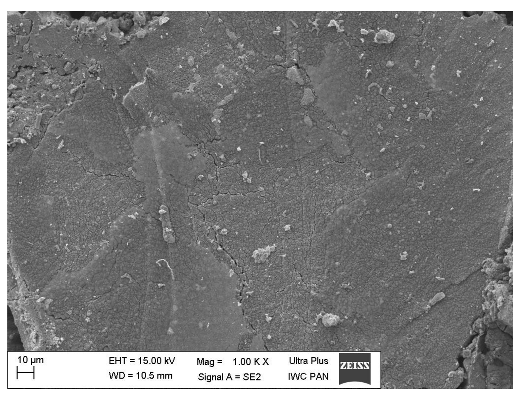


FIG I . $HgBa_2Ca_3Cu_4O_x$ single crystal with characteristic growth steps on the surface





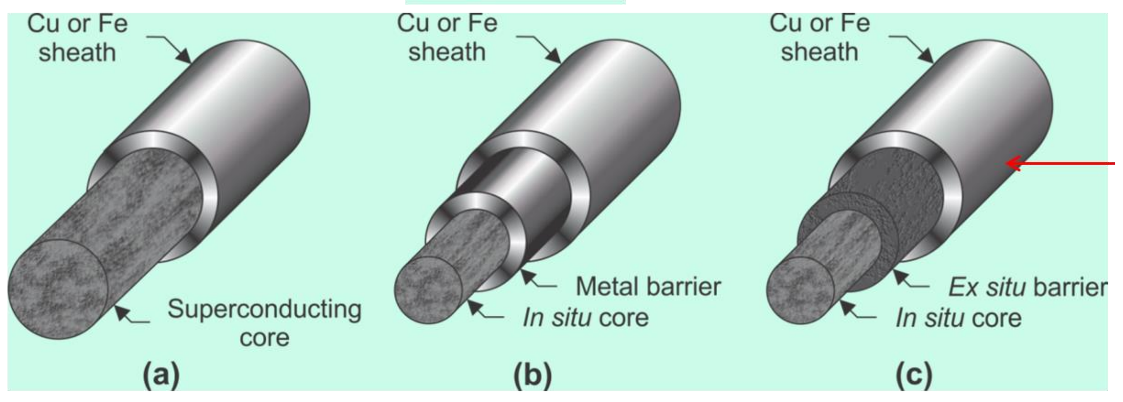
Fe-Se layers on LAO 001 with transition $T_{c\text{-onset}}$ over 120K, it normally has T_c around 10 K

Powder In Tube (PIT) superconducting wires

Powder in Tube technology allows easy and cheap production of long lengths of superconducting wires using processes like swaging and drawing

MgB_2 – T_c = 39 K, B_{c2} = 15-20 T
Good for low field generation and DC power lines
Replacement for NbTi

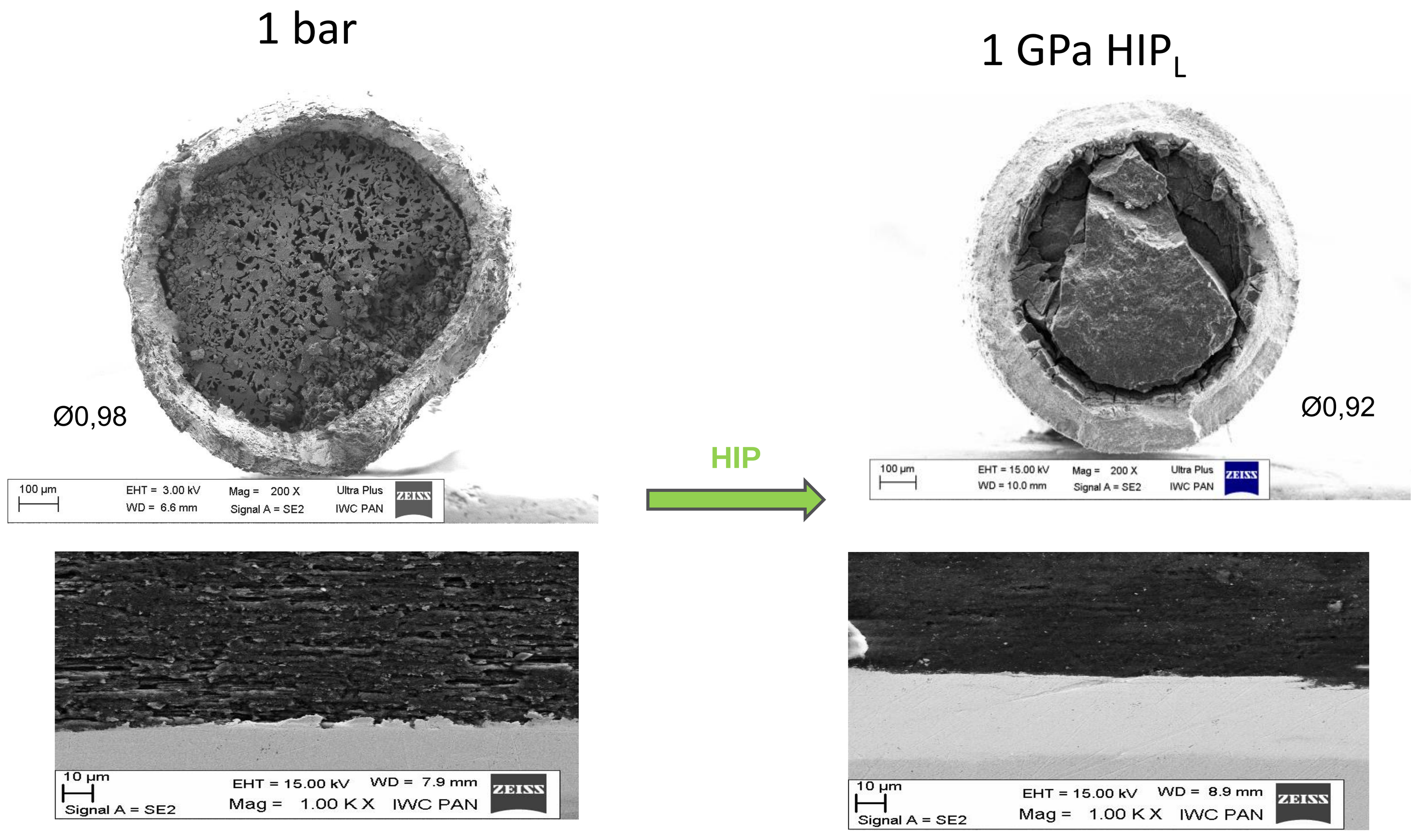
Iron Based SC - T_c = 10-30 K, B_{c2} > 50 T
Good for high field generation
Replacement for Nb_3Sn, YbaCuO, BSCCO



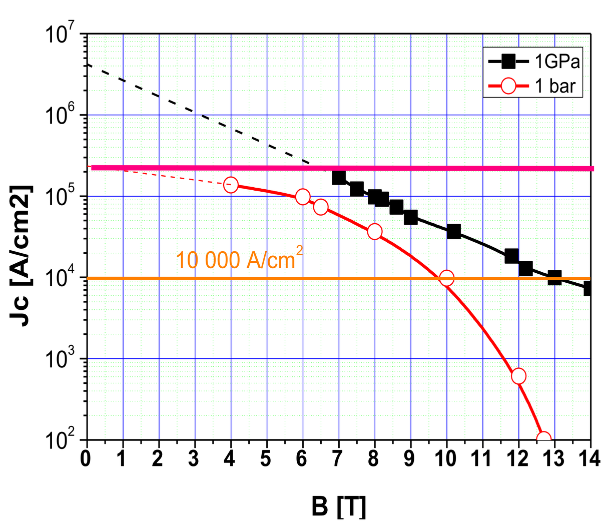
(a)Traditional PIT concept; (b) PIT with metal **Nb** barrier; typical for e.g. **HyperTech** *Higher costs of wire* (c) The new concept of PIT The *in/ex situ/ Cu*-stabilizer; *Much lower costs of wire !* **patent**

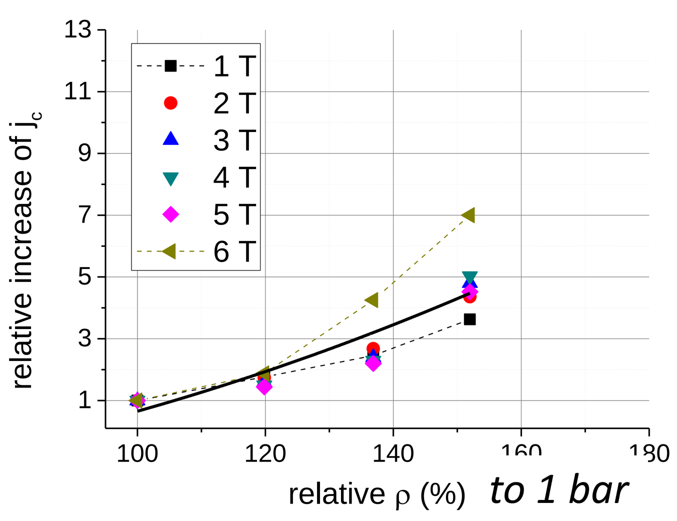
Single core PIT wire design: traditional and patented [2] in/ex situ structure

High pressure wire densification



Synthesis under high pressure (1 GPa HIP) significantly increases the density of superconducting cores in wires thanks to reduction of porosity.





Increased density leads to better electrical connectivity and higher critical current density j_c [3].

Additionally, critical magnetic field B_{c2} is increased due to changes in crystal structure and wires high field performance is exceptionally improved – in the example above (left plot) application criteria of j_c = 10 000 A/cm^2 is satisfied up to 13 T instead of 10 T.

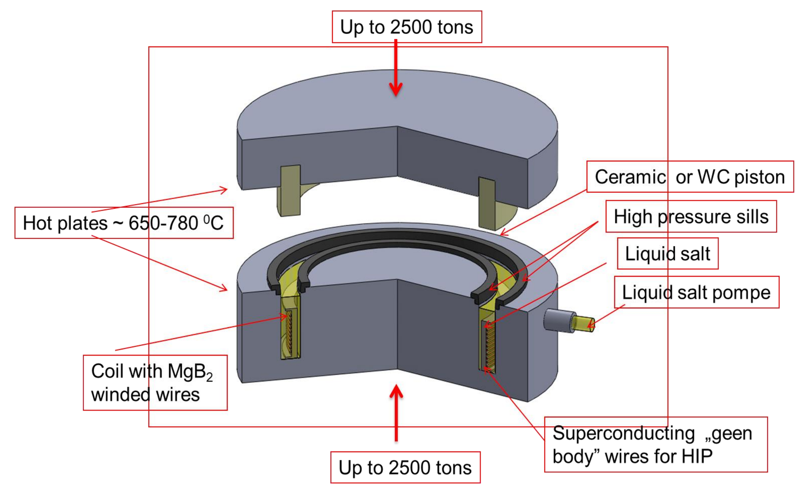
Superconductivity & Applications

Superconductors have no electrical resistance in certain temperature and magnetic field conditions. This makes superconducting wires useful in applications where large currents are used, like electromagnets and energy transfer lines.

We are currently developing HIPed MgB_2 wires dedicated to:

- SMES – Superconducting Magnetic Energy Storage – high power storage for system stabilization and short term power supply
- SCFL – Superconducting Fault Current Limiter - high power fuse, fully reversible, using phenomena of critical current in superconductors to instantaneously limit currents exceeding given limit

We are also working on hydrogen storage. Liquid hydrogen LH2 (15-20 K) can be used as a coolant for MgB_2 wires and used in hybrid energy transfer lines



Toroidal chamber for HIP of long wires

Cable for hybrid hydrogen energy line [4]

References

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2. Patent WO2008122802A1 „Composite electrical conductors and method for their manufacture", Bartek A. Glowacki, Andrzej Morawski
3. A. Morawski, T. Cetner, D. Gajda, A. J. Zaleski, W. Häßler, K. Nenkov, M. A. Rindfleisch, M. Tomsic, P. Przysłupski "MgB2 wire diameter reduction by HIP – a route for enhanced critical current density" Supercond. Sci. Technol. 31 7 075008 (2018).
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