# Influence of the oxygen partial pressure on the phase evolution during Bi-2212 wire melt processing

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***Abstract*—We have studied the influence of the oxygen partial pressure $pO_2$ up to 5.5 bar on the phase changes that occur during melt processing of a state-of-the-art Bi-2212 multifilamentary wire. Phase changes have been monitored *in situ* by high energy synchrotron X-ray diffraction (XRD). We found that the stability of Bi-2212 phase is reduced with increasing $pO_2$. For $pO_2$>1 bar a significant amount of Bi-2212 phase decomposes upon heating in the range 400 to 650 °C. The extent of decomposition strongly increases with increasing $pO_2$, and at $pO_2$=5.5 bar Bi-2212 decomposes completely in the solid state. Textured Bi-2212 can be formed during solidification when $pO_2$ is reduced to 0.45 bar when the precursor is molten. Since the formation of current limiting second phases is very sensitive to $pO_2$ when it exceeds 1 bar, we recommend to reduce the oxygen partial pressure below the commonly used $pO_2$=1 bar, in order to increase the $pO_2$ margins and to make the overpressure process more robust.**

***Index Terms*—Bi-2212, melt processing, XRD.**

permeable Ag wire matrix is needed in order to form Bi-2212. Oxygen is most conveniently supplied when the HT is performed in air at ambient pressure with an oxygen partial pressure ($pO_2$) of 0.21 bar. However, substantially higher critical current densities can be achieved when the same heat cycle is performed in a $pO_2$=1 bar.

Overpressure (OP) processing is a key for achieving homogeneous high critical currents in long lengths of Bi-2212 wires [3]. OP processing also enables varying $pO_2$ in a wide range above 1 bar. For the optimization of the processing procedure, as well as for the establishment of acceptable temperature and pressure margins, it is of interest to verify how $pO_2$ influences the phase sequence and the Bi-2212 precursor melting and recrystallization behaviors.

Since the development of high energy synchrotron beam lines it has become possible to directly observe the phase changes inside a superconducting wire that is placed inside a

# Synchrotron X-ray diffraction (XRD) *in situ* study of Bi-2212

- High energy synchrotron XRD in transmission geometry allows to observe the phase changes in a Bi-2212 wire during melt processing.
- The oxygen partial pressure can be varied and controlled during the entire heat cycle.

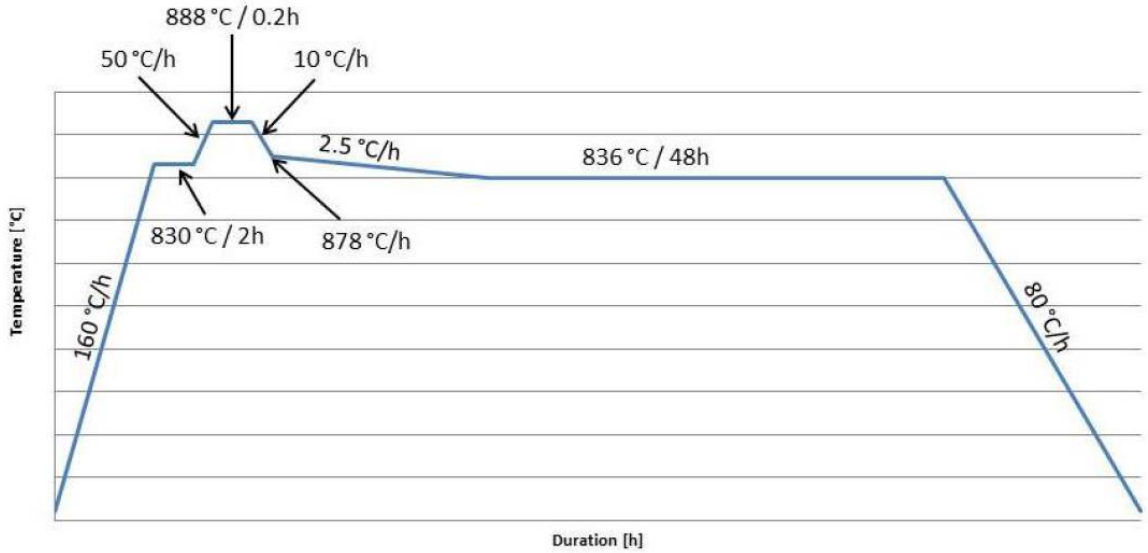
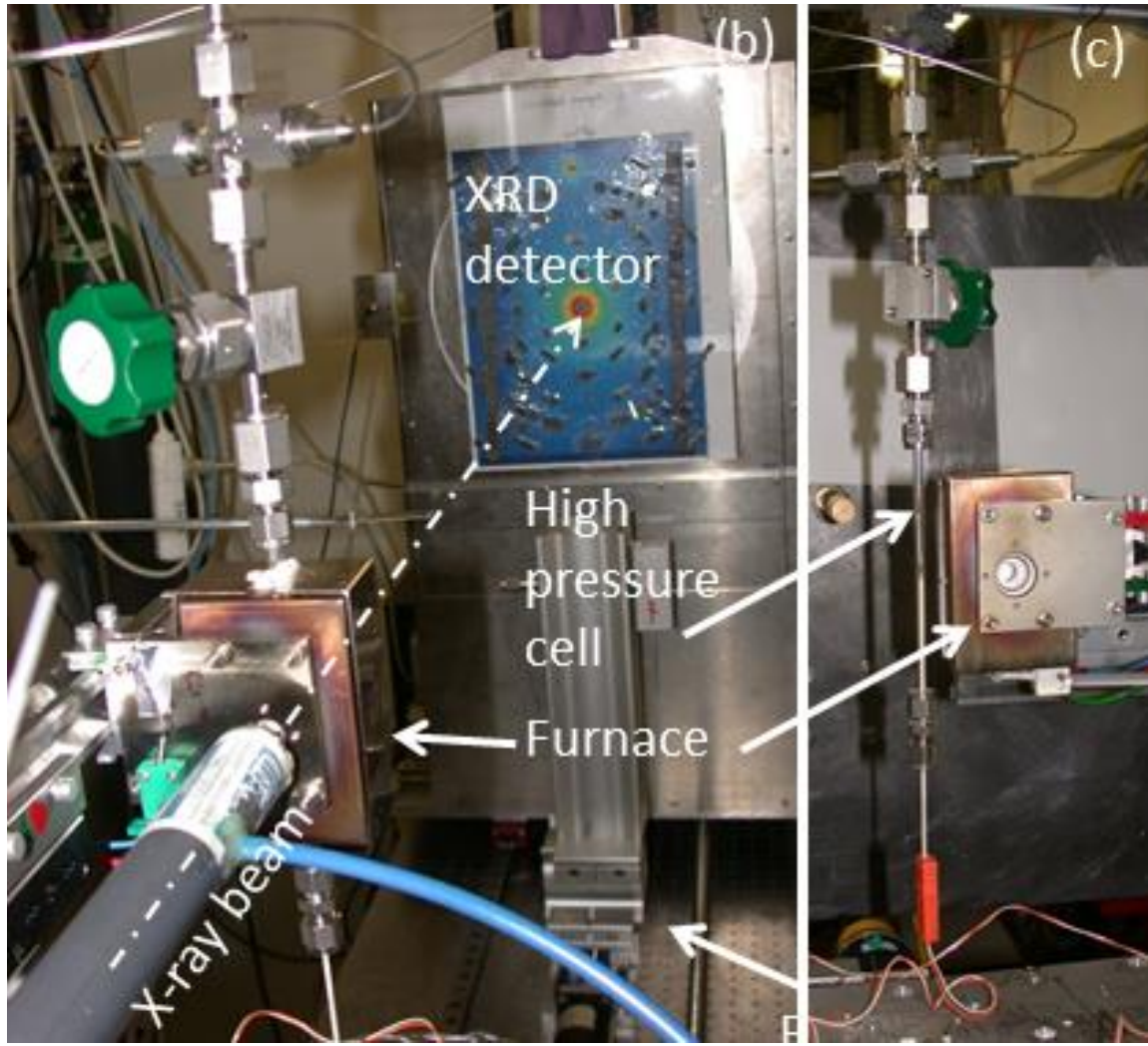


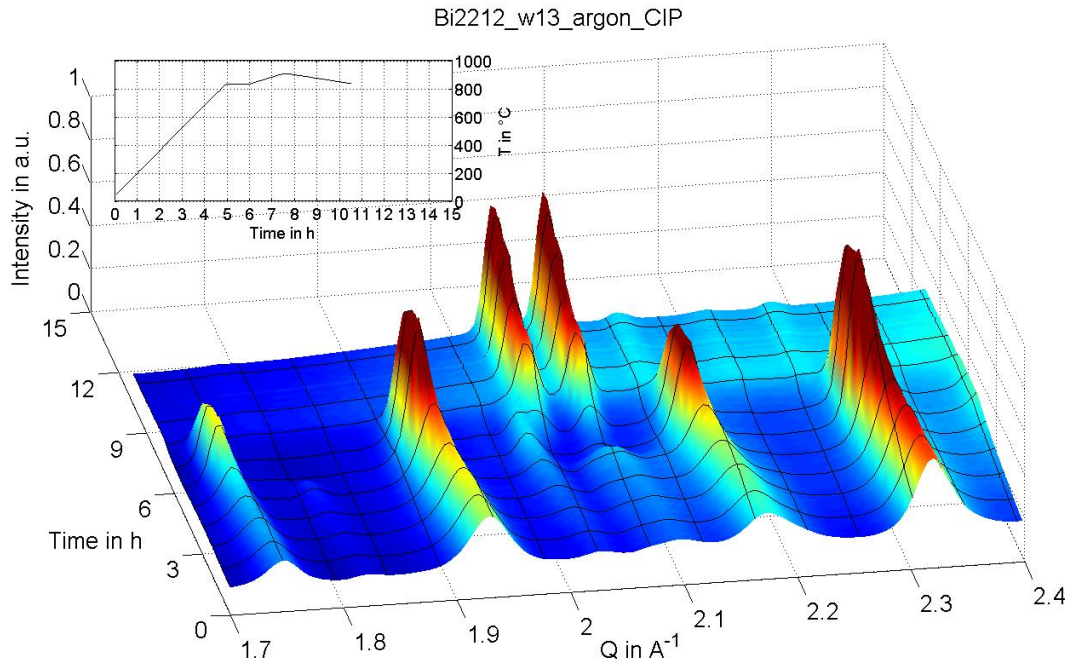

Figure 1: Typical heat treatment cycle for the melt processing of Bi-2212 wires [iii].



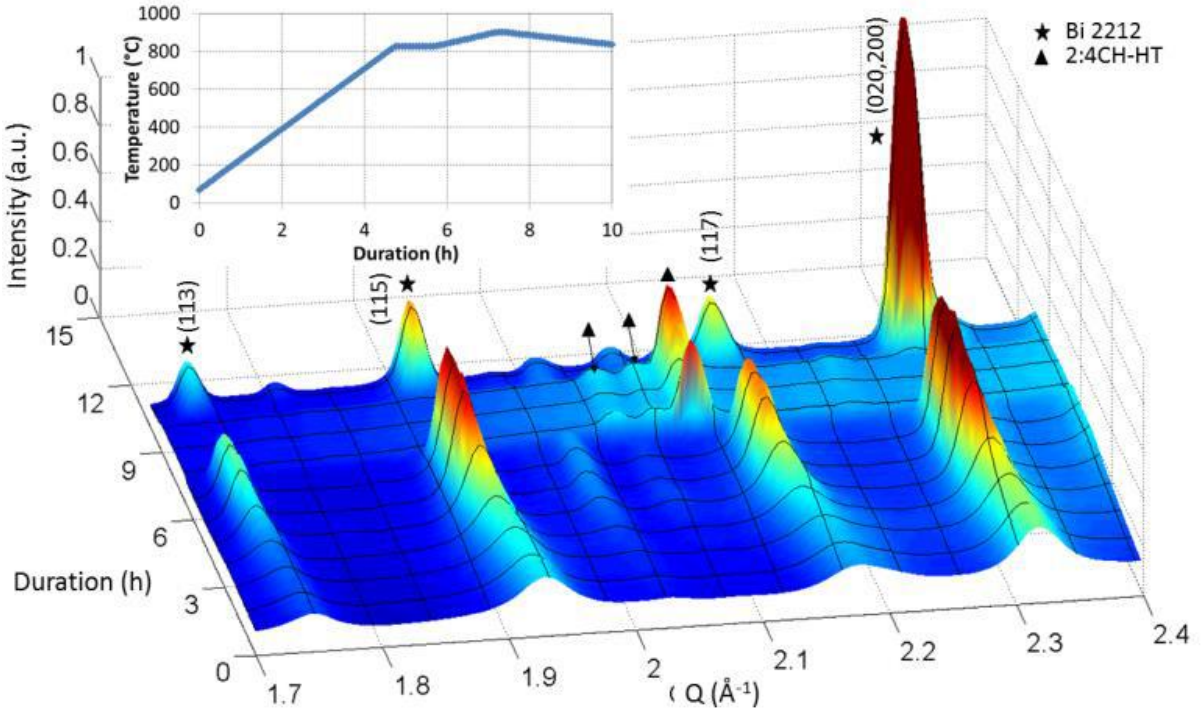

*High pressure cell and furnace mounted in the ID15B beamline of ESRF.*

# Melt processing of Bi-2212 wires

- In order to form continuous and textured Bi-2212 filaments the Bi-2212 precursor needs to be melted.
- During the melt processing an external oxygen supply through the oxygen permeable Ag wire matrix is required to crystallise Bi-2212.



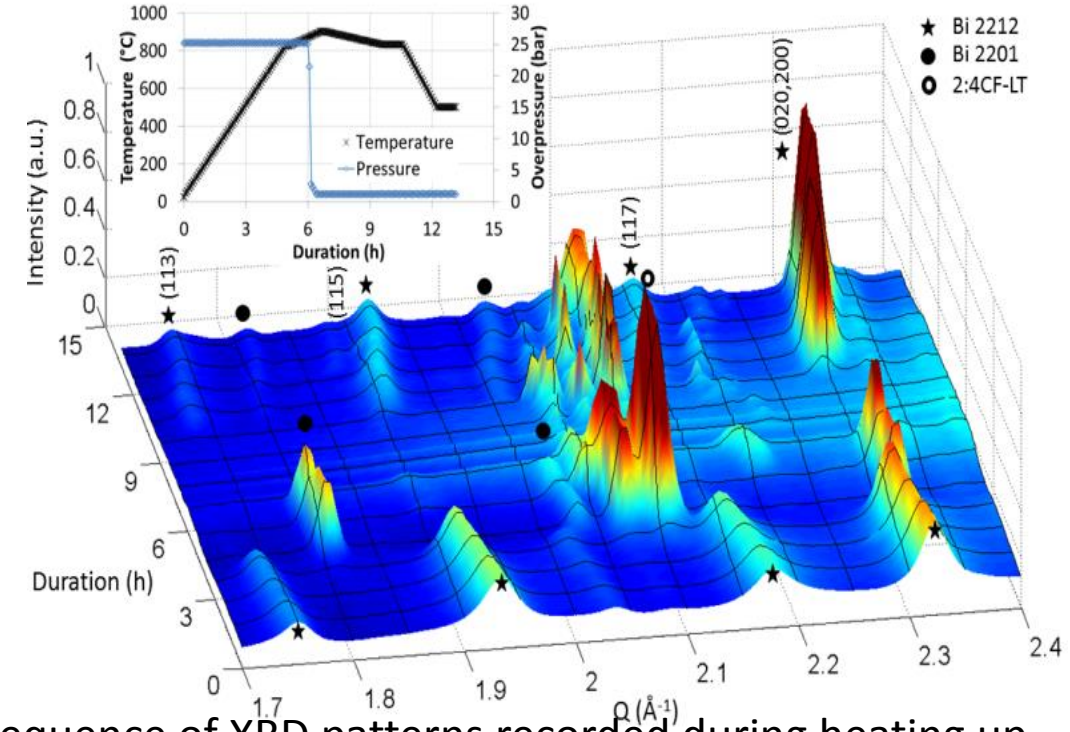

Sequence of XRD patterns recorded during heating in inert gas.



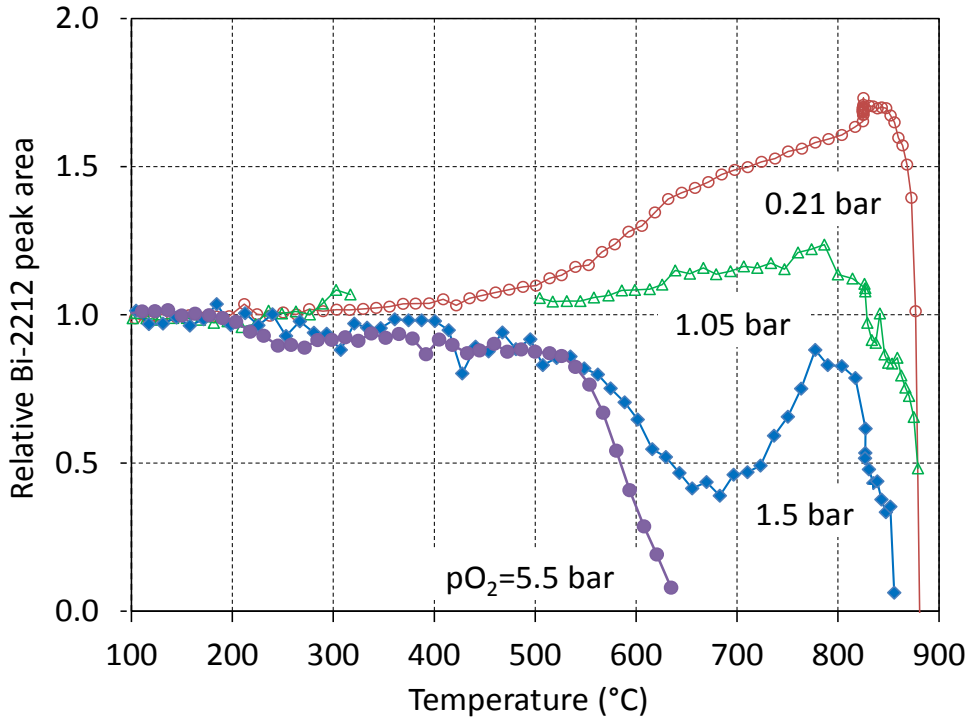

Sequence of XRD patterns recorded during heating at $pO_2$=0.21 bar.

# Influence of the oxygen partial pressure $pO_2$ on the phase evolution

- Overpressure processing enables varying $pO_2$ in a wide range above 1 bar.
- In the range $pO_2$=0.21-1.05 bar only a small amount of Bi-2212 decomposes in the solid state prior to precursor melting.
- Further increasing $pO_2$ strongly changes the phase sequence.




Sequence of XRD patterns recorded during heating up at $pO_2$=5.5 bar and cooling down at $pO_2$=0.45 bar.




Relative Bi-2212 peak area evolution during heating at different $pO_2$.

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# Strain induced irreversible critical current degradation in highly dense Bi-2212 round wire

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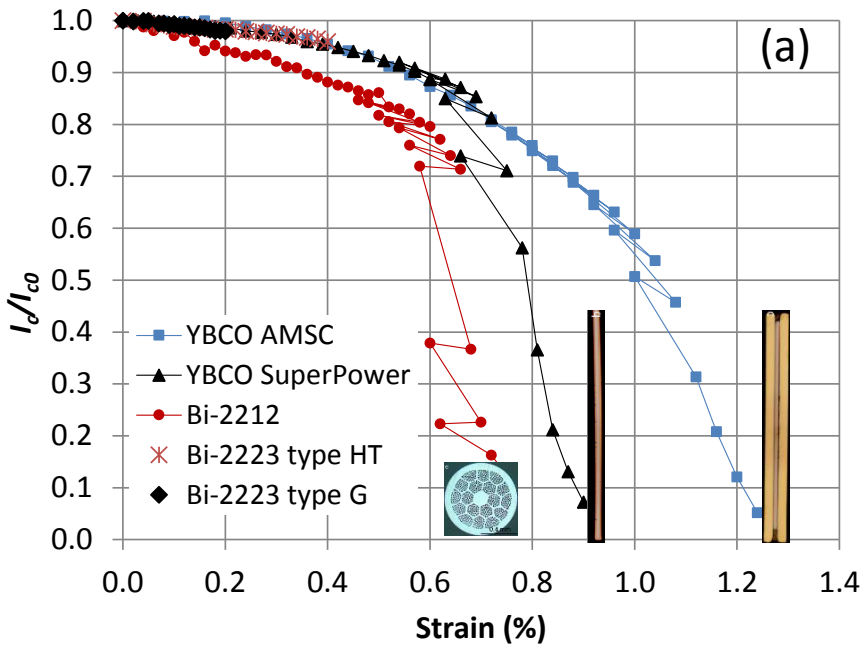
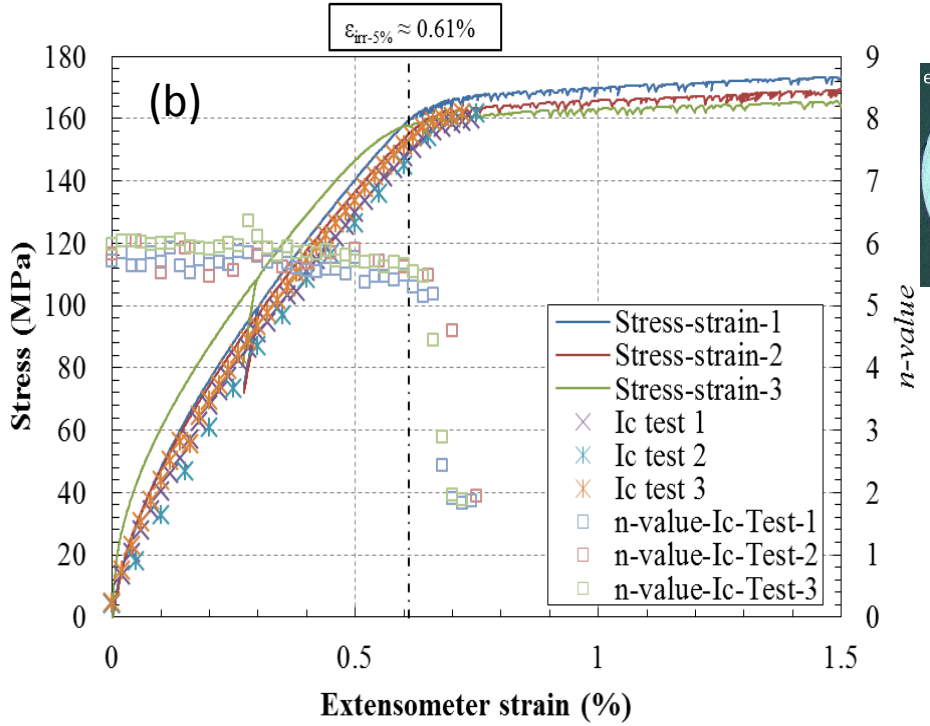
**Abstract**

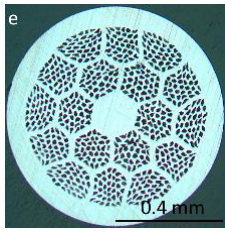
The strain induced critical current degradation of overpressure processed straight Bi-2212/Ag wires has been studied at 77 K in self-field. For the first time superconducting properties, lattice distortions, composite wire stress and strain have been measured simultaneously in a high energy synchrotron beamline. A permanent $I_c$ degradation of 5% occurs when the wire strain exceeds 0.60%. At a wire strain of about 0.65% a drastic *n-value* and $I_c$ reduction occur, and the composite stress and the Bi-2212 lattice parameter reach a plateau, indicating Bi-2212 filament fracturing. The x-ray diffraction measurements show that Bi-2212 exhibits linear elastic behaviour up to the irreversible strain limit.

# $I_c$, n-value and stress vs strain




*Comparison of the $I_c$ variation of different HTS as a function of uniaxial tensile strain.*




*Bi-2212 wire stress and n-value versus strain curves acquired at 77 K.*