INSTITUTE OF EXPERIMENTAL PHYSICS
SLOVAK ACADEMY OF SCIENCES
MATERIALS PHYSICS LABORATORY

Influence of annealing in argon on microstructural and superconducting properties of Al doped YBCO bulks

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Košice - 24.06.2009

Samples preparation:

Materials Physics Laboratory

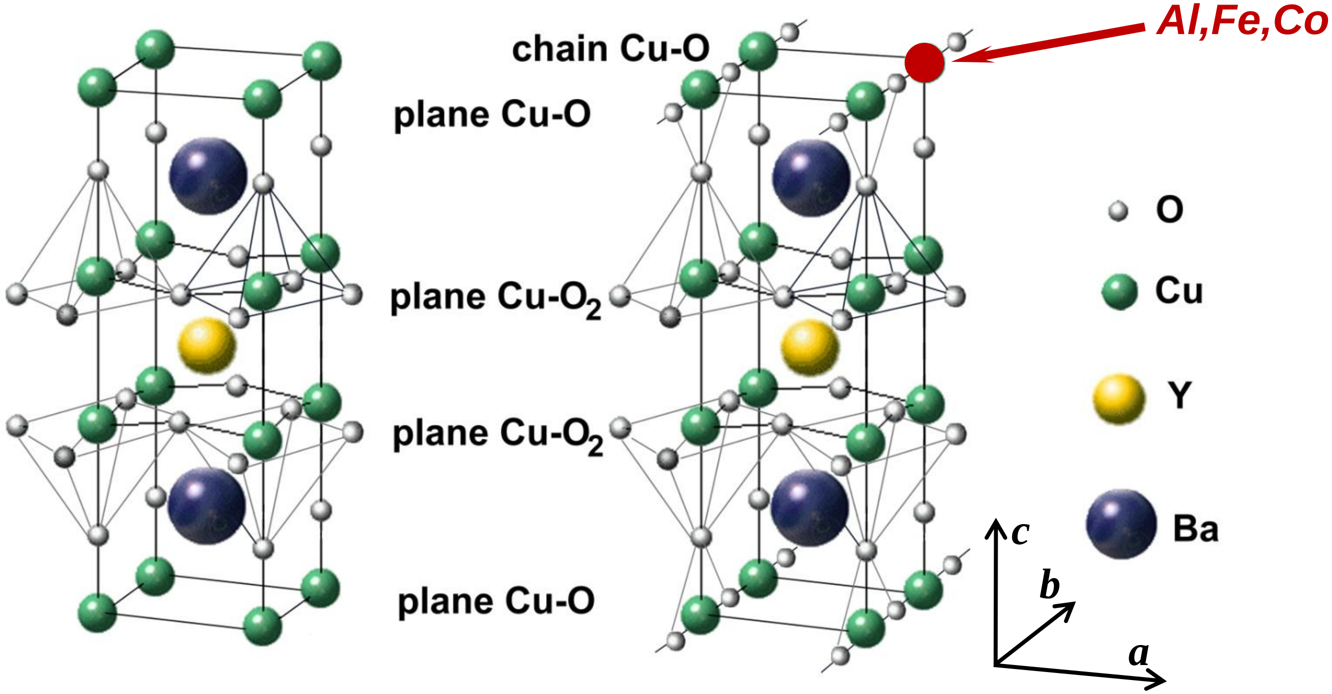
Magnetization measurements:

RNDr. Jozef Kováč, CSc.,
Atomic Institute of the AU in Vienna

X – ray measurements:

Institute of Materials Research in Košice,
RNDr. Viktor Kavečanský, CSc.

Substitution the Cu atoms in the CuO chains of $YBa_2Cu_3O_{7-\delta}$ lattice



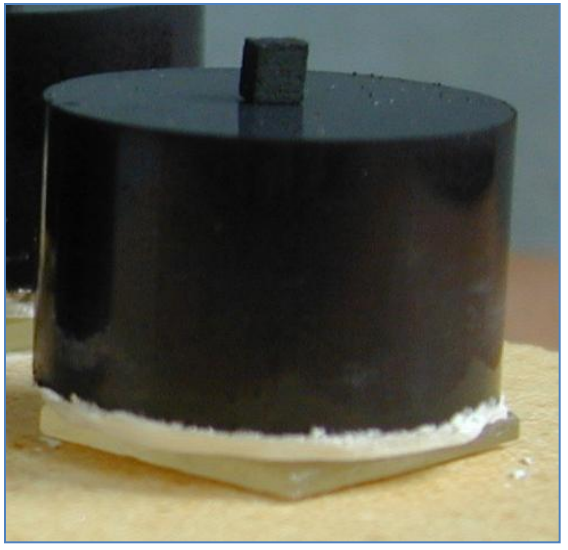
Tetragonal structure (δ > 0.5) **Orthorhombic structure (δ ≤ 0.5)**

Al G.Lacayo et al., *Physica* C *192* (1992) 207
Y.Zhu et al., *J. Mater. Res. 5* (1990) 1380
T.Siegrist et al., *Phys. Rev.* B *36* (1987) 8365

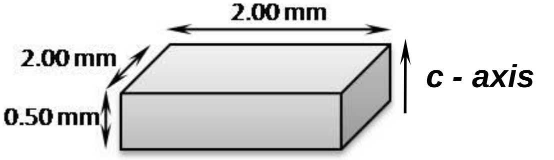
Fe Y.Xu et al., *Phys. Rev.* B *39* (1989) 6667
L.T.Romano et al., *Phys. Rev.* B 45 (1992) 8042

Co J.M.Tarascon et al., *Phys. Rev.* B *37* (1988) 7458
H.Renevier et al., *Physica* C *202* (1994) 143

Preparation of Al – doped YBCO bulk superconductors



Top Seeding Melt Growth process



The samples were cut from a – growth sectors of the bulks at the distance of 1 mm from the seed

Samples:

$YBa_2Cu_3O_7 + 0.25Y_2O_3 + 0.5$ wt. % $CeO_2 + Al_2O_3$

$YBa_2(Cu_{3-x}Al_x)O_7$, ($x = 0.0025, 0.005, 0.02, 0.05$)

TSMG:

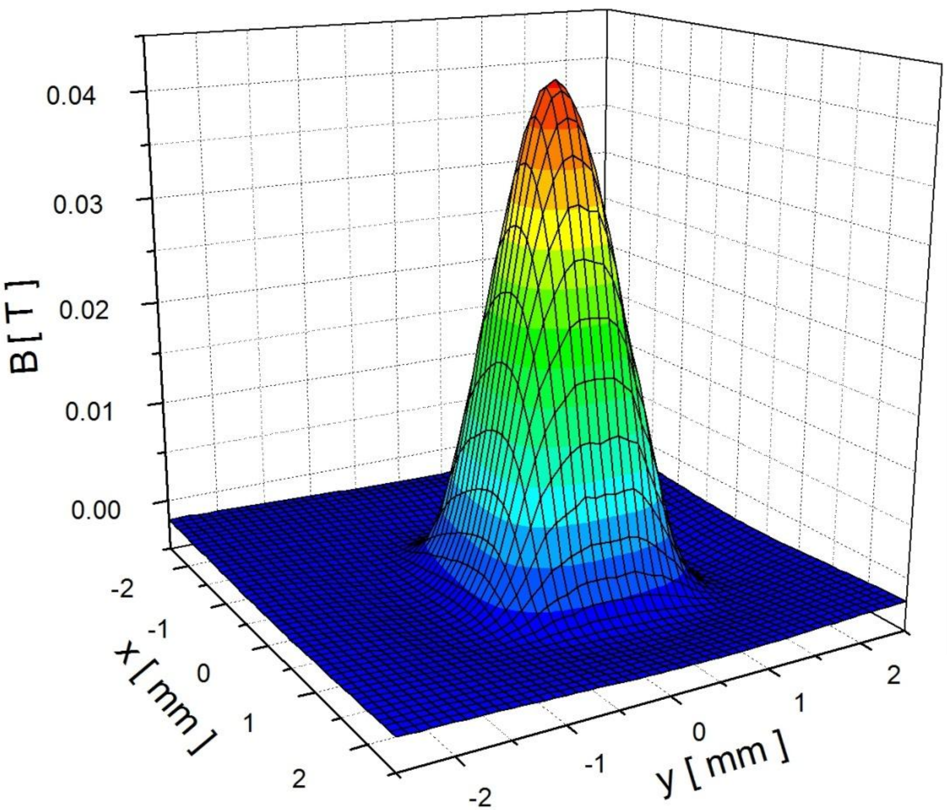
pellets $\phi = 20$ mm, Sm 123 seeds, chamber furnace in air

Oxygenation process

1) ***Standard oxygenation (SO)***
   The samples were heated to 800 °C in flowing O_2 atmosphere and kept there for 2 hrs, then cooled to 400 °C and held at this temperature for 240 hrs, then cooled down to room temperature.

2) ***Annealing in flowing argon***
   The samples were heated to 800 °C in flowing Ar atmosphere and annealed there for 2 hrs, then cooled to room temperature. After annealing in Ar the samples were heated to 400 °C in flowing O_2 atmosphere and held there for 240 hrs, then cooled down to room temperature.

Magnetization measurements



Checking samples for homogeneity by trapped field scanning

Bean model

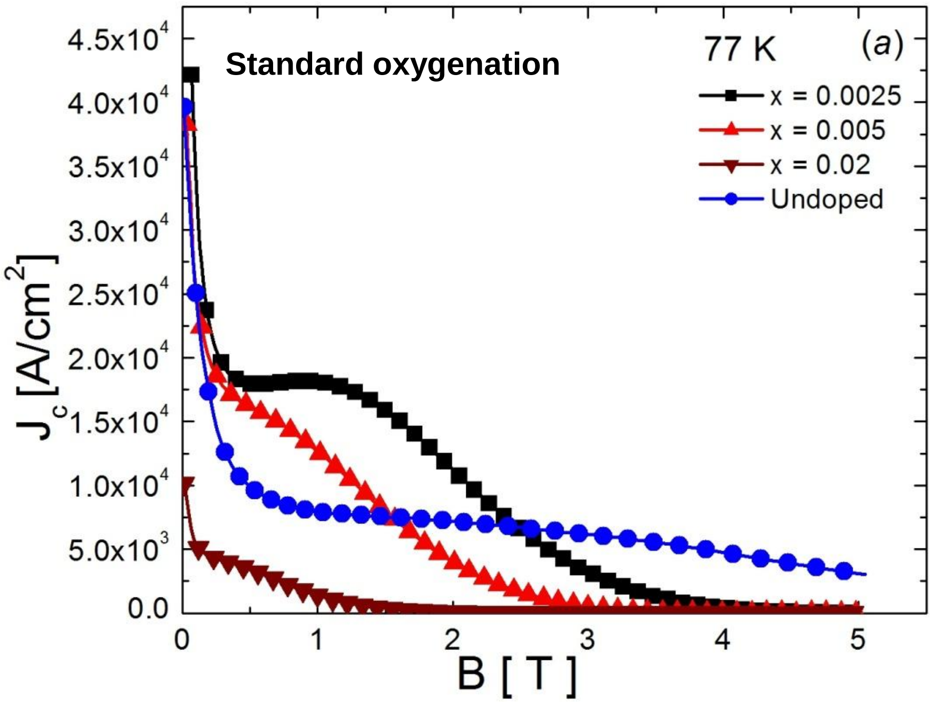
$$J_c(B) = \frac{m_i(B)}{\Omega}\frac{2}{b(1-b/3a)}$$

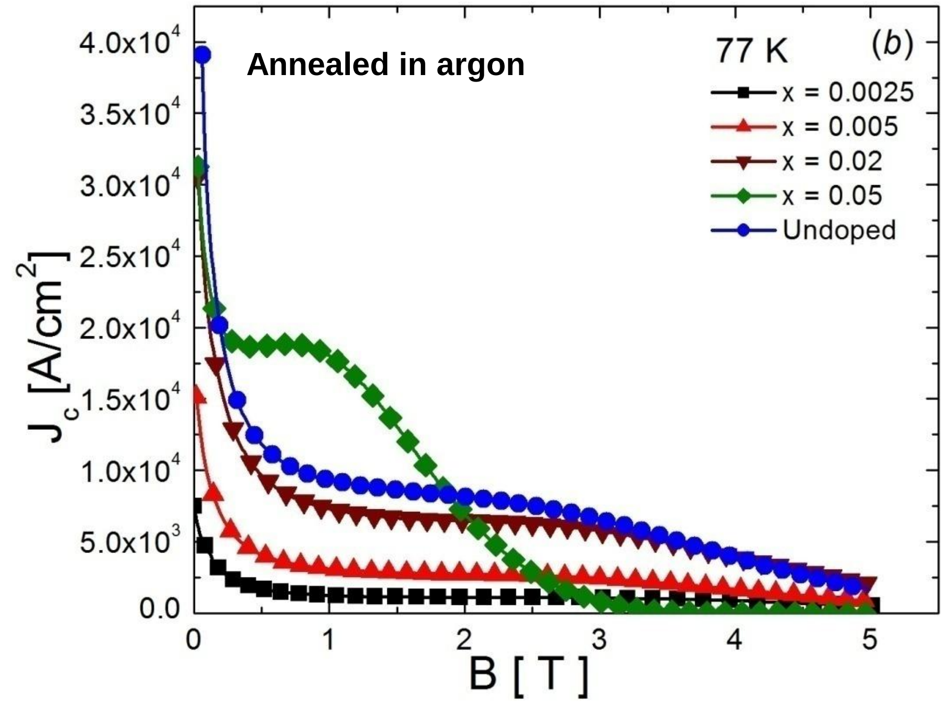
$$m_i = \frac{1}{2}(m_+ - m_-), \quad \Omega = a\times b\times c,\ a \geq b$$

Magnetization measurements:

VSM with magnetic fields of up to 5 Tesla at a constant sweep rate of 0.25 T/min, applied magnetic field parallel to the c-axis
T_c measured at applied magnetic field of 2 mT

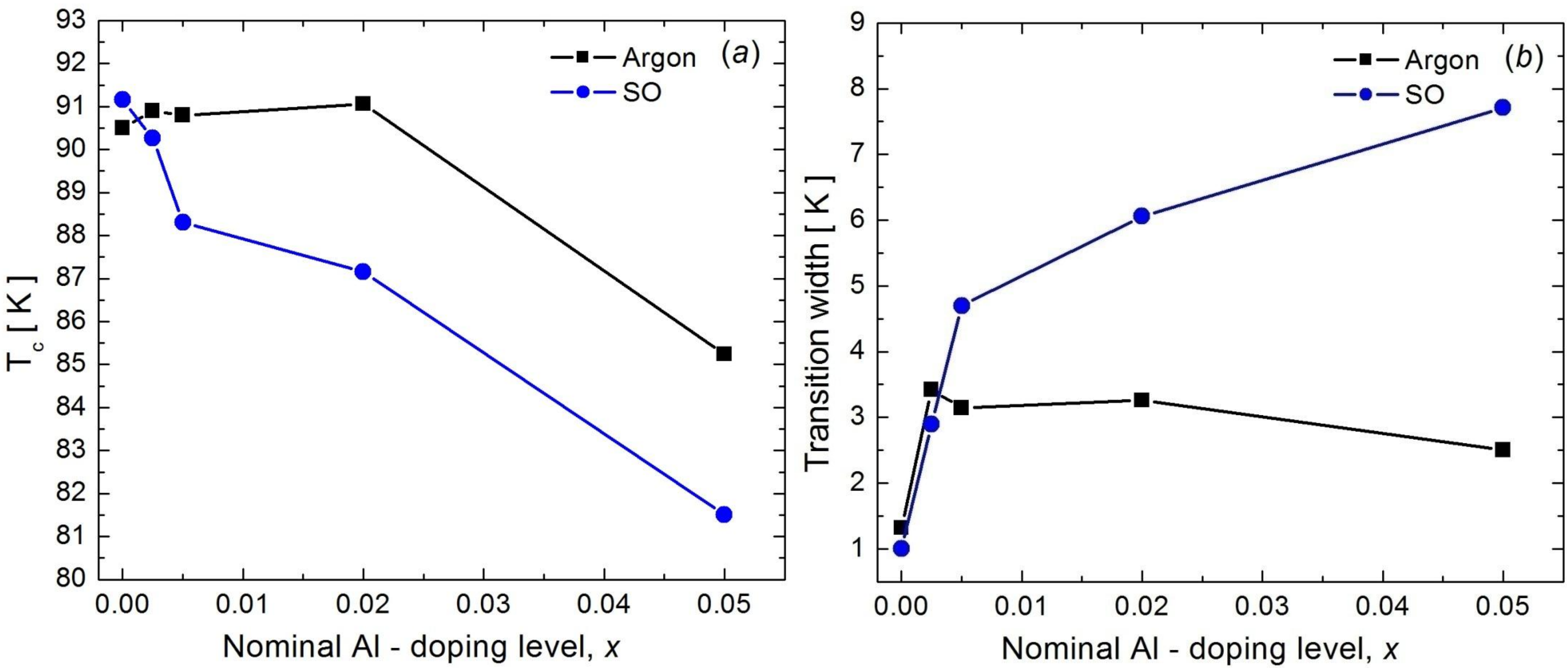
Critical current densities





x = 0.0025 (SO), x = 0.05 (Ar)
$J_c \approx 1.8 \cdot 10^4$ A/cm^2, $B = 1$ T

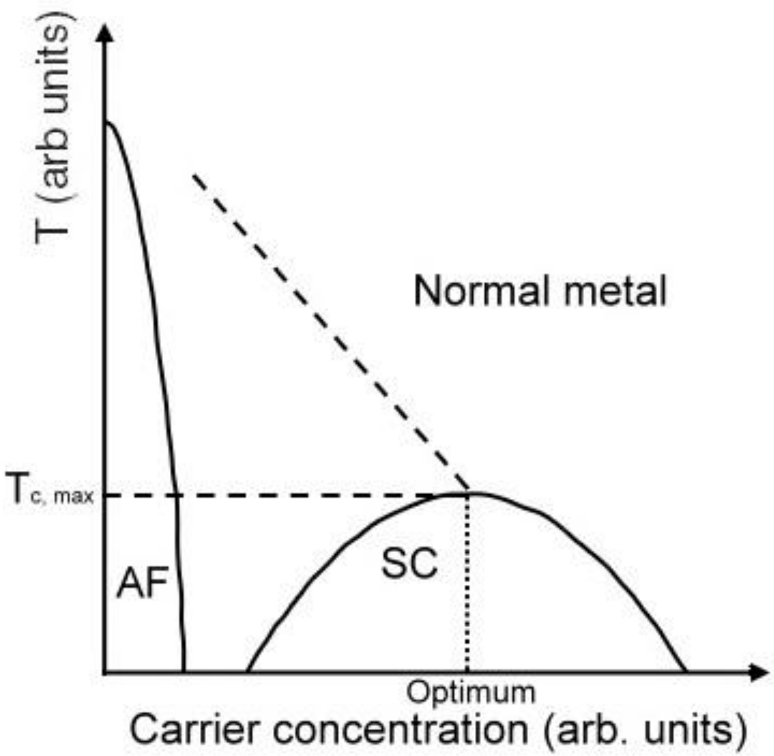
Transition temperature and transition width

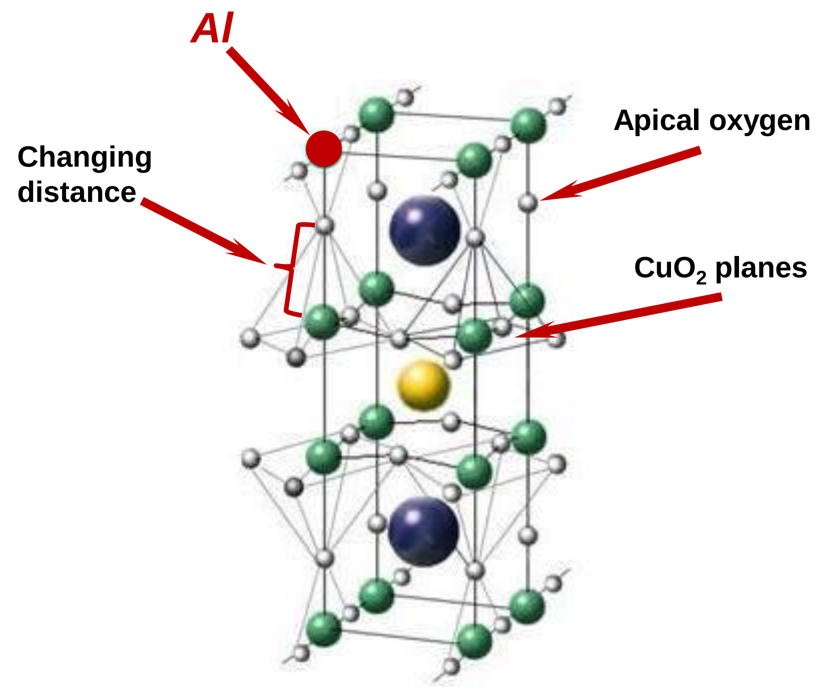


The rise of the transition width, ΔT_c, with increasing Al content for SO samples may reflect microscopic inhomogeneities entire the samples.

T. Siegrist et al., *Phys. Rev*. B 36 (1987) 8365

Influence of substituent on carrier concentration and T_c



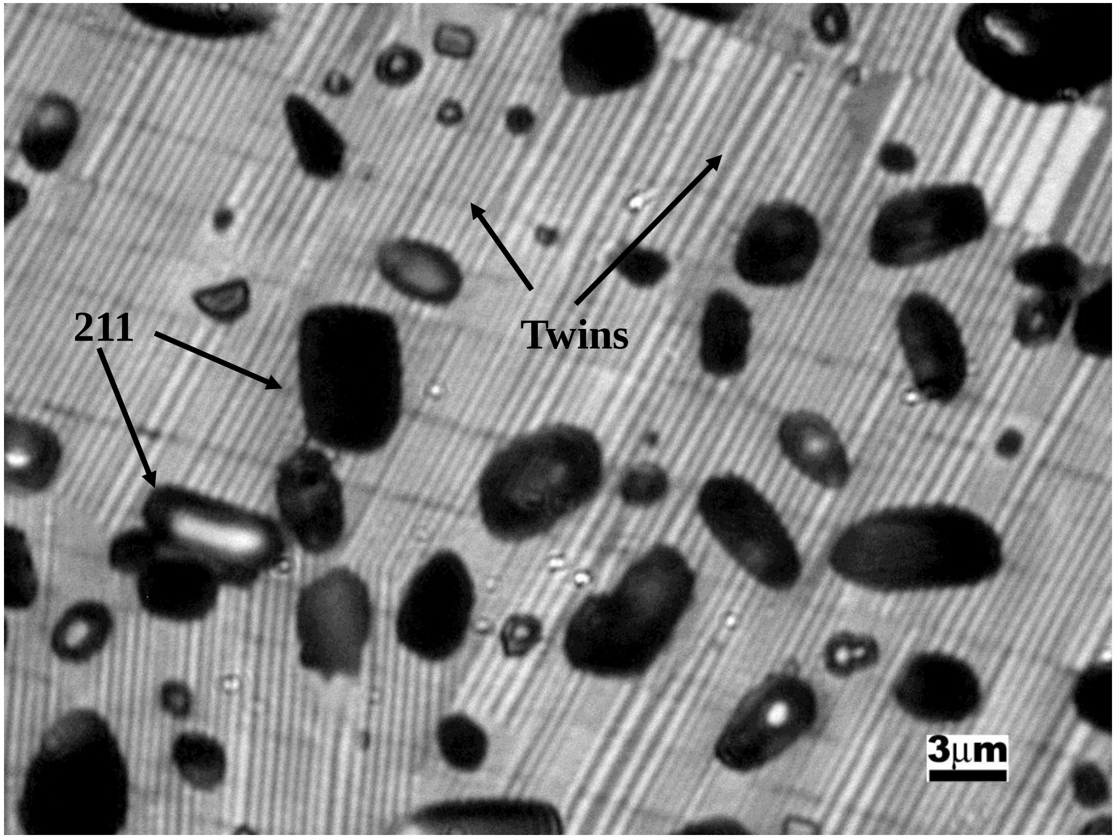


Increasing the distance between the Cu atoms in the CuO_2 planes and apical oxygen atoms

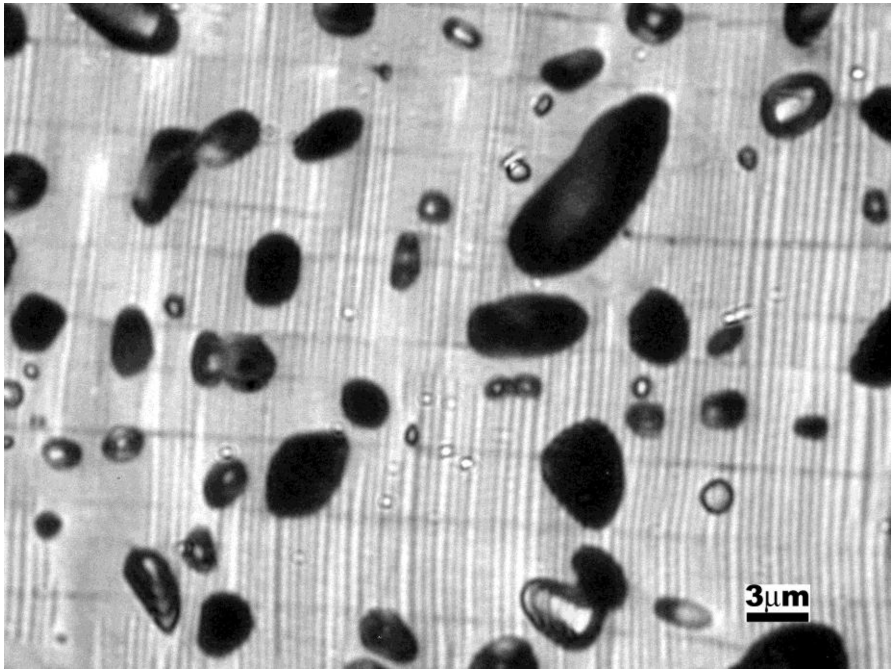
According to the BCS theory: $T_c \approx exp(-1/NV)$
N – carrier concentration,
V – volume fraction of the crystal lattice

H. Renevier et al., *Physica* C 220 (1994) 143
Li Ming, *International Journal of Quantum Chemistry* 50 (1994) 233

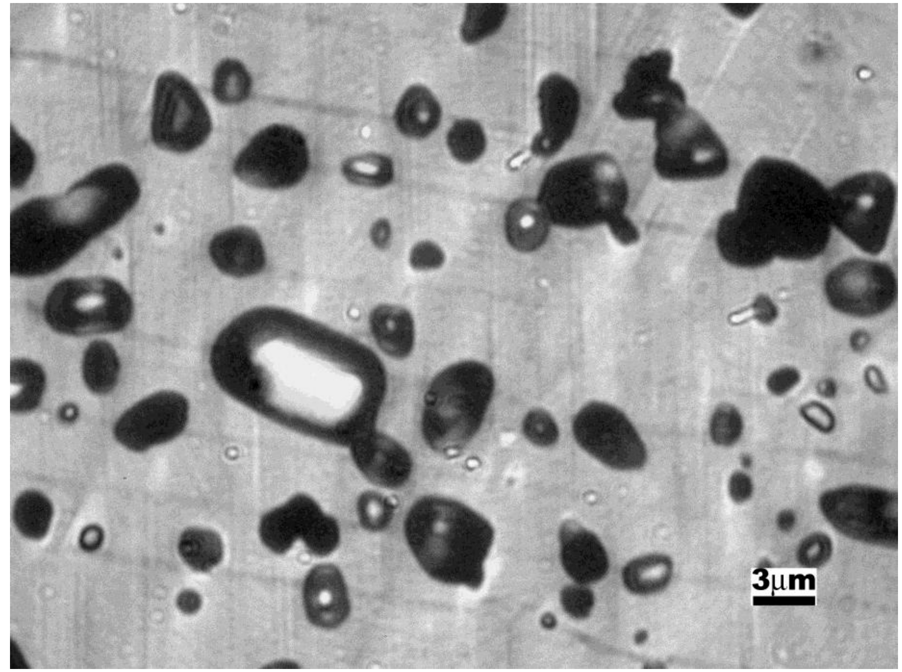
Twins in undoped YBCO bulks



Twinning structures in $YBa_2(Cu_{1-x}Al_x)_3O_{7-\delta}$ bulks after SO

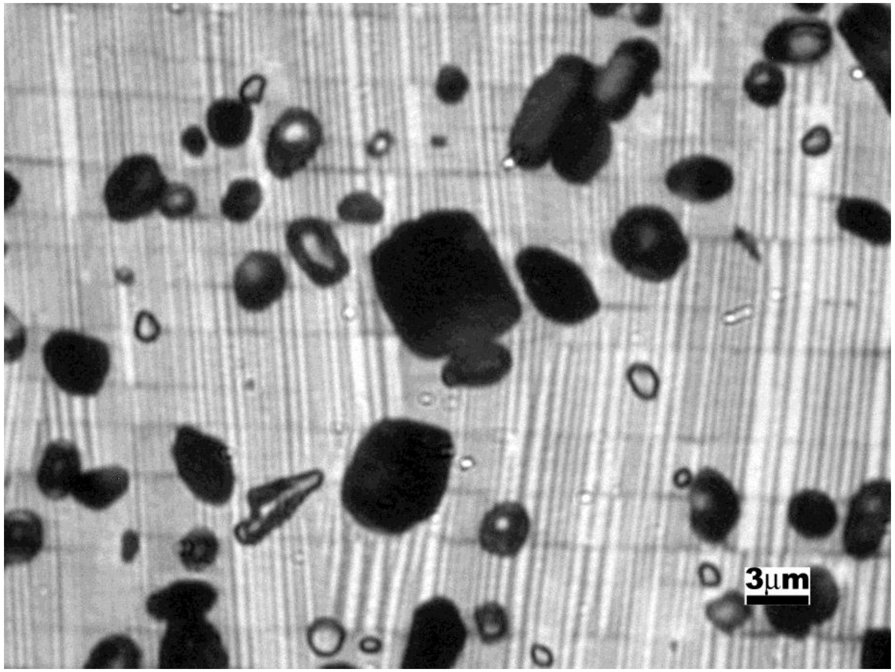


x = 0.005

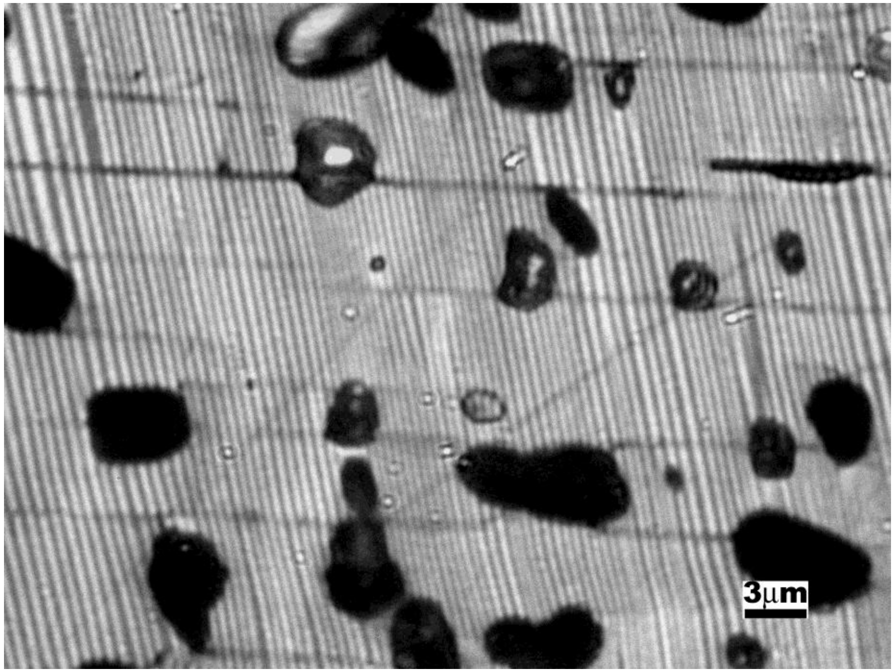


x = 0.05

Twinning structures in $YBa_2(Cu_{1-x}Al_x)_3O_{7-\delta}$ bulks after argon annealing

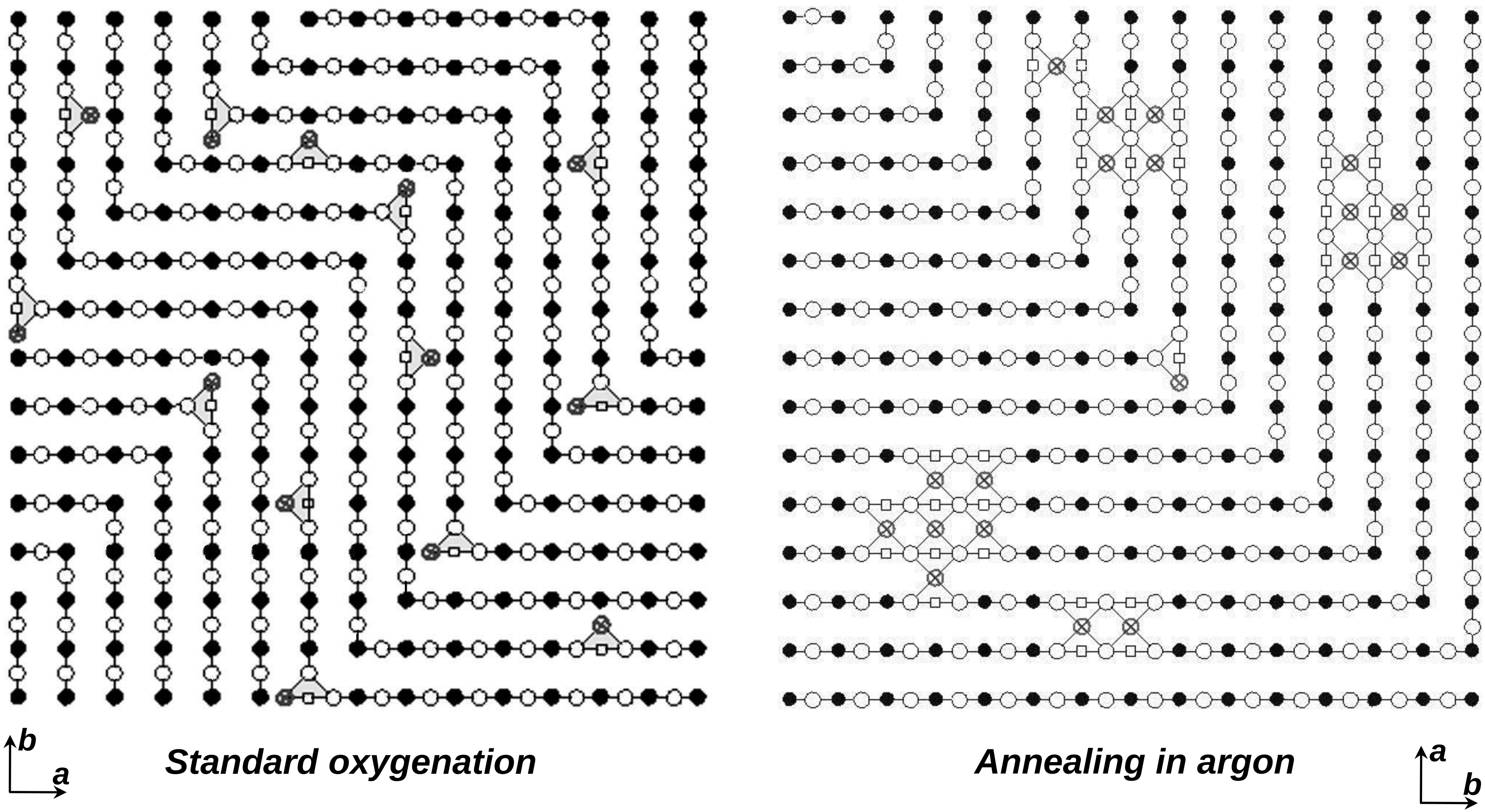


x = 0.005



x = 0.05

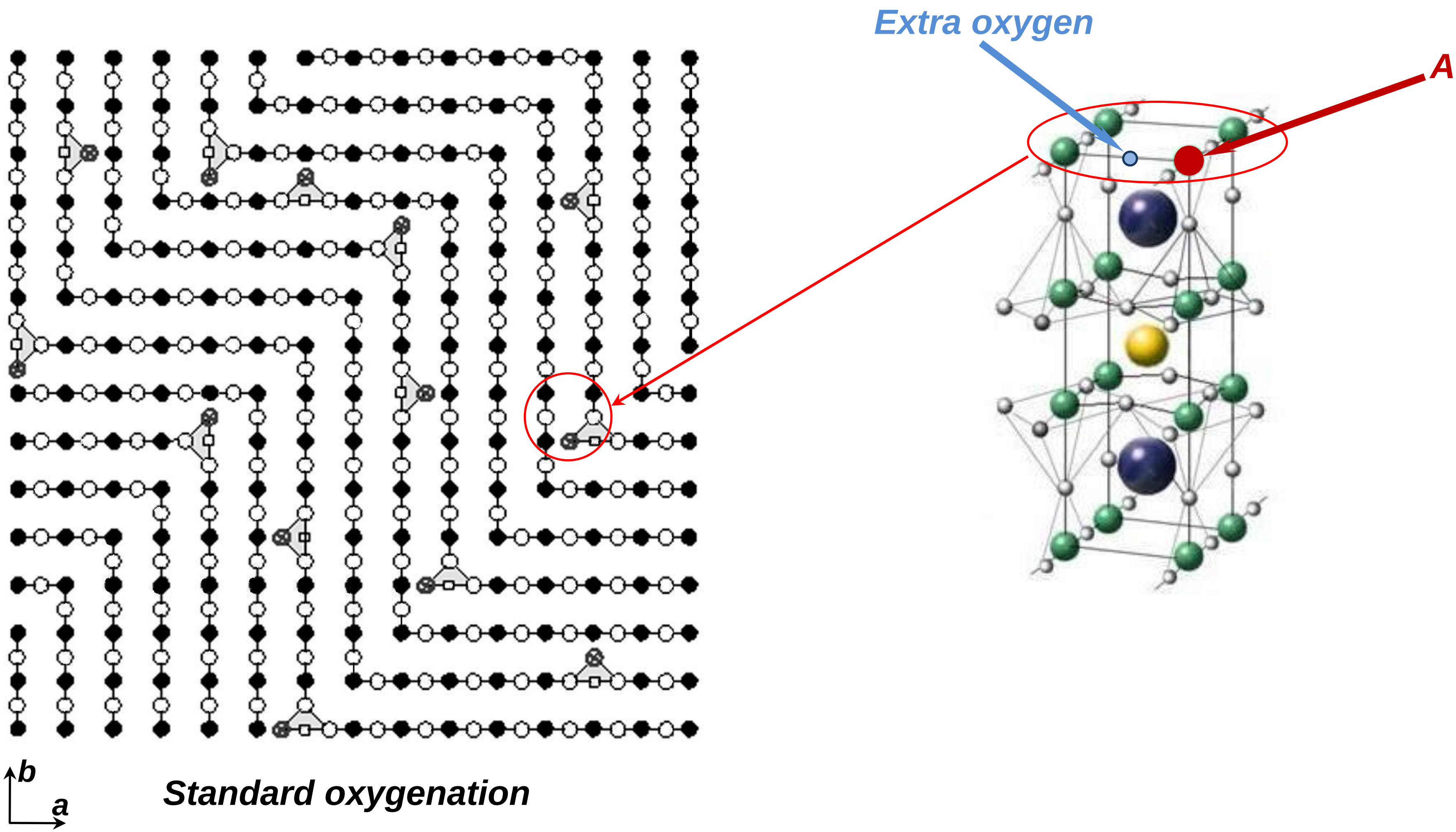
Influence of the Al atoms on twinning formation



Standard oxygenation ***Annealing in argon***

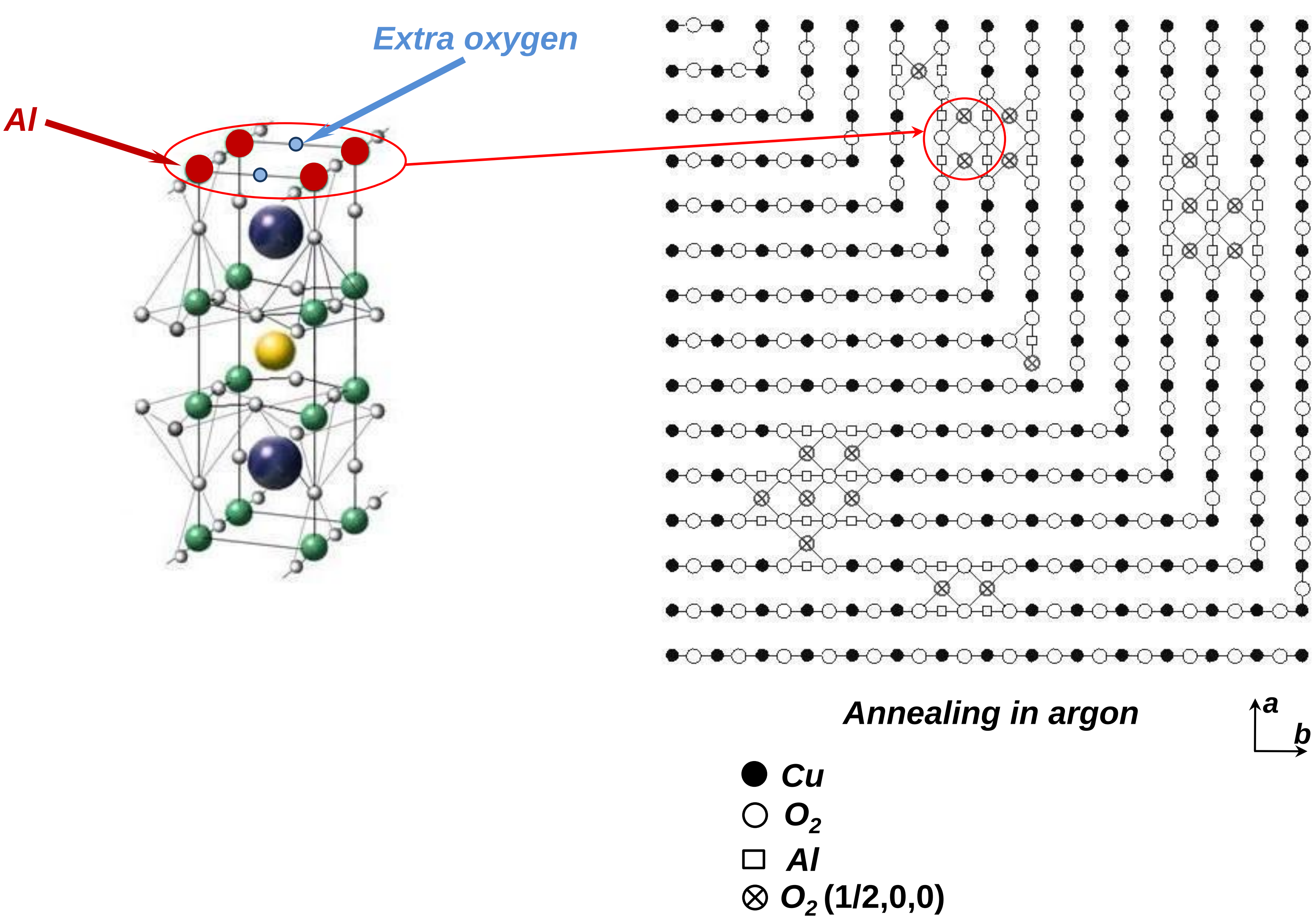
- ● ***Cu***
- ○ O_2
- □ ***Al***
- ⊗ O_2 **(1/2,0,0)**

Influence of the Al atoms on twinning formation

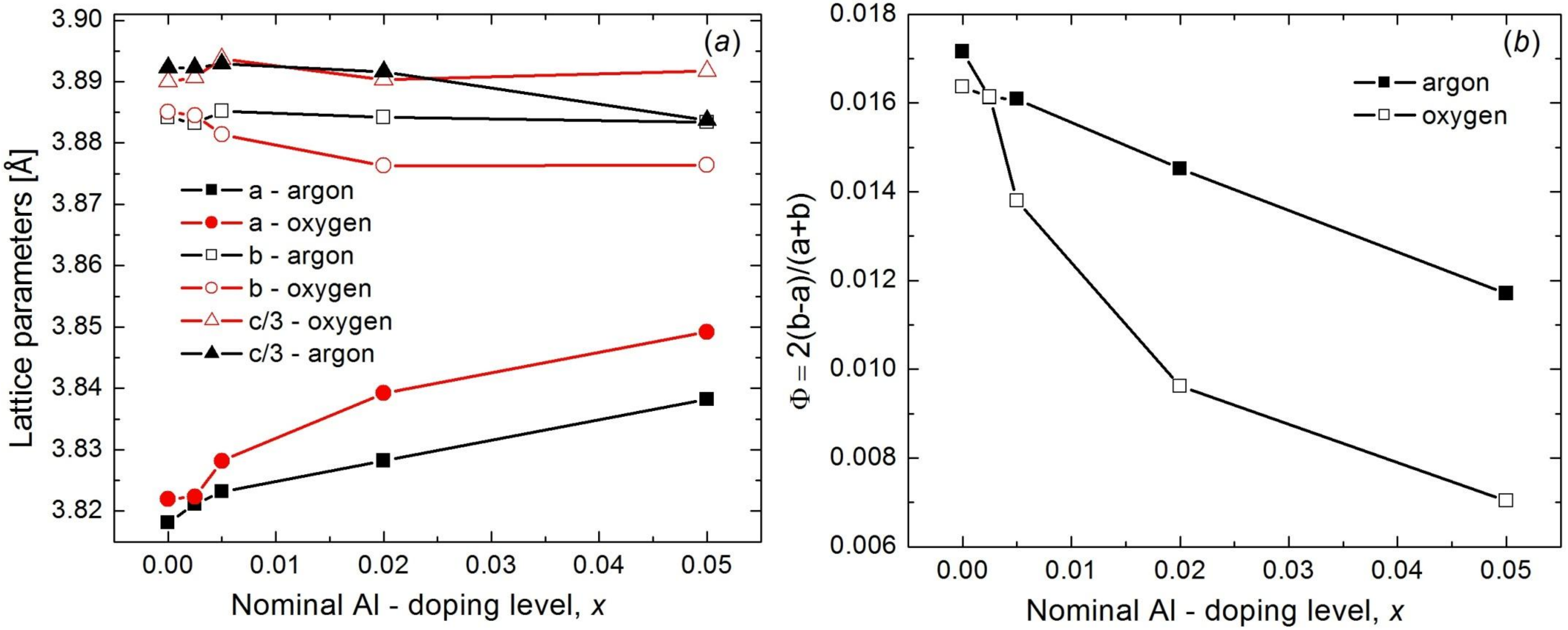


● *Cu*
○ O_2
□ *Al*
⊗ O_2 (1/2,0,0)

Influence of the Al atoms on twinning formation



X – ray diffraction studies for $YBa_2(Cu_{1-x}Al_x)_3O_{7-\delta}$



Conclusions

- ***Al doping and oxygenation procedure (SO, Ar) influence on:***

- ✓ **The transition temperature, T_c, and transition width, ΔT_c**
- ✓ **Orthorhombicty**
- ✓ **Twin spacing**
- ✓ **Pinning behaviour**

- ***It is supposed that these observed changes are caused by different Al distribution in the Y123 lattice:***

- ✓ ***random distribution of the Al atoms after SO***
- ✓ ***clustering after annealing in Ar***

Ďakujem za pozornosť