3MP4-16

EFFECT OF THE Sn CONCENTRATION IN BRONZE MATRIX ON THE PRE-REACTION FORMATION OF Nb_3Sn LAYERS IN BRONZE-PROCESSED SUPERCONDUCTING STRANDS OF DIFFERENT DESIGN

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The goal of the present work is to study and analyze the effects of Sn concentration (14 or 16 %Sn), the mode of Ti-doping and the shape of Nb filaments on the thickness of the "spurious" layers of pre-reaction Nb_3Sn grains in the state before diffusion annealing. **All samples of wires were produced and tested at Bochvar Institute (VNIINM), Moscow, Russia;**

Design: the W16C strand has 463 sub-elements with 37.5 c**oupled** Nb filaments; the W16 ZC strand has 463 sub-elements with 3 *extended* Nb filaments; the BO-7 and BO-5 have 367 sub-elements with 36 c**oupled** Nb-filaments.

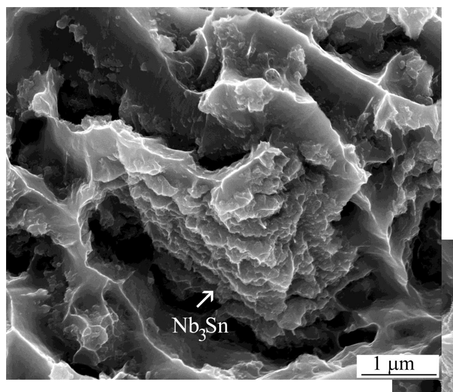
THE SAMPLES OF Nb_3Sn-BASED MULTIFILAMENTARY WIRES

Sample	Number of filaments	Strand's ∅, mm	Filament's size, μm x μm	Matrix	Shape of filamens	Stabili-zing Cu, %	Barrier material
W16C	34725	0.8	2.1 x 3.7	Cu-16Sn-0.24Ti	coupled	8.0	Nb-Ta
W16Z	1389	0.8	1.2 x 65	Cu-16Sn-0.24Ti	extended	8.0	Nb-Ta
BO-5	13212	0.82	2.1 x 3.7	Cu-14.6Sn-0.24Ti	coupled	42.6	Nb-Ta
BO-7	13212	0.82	2.1 x 3.7	Cu-14.0Sn	coupled	42.6	Nb-Ta

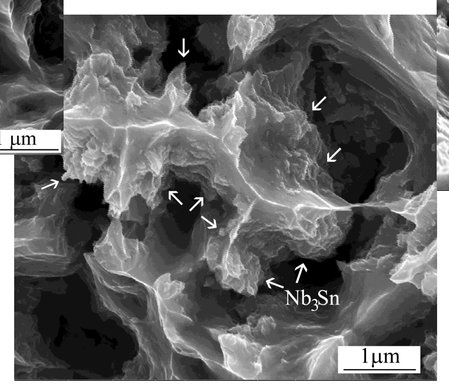
Short intermediate preliminary Heat Treatment (HT)

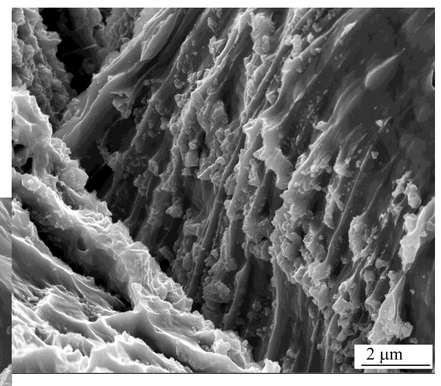
The HT at 500°C [1] was made after every 37-9% of cold deformation starting from a 17.5 mm strand's diameter. The total duration of HT's time did not exceed 1 hour. The time of HT (t_{HT}) differs with the differing of strand's diameter (for example, t_{HT} = 10 min at Ø = 17.7 mm and t_{HT}. = 0.5 min at Ø = 0.8 mm)

Sample W16C



Central part of strand



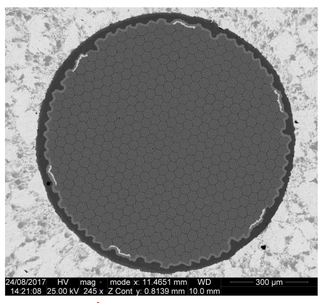


Near Nb-barrier

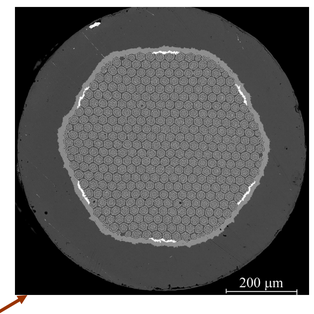
METHODS

Images were made by SEM (Inspect-F, FEI). The compositions of the matrix after HT were determined using the electron probe microanalysis (EPMA) method with Energy Dispersive X-ray spectrometer (EDX, FEI)

W16C

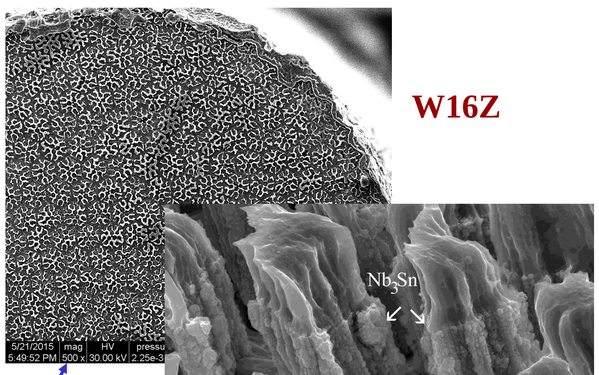


BO-5



Polished cross-sections

W16Z

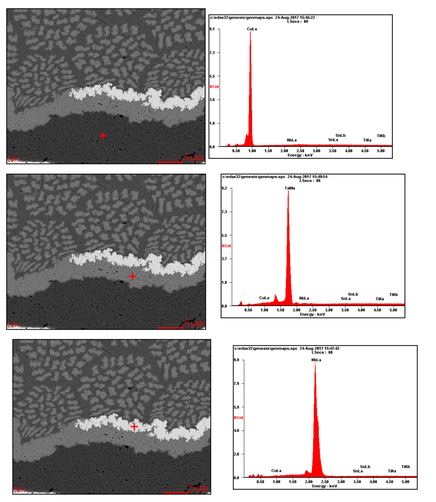


The surface of sample W16 after chemical etching of matrix

The Concentration of Sn (wt%) in the matrix after HT

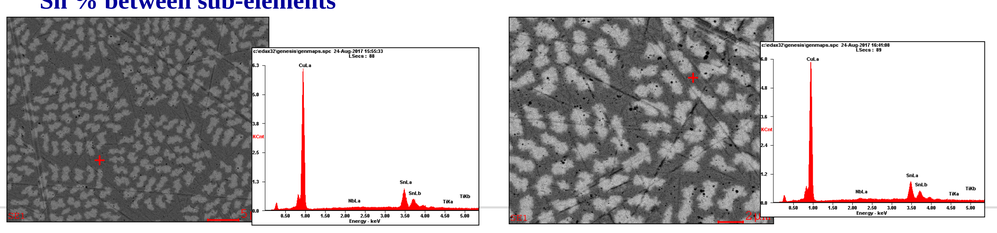
L (μm)	W16C	W16Z	BO-7	BO-5
100	14.3 (14.3)	14.0 (13.5)	12.2 (11.8)	12.2 (10.0)
150	14.7 (13.7)	14.1 (13.5)	12.6 (11.9)	12.3 (9.8)
200	15.3 (13.6)	13.9 (13.3)	12.3 (11.4)	12.6 (11.3)
250	14.7 (13.8)	14.2 (13.5)	13.4 (11.8)	12.4 (11.4)
300	14.5 (13.8)	14.4 (13.7)		12.9 (11.0)
350	14.8 (14.2)	14.3 (13.8)		

L – the distance from Nb-barrier

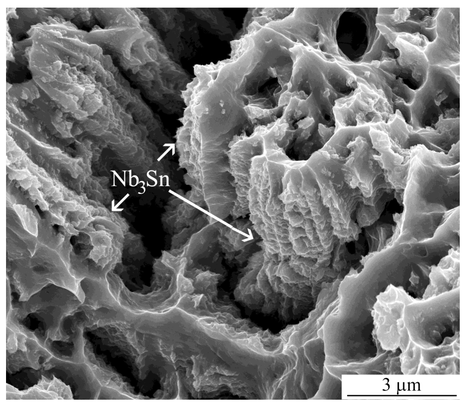


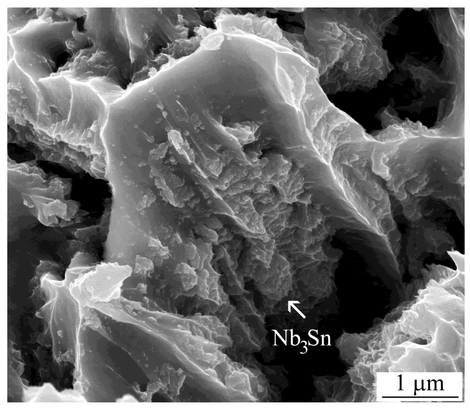
Sn % between sub-elements

Sn % inside sub-element

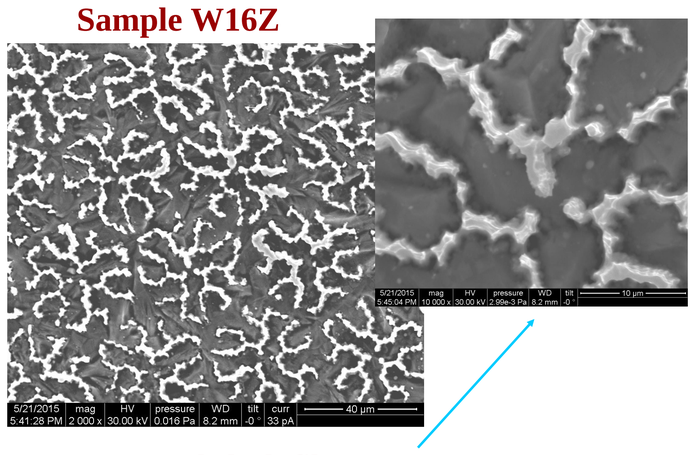


Sample W16Z



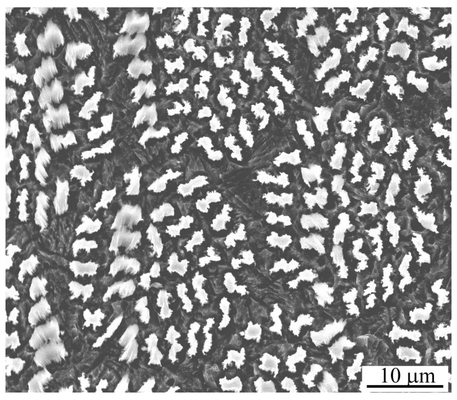


Sample W16Z



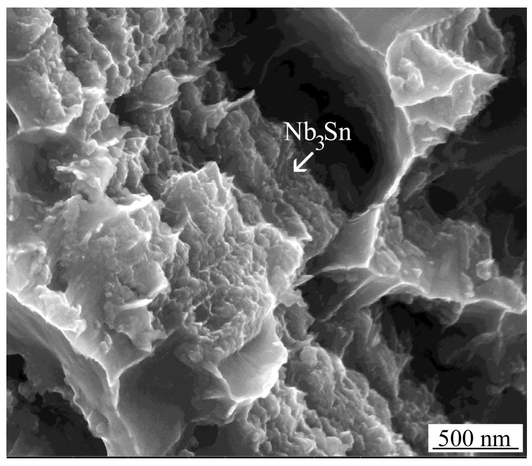
Extended Nb-filaments

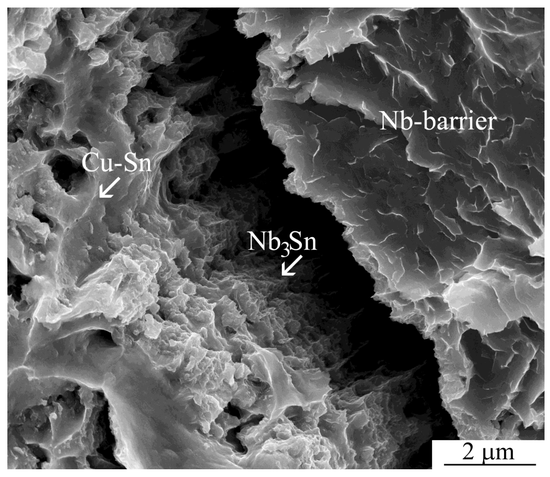
Sample W16C



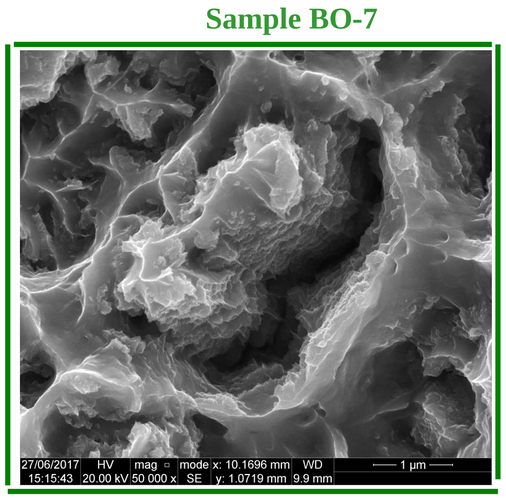
Coupled Nb-filaments

Central part of strand — Sample BO-5 — Near Nb-barrier

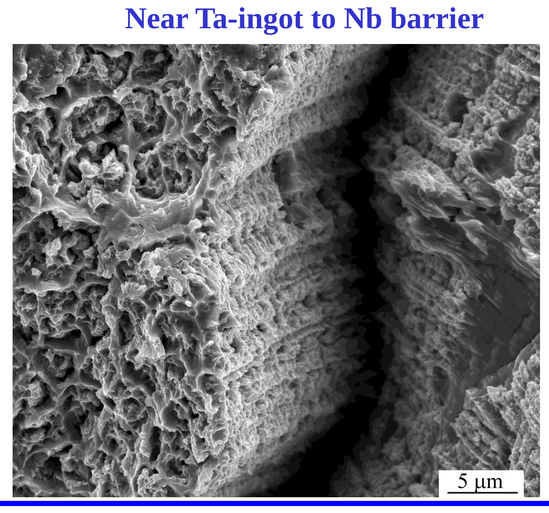




Sample BO-7



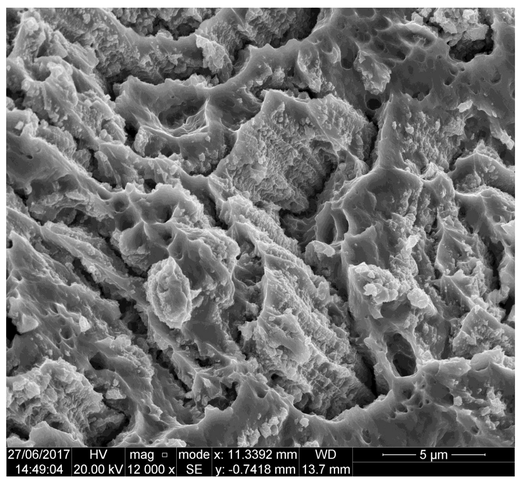
Near Ta-ingot to Nb barrier



The characteristics of pre-reaction Nb_3Sn layers

Sample	L^a_{av}, nm	$d_{max}{}^b$, nm	$d_{av}{}^c$, nm
BO-5[c]	105	33	25
BO-7	112	40	33
W16C	140	44	34
W16Z	200	58	46

[a] Average width of layer; [b] Average grain size; [c] Maximal grain size.



CONCLUSIONS

- In the wires with coupled Nb filaments the average thickness of pre-reacted layers increases from 105 nm to 140 nm with an increase of the initial Sn concentration in bronze matrix from 14% to 16%.
- The thickest parasitic layers (200 nm) are formed in the strands with 16% Sn in matrix and extended spider-shaped Nb filaments.
- To minimize the parasitic layers formation the strands with more than 14% Sn in bronze matrix should be heat treated at temperature lower than 500°C or with shorter annealing times.

[1] E.I. Plaschkin, E.V. Nikulenkov, N.I. Salunin, A.K. Shikov, G.P. Vedernikov, V.S. Belyaev, O.V. Malafeeva, A.E. Vorobieva, A.G. Silaev. The method for manufacturing of composite superconductor based on Nb3Sn. RF Patent No 2152657, 2000. Available: http://bd.patent.su/2152000-2152999/pat/servl/servlet7e91.html

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