Fabrication of new internal tin Nb_3Sn wire using Sn-Zn alloy as Sn core

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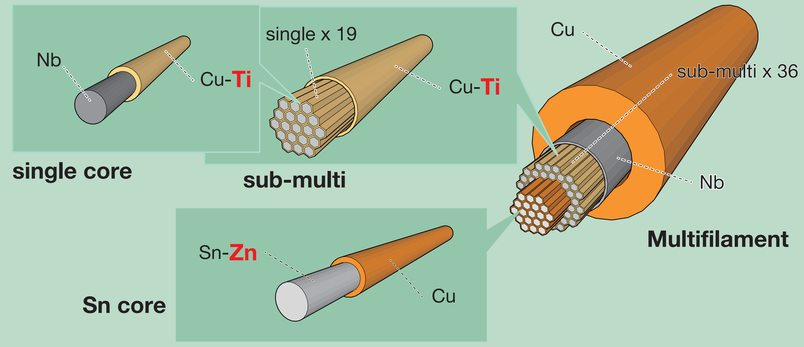
Purpose

- Zn addition to IT Nb_3Sn wire
- Prevent Sn-Ti compound at the boundary of Nb filament pack when doping Ti to Sn core

Dope Ti to Cu matrix + dope Zn to Sn core

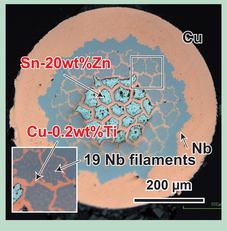
SPECIMEN

Wire fabrication



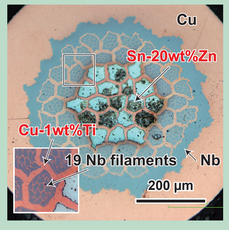
Cross section

SZ-CT02 Ø0.6



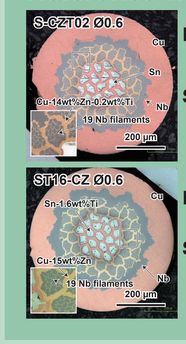
Cu-0.2wt%Ti/Sn-20wt%Zn

SZ-CT1 Ø0.8



Cu-1wt%Ti/Sn-20wt%Zn

Reference wire



Matrix
Cu-14wt%Zn-0.2wt%Ti

Sn core
pure Sn

Matrix
Cu-15wt%Zn

Sn core
Sn-1.6wt%Ti

Heat treatment

First annealing
210°C/20 h + 550°C/100 h + 650°C/100 h

→ **Additional anenaling**
685 ~ 715°C for 100 h

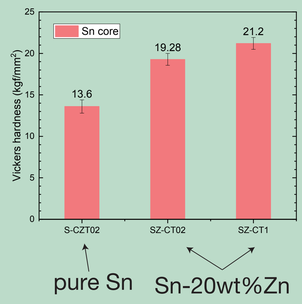
Wire specification

Reference wire

Sample name	S-CZT02	SZ-CT02	SZ-CT1	ST16-CZ
Wire diameter (mm)	0.6	0.6	0.8	0.6
No of Nb filament	684	684	684	684
No of Sn core	19	19	19	19
Filament diameter (μm)	7.46	7.46	7.31	7.46
Sn core	Sn	Sn-20wt%Zn	Sn-20wt%Zn	Sn-1.6wt%Ti
Matrix	Cu-14wt%Zn-0.2wt%Ti	Cu-0.2wt%Ti	Cu-1wt%Ti	Cu-15wt%Zn
overall Zn content (wt%)	4.26	2.21	2.21	4.57
Area fraction				
Nb	35.84	35.84	35.84	35.84
Sn	19.58	24.07	24.07	19.58
Matrix	44.58	40.09	40.09	44.58

RESULTS

Workability of the new IT wire



Hardness of Sn core

pure Sn: 13.6 kgf/mm²

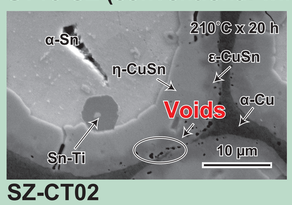
→ Sn-20wt%Zn: **19.28** kgf/mm²

1.42 times

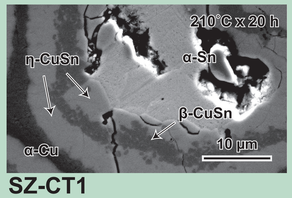
Workability of SZ-CT wires is improved

Microstructure after 210°C for 100 h HT

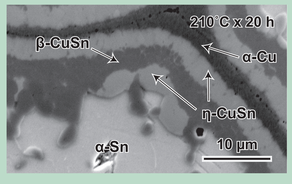
ST16-CZ (conventional wire)



SZ-CT02



SZ-CT1



ST16-CZ (pure Sn core)

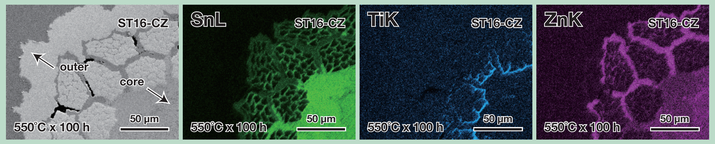
- Fundamentaly diffusion reaction is same as Sn/Cu
- η-CuSn and ε-CuSn phase are formed
- much void between η and α-Cu

SZ-CT02 and SZ-CT1 (Sn-Zn core)

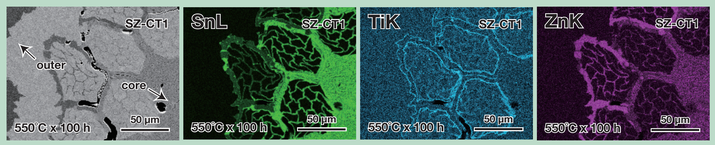
- Fundamentary diffusion reaction is same as Sn-Zn/Cu
- η-CuSn and β-CuZn phase are formed
- almost no voids
- almost no differences regardless of Ti content

EDX mapping after 550°C for 100 h HT

Ti dope to Sn core (ST16-CZ)



Ti dope to Cu matrix (SZ-CT1)



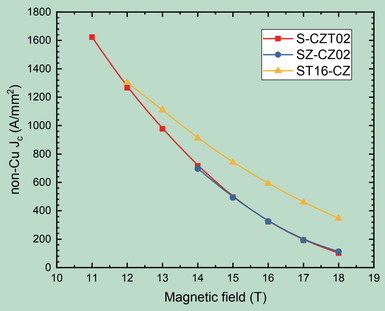
ST16-CZ (Ti dope to Sn core)

- ununiform Ti distribution
- Sn diffusion seems to be avoided by Ti segregation

SZ-CT1 (Ti dope to matrix)

- uniform Ti distribution
- Sn diffusion is promoted
- Zn diffuse sufficientry to outward even if Zn dope to Sn core.

Premitive data of J_c-B characteristic



- almost same performance
- high field performance is low

→ Ti content is low

no data for SZ-CT1

CONCLUSION

- Workability of new IT wire is improved by using Sn-Zn alloy as Sn core.
- At 210°C, solid β-CuZn without voids is formed in case of doping Zn to Sn core.
- Ti distribution is improved by Ti doping to matrix.
- Zn distribution is uniform even if Zn dope to Sn core
- Increase of Ti content is necessary for improvement of J_c

Acknowledgment
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