Activities of Chinese National Technical Committee on Superconductivity

Jie Li

2015.11.25, ACASC 15

OUTLINE

1 **Organization**

2 **Present work** (domestic, international)

3 **Difficulty**

4 **Future work**

1. Standardization work on Superconductivity in China (ppt), Yanwei MA (IEE, CAS) in Tower Hall Funabori, Tokyo, 2013;
2. Introduction to Chinese National Technical Committee on Superconductivity (in Chinese), Dongning Zheng, 2013
3. PPTs in the 13th national conference on superconductivity, Suzhou, 2015, by Cheng ZENG (UEST) , Kexi Xu (SHU), Chuangbing CAI (SHU), et al.

OUTLINE

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3 **Difficulty**

4 **Future work**

SAC/TC265

National Technical Committee on Superconductivity

中国国家标准化管理委员会
Standardization Administration of the P.R.C.

Chairperson: Prof Yang, Qiangsheng (IOP)

Deputy Chairpersons: Zheng, Dongning (IOP)

Xiao, Ling (GRINM)

Secretary: Liu, Yiping

Advisors: Gan, Zizhao; Zhao, Zhongxian;

Yang, Guozhen; Zhou, Lian

Formally established in Aug. 2003
The secretariat is in the Inst. Of Phys., CAS

WG of large scale and power applications in April 2014

Convener: Wang, Qiuliang (IEE)

WG of small scale and electronic applications in August 2014

Convener: Chen, Jian (NJU)

SAC/TC265 Member Institutions

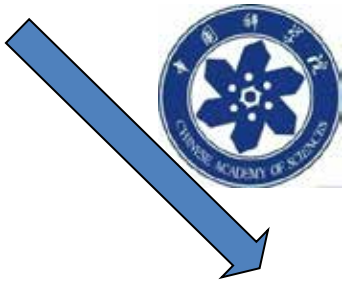
- Institute of Physics, CAS
- Shanghai Institute of Microsystem and Information Technology (SIMIT)
- Institute of Electrical Engineering, CAS
- Beijing General Research Institute for Non-Ferrous Metals
- Northwestern Research Institute for Non-Ferrous Metals
- National Institute of Metrology
- Changsha Mineral Institute
- Peking University
- Tsinghua University
- Nanjing University
- University of Electronic Science and Technology
- University of Science and Technology of China
- Western Superconducting Technologies Co. Ltd
- China Electric Power Research Institute
- North China Electric Power University
- Innova Superconductor Technology

Organization

SAC 中国国家标准化管理委员会 Standardization Administration of the P.R.C.

IEC International Electrotechnical Commission

TC 90 Superconductivity



SAC/TC265

SC Technology Standardization

1. Converting IEC standards into Chinese standards (IDT, MOD, NEQ);
2. Developing new independent Chinese standards;
3. Encouraging researches aimed for new Chinese standards;
4. Promoting the usage of SC standards;

TC90 Activities

1. Participating international standards development activities (convener, vote, comment, RRT, others);
2. Recommending Chinese experts to TC90 working groups;
3. Participating/hosting IEC/TC90 plenary & WG meetings;

OUTLINE

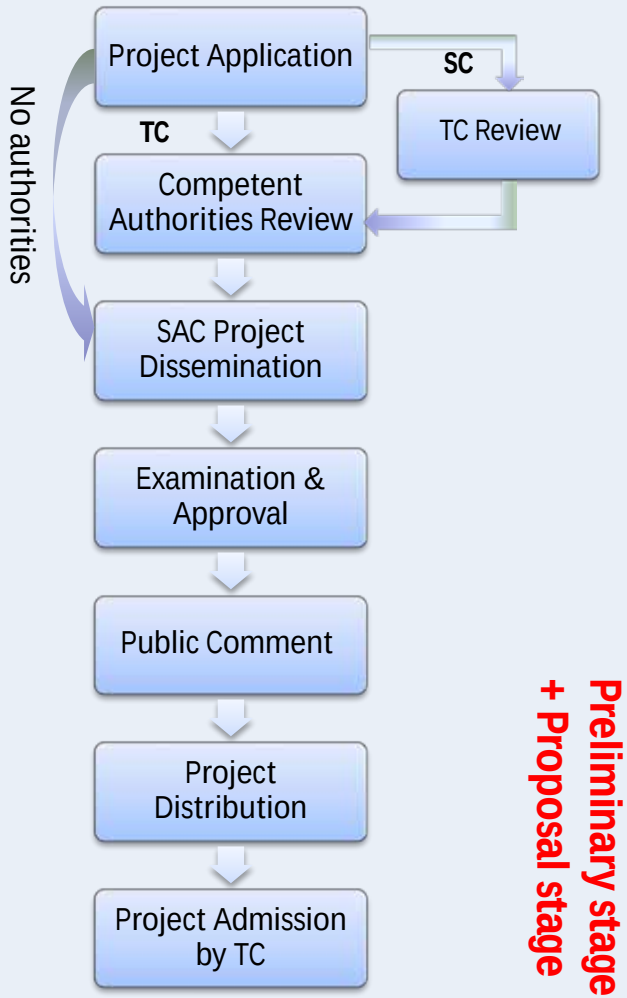
1 Organization

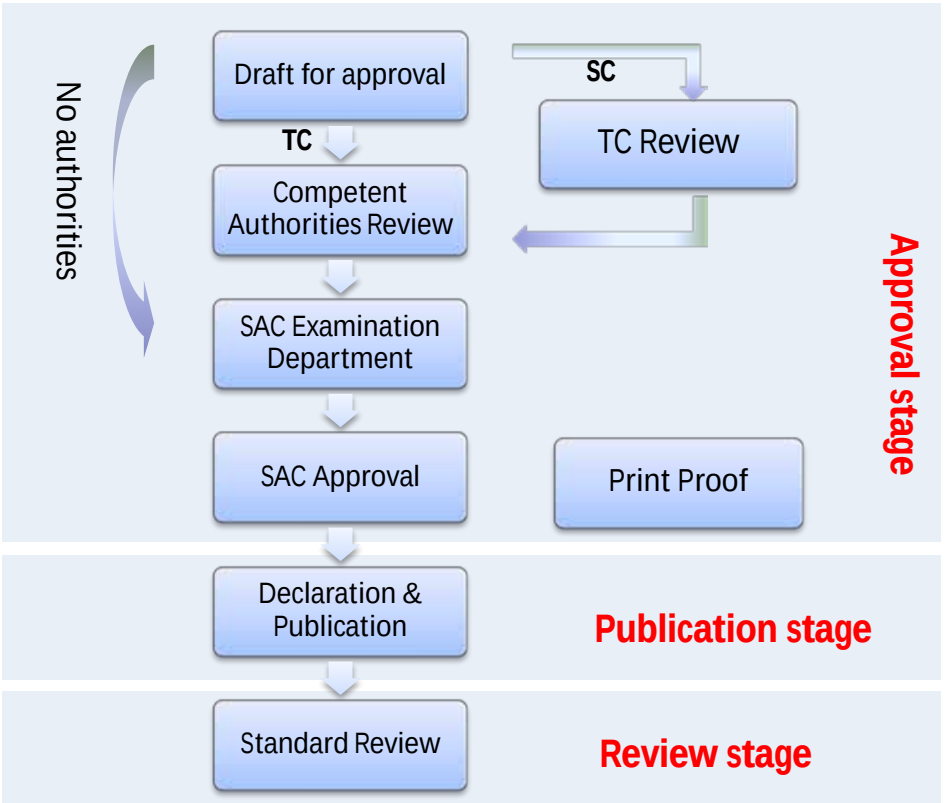
2 **Present work** (domestic, international)

3 Difficulty

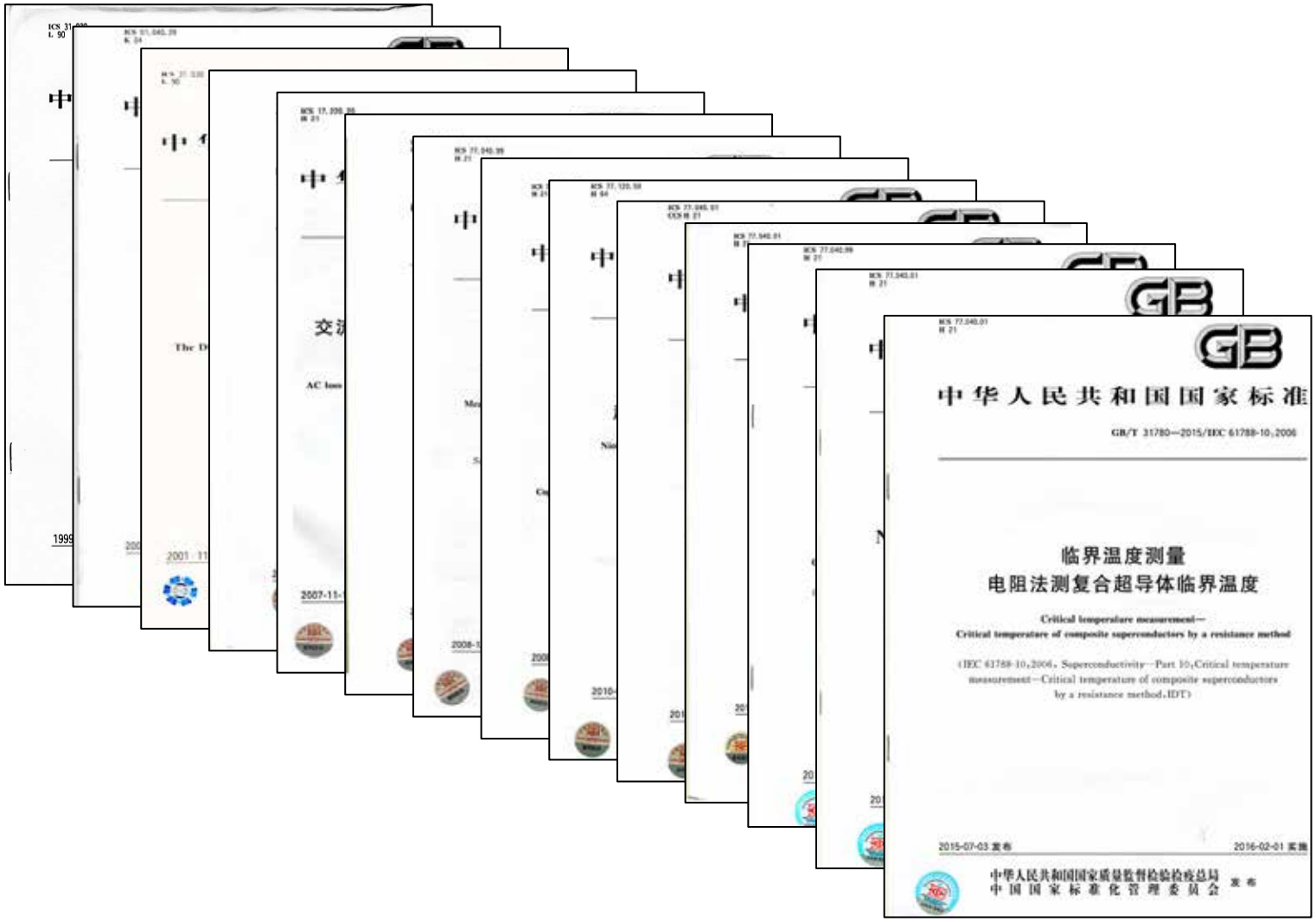
4 Future work

China standard development procedure





16 national standards on Superconductivity published



Publications issued by SAC/TC265

	Standard No	Title	Execute Date	IEC No
1	GB/T 17711-1999	钇钡铜氧(123相)超导薄膜临界温度Tc的直流电阻试验方法 The DC electric resistance test method for the critical temperature Tc of a $YBa_2Cu_3O_{7-d}$ superconducting thin film	1999-10-01	/
2	GB/T 18502-2001	银或银合金包套铋系氧化物超导体直流临界电流的测定 The DC critical current of Ag- and/or Ag alloy-sheathed bismuthal oxide superconductor	2002-05-01	IEC 61788-3
3	GB/T 13811-2003	电工术语 超导电性 International Electrotechnical Vocabulary : Superconductivity	2003-06-01	IEC 60050-815: 2000
4	GB/T 21115-2007	块状氧化物超导体磁浮力的测量 Measurement for levitation force of bulk oxide superconductor	2007-12-01	/
5	GB/T 21227-2007	交流损耗测量：Cu/Nb-Ti 多丝复合线磁滞损耗的磁强计测量法 AC loss measurements - Magnetometer methods for hysteresis loss in superconducting multifilamentary composites	2008-05-01	IEC 61788-13: 2003
6	GB/T 21546-2008	铌钛复合超导体的直流临界电流测量 Critical current measurement - DC critical current of Nb-Ti composite superconductors	2008-11-01	IEC 61788-1: 2006

Publications issued by SAC/TC265 (cont.)

	Standard No	Title	Execute Date	IEC/IS No
7	GB/T 22586 - 2008	高温超导薄膜微波表面电阻测试 Measurements of surface resistance of high temperature superconductor thin films at microwave frequencies	2009-05-01	IEC 61788-7: 2006
8	GB/T 22587-2008	基体与超导体体积比测量-Cu/NbTi复合超导体中铜与超导体的体积比测试方法 Matrix to superconductor volume ratio measurement - Copper to superconductor volume ratio of Cu/Nb-Ti composite superconducting wires	2009-05-01	IEC 61788-5: 2000 (MOD)
9	GB/T 25080-2010	超导用Nb-Ti合金棒坯，粗棒和细棒 Niobium-Titanium Alloy Billets, Bar, and Rod for Superconducting Applications	2011-04-01	ASTM B884-2005 (MOD)
10	GB/T 25897-2010	剩余电阻比测量- 铜/铌-钛复合超导体的剩余电阻比 Superconductivity: Residual resistance ratio measurement of Nb-Ti composite superconductors	2011-05-01	IEC 61788-4: 2007
11	GB/T 28871-2012	铌三锡（Nb_3Sn）复合超导体的直流临界电流测量 Critical current measurement - DC critical current of Nb_3Sn composite superconductors	2013-02-15	IEC 61788-2: 2006

Publications issued by SAC/TC265 (cont.)

	Standard No	Title	Execute Date	IEC No
12	GB/T 30109-2013	交流损耗测量－液氦温度下横向交变磁场中圆形截面超导线总交流损耗的探测线圈测量法 AC loss measurements - Total AC loss measurement of round superconducting wires exposed to a transverse alternating magnetic field at liquid helium temperature by a pickup coil method	2014-05-15	IEC 61788-8: 2010
13	GB/T 30537-2014	块状高温超导体的测量-大晶粒氧化物超导体的俘获磁通密度 Measurements for bulk high temperature superconductors - Trapped flux density of large grain oxide superconductors	2014-11-01	IEC 61788-9: 2005
14	GB/T 31522-2015	基体与超导体体积比测试 – Nb_3Sn复合超导线铜与非铜体积比 Matrix to superconductor volume ratio measurement - Copper to non-copper volume ratio of Nb_3Sn composite superconducting wires	2015-12-01	IEC 61788-12: 2013
15	GB/T 31527-2015	力学性能测量 – NbTi/Cu复合超导线室温拉伸试验方法 Mechanical properties measurement - Room temperature tensile test of Cu/Nb-Ti composite superconductors	2015-12-01	IEC 61788-6: 2011
16	GB/T 31780-2015	临界温度测量 – 电阻法测复合超导体临界温度 Critical temperature measurement - Critical temperature of composite superconductors by a resistance method	2015-02-01	IEC 61788-10: 2006

On-going projects of China national standards

No	Project No (IEC)	Title	Status
1	20132581-T-491 (IEC 61788-14 Ed.1.0)	超导电力设备—对超导电力设备用电流引线特性测试的基本要求 （WANG Qiuliang in IEE, CAS） Superconducting power devices - General requirements for characteristic tests of current leads designed for powering superconducting devices	Application: Oct. 11, 2012 Approved: April 10, 2013 Current status: Exp. work
2	20132582-T-491 (IEC 61788-15 Ed.1.0)	电性能测试—微波频率下超导薄膜的本征表面阻抗 （CHEN Jian in NJU） Electronic characteristic measurements - Intrinsic surface impedance of superconductor films at microwave frequencies	Application: Oct. 11, 2012 Approved: April 10, 2013 Current status: Exp. work
3	20142502-T-491 (IEC 61788-7 Ed.2.0) GB/T 22586 **Ed2**	电子学特性测量—超导体在微波频率下的表面电阻 （ZENG Cheng in UESTC ） Electronic characteristic measurements - Surface resistance of superconductors at microwave frequencies	Application: Aug. 20, 2014 Approved: Dec. 23, 2014 Current status: WG started
4	20142503-T-491 (IEC 61788-18 Ed.1.0)	力学性能测量—银和/或银合金包套Bi-2223和Bi-2212复合超导体室温拉伸试验方法 （CHENG Junsheng in IEE, CAS） Mechanical properties measurement - Room temperature tensile test of Ag- and/or Ag alloy-sheathed Bi-2223 and Bi-2212 composite superconductors	Application: Aug. 20, 2014 Approved: Dec. 23, 2014 Current status: WG started
5	20151364-T-491 (IEC 61788-5:Ed. 2.0) GB/T 22587 **Ed2**	基体与超导体体积比测量—铜-铌钛(Cu/Nb-Ti)复合超导体铜-超[体积]比的测量 （FENG Ran in WST） Matrix to superconductor volume ratio measurement - Copper to superconductor volume ratio of Cu/Nb-Ti composite superconducting wires	Application: Jan. 23, 2015; Approved: July 31, 2015; Current status: WG started

On-going projects of China national standards (cont.)

No	Project No (IEC)	Title	Status
6	20151365-T-491 (IEC 61788-3 Ed.2.0) GB/T 18502 **Ed2**	临界电流测量—银和/或银合金包套Bi-2212和Bi-2223氧化物超导体的直流临界电流 （ZHANG Guomin in IEE, CAS） Critical current measurement - DC critical current of Ag- and/or Ag alloy-sheathed Bi-2212 and Bi-2223 oxide superconductor	Application: Jan. 23, 2015; Approved: July 31, 2015; Current status: WG started
7	(IEC 61788-16: 2013)	电性能测试 微波频率下超导体表面电阻随功率的变化 （ZHAO Xinjie in TJU） Electronic characteristic measurements - Power-dependent surface resistance of superconductors at microwave frequencies	Application: June 17, 2015; Public comment: Sept. 24, 2015;
8	(IEC 61788-17: 2013)	电性能测试 大面积超导薄膜的局域临界电流密度及其分布 （CAI Chuanbing in SHU） Electronic characteristic measurements - Local critical current density and its distribution in large-area superconducting films	Application: June 17, 2015; Public comment: Sept. 24, 2015;

Standards issued by IEC/TC90 are all numbered as

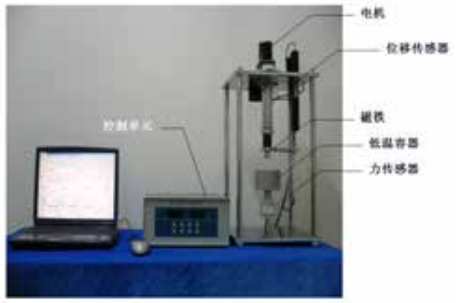
IEC 61788-XX

① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ ⑪ ⑫ ⑬ ⑭ ⑮ ⑯ ⑰ ⑱ ⑲ ⑳ ㉑ + **2**

Red: finished; Blue: on-going; Black: no yet started

Standardized Measurement Setups

- Even for standards identically adopted from IEC standards by translation (IDT), standardized measurement devices are always established, and careful experiments are carried out;
- For independently developed standards, and standards adopted from international standards with modification (MOD), round robin tests are required to be carried out.



Measurement for levitation force of bulk oxide superconductor

GB/T 21115-2007

DC critical current of Nb-Ti composite superconductors

GB/T 21546-2008

Measurements of Rs of high-Tc supercond. thin films at MV frequencies

GB/T 22586-2008

Residual resistance ratio of Nb-Ti composite superconductors

GB/T 25897-2010

GB/T 30537-2014 (SHU)

IEC-61788-9 (IDT)

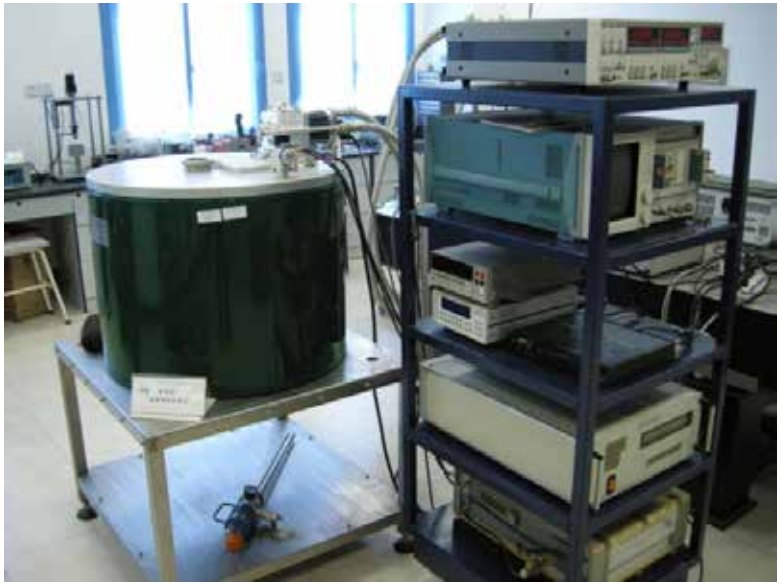
Trapped flux density of large grain oxide superconductors

Developed by:

GRINM,

SHU,

and IOP.

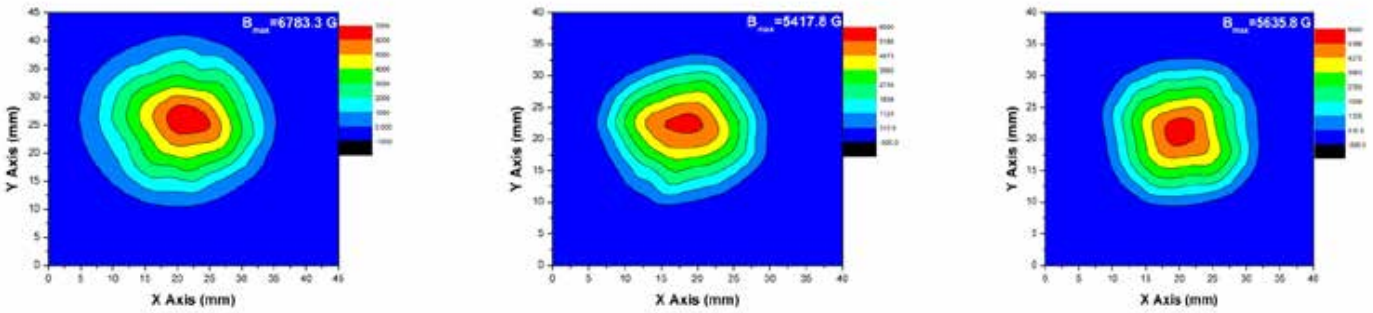


Magnet system

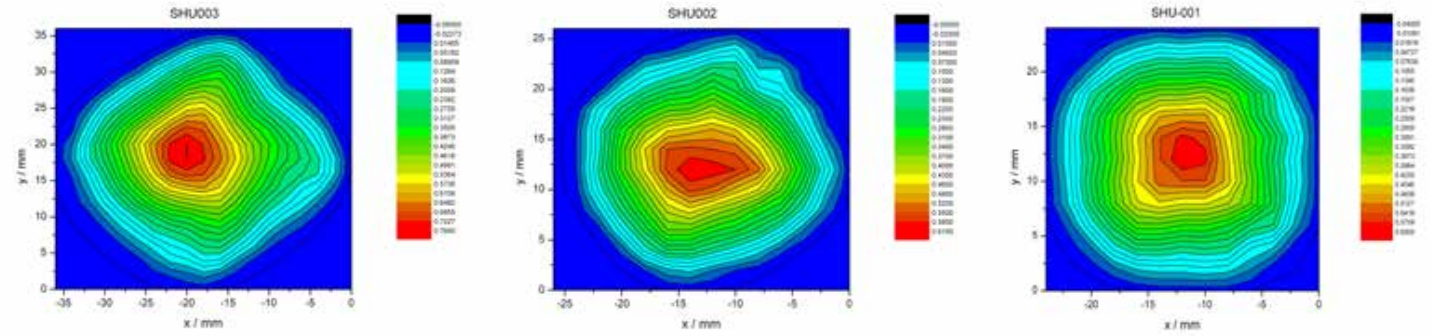
Hall sensor
in-plane scanning

Control system

Present work (domestic)



SHU



IFW Dresden

Experiment condition:

Field cooled;

H_m=2.0 T; T=77 K

d=1.2 mm;

Experiment dates:

SHU: 2013-04-02; 2013-06-10;

IFW: 2014-01-06

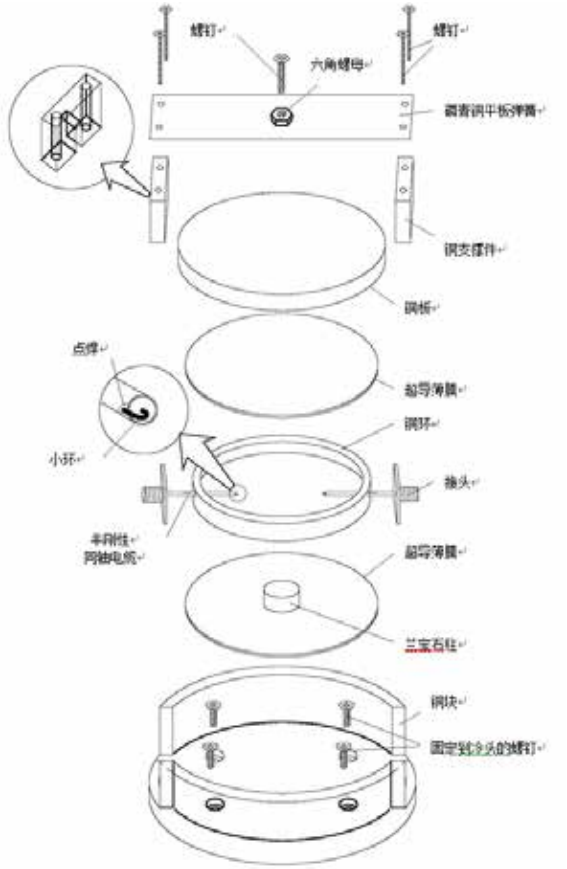
	B_{max} (T)	$\overline{B}_{max}$(T)	$(B_{max}-\overline{B}_{max})^2$	S (T)	COV (%)
BJ-YBCO-30	0.683 0.674 **0.66**	0.674	0.000081 0.000016 **0.0002**	0.012	<1.78
SHU-YBCO-25A	0.572 0.564 **0.57**	0.569	0.000009 0.000025 **0.000001**	0.004	<0.70
SHU-YBCO-25B	0.565 0.542 **0.55**	0.552	0.00017 0.00010 **0.000004**	0.012	<2.2

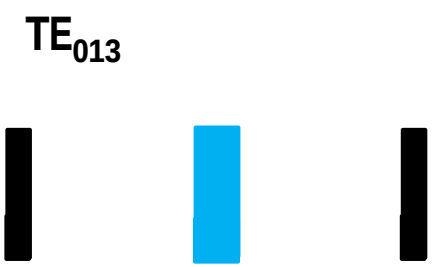
GB/T 22586 ed.2, in process (UESTC)

IEC-61788-7(MOD)

Surface resistance of superconductors at microwave frequencies

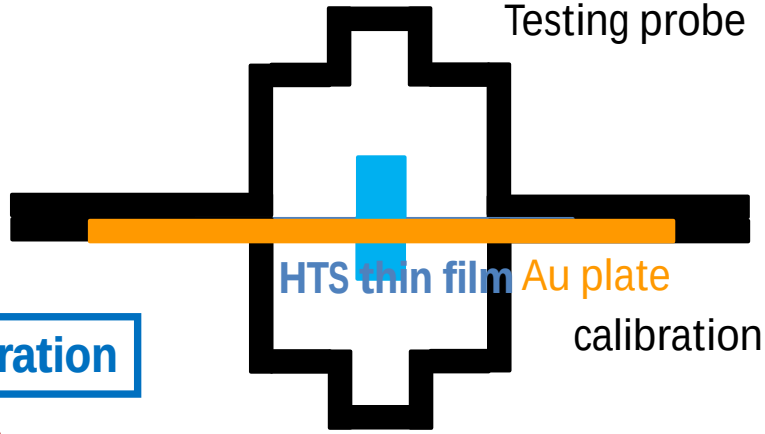
The standard two-resonator method (STR)





- Rs of the films, and ε_r and tanδ of the sapphire rod obtained.
- The result is the average R_S of two HTS thin films;
- Rs at a single frequency measured;
- Two temperature cycles;

Improved image type sapphire resonator method (ISR)



Working mode: TE_{01d}

Hø=0, Ez=0

$$\frac{1}{Q_0} = A + BR_s$$

Calibration

A value

B value

TE_{011} → TE_{012}

the testing probe is short-circuited by perfect conductor $Rs=0$

$$A = 1/Q_{0H}$$

the testing probe is short circuited by an Au plate TE_{011}

$$B = (1/Q_{0Au} - A)/Rs_{Au}$$

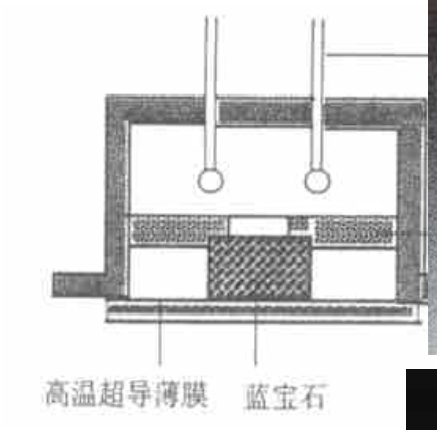
Rs determination

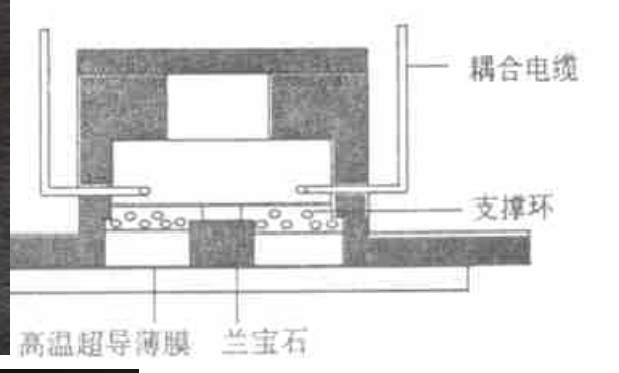
the testing probe is short circuited by the HTS film specimen

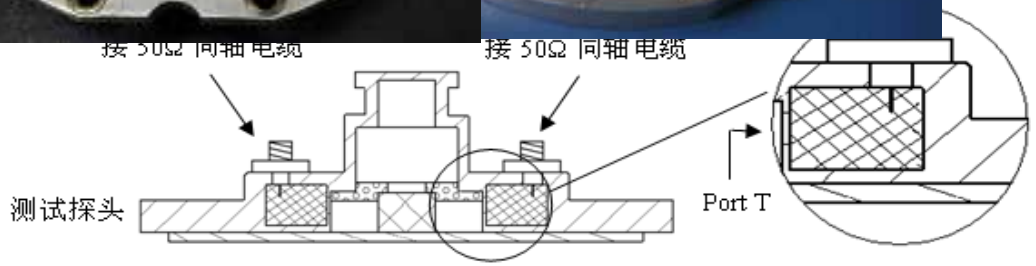
$$Rs_{HTS} = (1/Q_{0HTS} - A)/B$$

ICTD 2009, doi:10.1109/CAS-ICTD.2009.4960774; Chinese Sci Bull, doi: 10.1007/s11434-009-0639-8

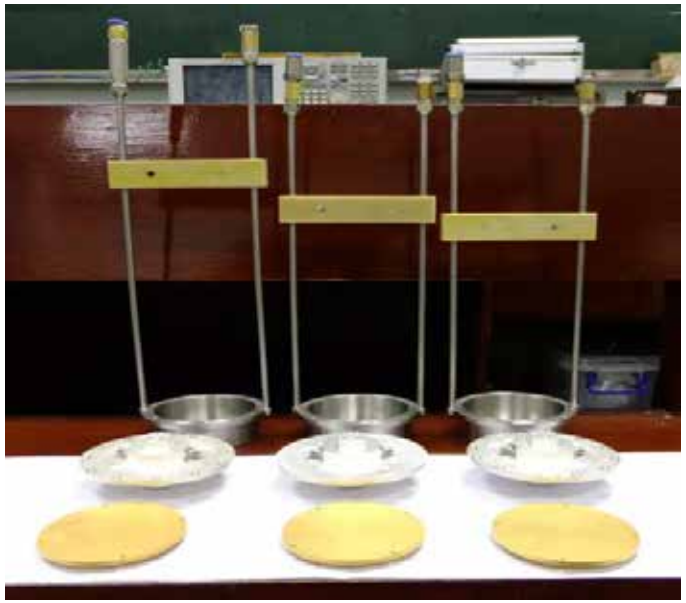
Present work (domestic)







Round Robin Test



Rs of Au plates: 17.16 mW

Samples (#1, #2, #3, #4):

f 50.8mm YBCO/LAO/YBCO thin films

YBCO thickness≈500nm

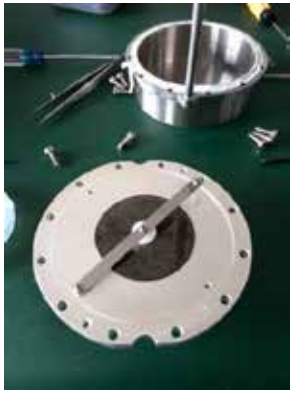
LAO thickness 0.5mm

Participating institutions:

UESTC; NJU; THU

Measurement Apparatus:

ISR (a, b, c); **STR** (z)



Experimental procedures:

The four pieces of HTS thin films were measured using the three ISR apparatus (a, b, c) at three sites respectively, each for three times; and then measured using the STR apparatus (z) for comparisons; finally, misclosure tests were carried out.

Present work (domestic)

Round Robin Test

Rs @ 10 GHz, 77 K. Unit: mΩ

No.	x_{ik}	x_{i1}	x_{i2}	x_{i3}	$\overline{x_i}$	$\overline{\overline{x}}$	Misclosure of round			Criterion	(S_R)	COV (COV*)
							x_{r1}	S_{r1}	CD	$\lvert x_{r1} - \overline{x_i} \rvert \leq CD$		
1	x_{1k}	0.324	0.347	0.340	0.337	0.348	0.324	0.01179	0.00272	valid	0.0154 (0.0221)	4.4% (6.4%)
	x_{2k}	0.348	0.394	0.367	0.369							
	x_{3k}	0.332	0.345	0.338	0.338							
2	x_{1k}	0.338	0.338	0.337	0.338	0.351	0.339	0.00071	0.00163	valid	0.0062 (0.0127)	1.8% (3.6%)
	x_{2k}	0.353	0.354	0.370	0.359							
	x_{3k}	0.354	0.354	0.363	0.357							
3	x_{1k}	0.326	0.324	0.328	0.326	0.346	0.366	0.00200	0.00462	invalid	0.0136 (0.0217)	3.9% (6.3%)
	x_{2k}	0.364	0.359	0.365	0.363							
	x_{3k}	0.338	0.332	0.375	0.348							
4	x_{1k}	0.310	0.315	0.297	0.307	0.318	0.313	0.00930	0.02148	valid	0.0079 (0.0144)	2.5% (4.5%)
	x_{2k}	0.343	0.325	0.328	0.332							
	x_{3k}	0.317	0.313	0.313	0.314							

University of Electronic Science and Technology of China

Meaning of symbols and subscripts

No：Sample

Subscript *i*：laboratory
(*i* = 1, 2, 3 stands for UESTC, THU and NJU, respectively;

Subscript *k*：measurement

$\bar{x}_i$ ：average of individual lab *i*　　$\bar{\bar{x}}$ ：general average

x_{r1} : value measured again in lab1　　s_{r1} ：Standard Deviation of Repeatability of Lab1

S_R ：Standard Deviation of Reproducibility

***CD* value**： $(CD = \frac{4}{\sqrt{3}} s_{r1})$　$|x_{r1} - \bar{x}_i| \pounds CD$ ， valid

COV： coefficient of variant inside lab　　$COV = s_r / \bar{\bar{x}}$

COV*： coefficient of variant inter labs　　$COV^* = S_R / \bar{\bar{x}}$

Present work (domestic)

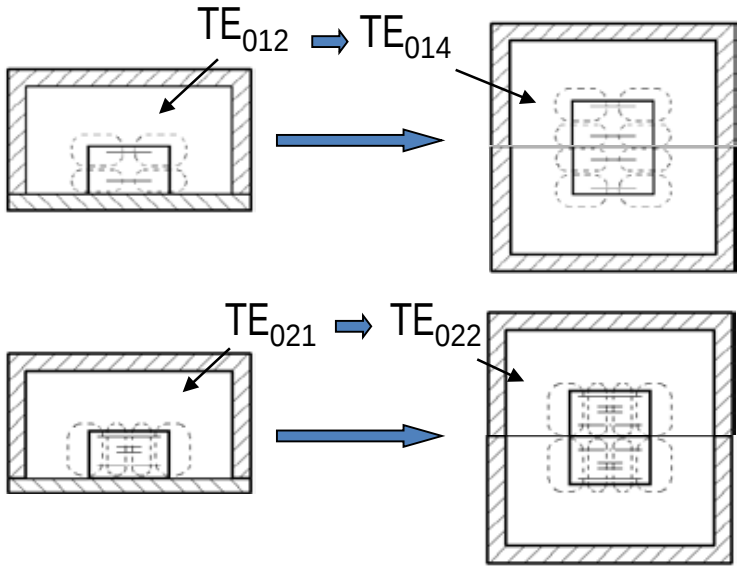
No	STR	ISR	Aver.	S	RSU
1	0.397	0.348	0.373	0.0346	9.3%
2	0.404	0.351	0.378	0.0375	9.9%
3	0.363	0.346	0.355	0.0120	3.4%
4	0.344	0.318	0.331	0.0184	5.6%

The target precision in IEC 61788-7：2006 (GB/T 22586-2008) is 20%

The improved image type sapphire resonator method (ISR) will be added to GB/T 22586 Ed 2.0 as a normative annex.

- Absolute Rs value of a single piece of film measured;
- Rs at multifrequencies can be measured;
- One thermal cycle needed;
- No patterning of the film needed.

$H_\varphi = 0$ ； $Ez = 0$



Vote on behalf of China in IEC/TC90

IEC/TC90 working documents in 2015

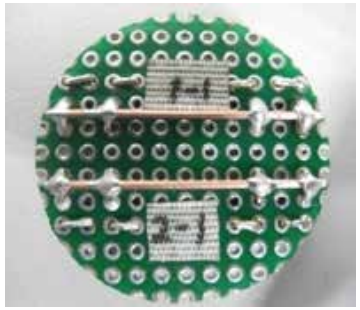
IEC No.	Title	Document	CN Comments	WG Agree
61788-23	Residual resistance ratio measurement of Nb superconductors	**347 NP 2015-01-09**	**38** (te 16; ed 18; ge 4)	**37** (p.a. 6)
61788-24	Critical current measurement - Retained critical current after double bending at room temperature of Ag-sheathed Bi-2223 superconducting wires	**348 NP 2015-01-23**	**Against**	
61788-4	Residual resistance ratio measurement - Residual resistance ratio of Nb-Ti and Nb_3Sn composite superconductors	**349 CDV 2015-04-10**	**37** (ed 31; te 6)	**33** (p.a. 1)
61788-21	Superconducting wires - Test methods for practical superconducting wires - General characteristics and guidance	**353 FDIS 2015-05-01**	**9** (ed 7; ge 2)	¾
61788-25	Mechanical properties measurement - Room Temperature Tensile Test on REBCO Wires	**355 NP 2015-09-11**	**34** (ed 27; te 6; ge 1)	**29**
61788-22-1	Superconducting electronic devices - Generic specification for sensors and detectors	**356 CD 2015-10**	**17** (ed ; te)	

- **Vote+Comment to IEC/TC90 working documents >95%**
- **>80% Comments were adopted by working groups.**

Round Robin Test of RRR of Nb_3Sn Wires

- Six specimens from *Western Superconducting Technologies*
- Internal Tin method
- Each of three specimens cut from two different wires

  #1-1, 1-2, 1-3; #2-1, 2-2, 2-3
- Participants
  - Western Superconducting Technologies (China)
  - Institute of Plasma Physics, CAS (China)
  -
  -
  -
  -



Institute	Country	(1-1)	(1-2)	(1-3)	(2-1)	(2-2)	(2-3)	Measured date
WST	China	153	156	158	182	178	181	Jun-13
IPP	China	152	159	158	189	173	183	Nov-13
YNU	Korea	149	153	154	176	168	178	Jun-14
KIT	Japan	150	153	151	175	157	173	Sep-14
FNL	USA	143	153	153	179	165	178	Mar-15
DURHAM	UK	148	156	157	182	171	182	Aug-15
AVE		149	155	155	180	169	179	
STD		3.52	2.41	3.07	5.22	7.35	3.64	
COV(%)		2.36	1.55	1.98	2.89	4.36	2.03	

Round Robin Test of Residual Resistance Ratio of Nb_3Sn Wires, D.H. Kim @Eucas 15

Chinese Experts in IEC/TC90 Working Groups

No	Working group name	Chinese experts
WG1	Terms and definitions	ZHENG Dongning (IOP, CAS); ZHANG Hong (IME, CAS)
WG2	Critical current measurement of Nb-Ti composite superconductors	WANG Jingrong (NIN); HUI Dong (CEPRI)
WG3	Critical current measurement method of oxide superconductors	**HUA Chongyuan (GRINM);** YAN Guo (WST)
WG4	Test method for residual resistivity ratio of Cu/Nb-Ti and Nb_3Sn composite superconductors	**LI Jie (IOP, CAS); GAO Huixian (WST);** PU Minghua (Swjtu)
WG5	Tensile test and electro-mechanical properties of composite superconductors	**XIN Ying (TJU); CAI Chuanbing (SHU); WANG Qiuliang (IEE, CAS); WANG Jingrong (NIN); LU Yafeng (NIN);** WANG Yinshun (NCEPU)
WG6	Matrix composition ratio of composite superconductors	LIU Xianghong (WST);
WG7	Critical current measurement method of Nb_3Sn composite superconductors	**ZHANG Hong (IME, CAS);** WANG Jingrong (NIN)
WG8	Electronic characteristic measurements	**CHEN Jian (NJU); LI Tao (GRINM);** LUO Zhengxiang (UEST); JI Zhengming (NJU)
WG9	Measurement method for AC losses in superconducting wires	**WEN Huaming (IEE, CAS);** ZHENG Dongning (IOP, CAS); DING Shiying (NJU); WANG Yinshun (NCEPU)
WG10	Measurement for bulk high temperature superconductors - Trapped flux density in large grain oxide superconductors	**JIA Yulei (GRINM); WEN Huaming (IEE, CAS);** ZHANG Cuiping (NIN)
WG11	Critical temperature measurement - Critical temperature of composite superconductors	CAO Liezhao (USTC); MA Ping (PKU)
WG12	Current Leads	**WANG Yinshun (NCEPU)**
WG13	General characteristics for practical superconducting wires	**XIN Ying (TJU); ZHANG Guomin (IEE, CAS); LI Jianfeng (WST)**
WG14	Superconducting electronic devices - Generic specification for sensors and detectors	**CHEN Jian (NJU); YOU Lixing (SIMIT)**

Participating/hosting IEC/TC90 plenary & WG meetings

China has hosted two TC90 plenary meetings (4th and 14th)

- Bell Tower Hotel in Xi'an, China on 20th-22th August, 2012. 34 participants from 6 countries

Plenary meeting scene

- Beijing, China in October, 1996

Prof Zhang is honored for the IEC 1906 Award

in recognition of his remarkable contribution to IEC 61788-20 and IEC 61788-21 as an expert since the start of WG 13.

OUTLINE

1 Organization

2 **Present work** (domestic, international)

3 **Difficulty**

4 Future work

Difficulties and shortcomings

Difficulties:

- **Financial resource**
  - Little financial support dedicated for superconductivity standards from the government level.
  - Quite limited operating funds from CAS.
- **Human resource**
  - Not many researchers willing to take part in standardization work in the superconductivity community.
  - Lack of young people with expertise both in superconductivity and standardization.

Shortcomings:

- Few IEC standards proposed and developed by China; Few independently developed Chinese standards;
- Lack of promotion of standardization activities in companies and industries;
- “Aged” committee for more than 10 years.

OUTLINE

1 Organization

2 **Present work** (domestic, international)

3 Difficulty

4 **Future work**

Future Work related to standardization

- New committee with members from universities, research institutes, industries, as well as final users.
- Gradual conversion of all IEC standards into Chinese standards.
- New standard proposal from enterprises.
- Recommendation of Chinese members to TC90 working groups.

- Promotion of research works in relevant institutions for possible standards
  - Tensile test on practical SC wires in cryogenic temperatures
  - Critical bending radius test of REBCO Wires
  - The minimum quench energy (MQE) measurement
  - General guideline to SC Microwave filters
  - **Ic measurements of 2G HTS long tape**
  - ...

R & D of 2G HTS Practical Wires @ China

R2R: roll to roll processing

Institution	Buffer Layer		SC Layer		
	On textured NiW	On untextured tape via IBAD	MOCVD	PLD	MOD
Tsinghua U	√	√			√
BJTU	R2R				√
NINM/XTU					√
SWJT	√				R2R
JLU			√		
CAS	√				√
UESTC	R2R	√	√		
GRINM	R2R			R2R	
SJTU-SC	R2R	R2R		R2R	
SHU-SCSC	R2R	R2R			R2R
SAMRI		R2R	R2R		

Kilometer-class production lines have been set up!

Thank you for your attention!