Nb/SUS Joint of Helium Vessel Base Plate for SRF Cavity Dressing

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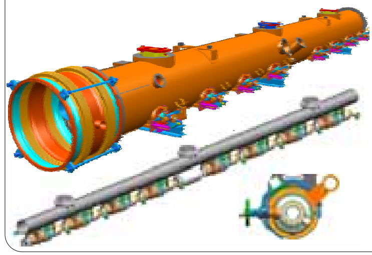
Abstract

Different material joint is a key issue for dressing of the SRF cavity. So far the baseline design of ILC is to use titanium Helium vessel, however, it will make very complicated procedure point of high vessel regulation code. If material is changed to SUS316L from niobium at the place close to cavity, the regulation control will be more relaxed. We have developed the joining method niobium and SUS316L applying HIP technology, and demonstrated to work in the STF program. The result will be presented in this paper.

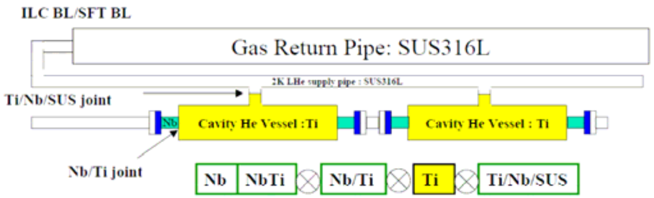
Introduction

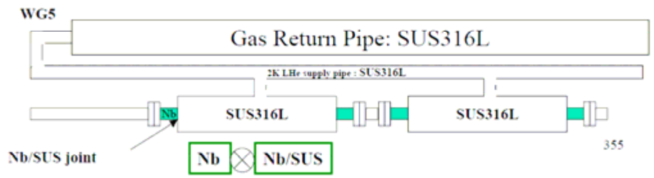
High Pressure regulation for low extremely low Temperature is a hidden serious issue to construct such a huge accelerator system like ILC.
We need some ideas to overcome this issue.



High Pressure Regulation

Niobium, Titanium and other different material joints (Nb/Ti, Nb/SUS) are issues of high pressure regulation. Generally speaking from safety point of view, one should no use none experienced material at low temperature for such a huge accelerator like ILC.





Mechanical properties

Requested values @ absorbed energy J[Joule] at 4.2K for JPN regulation:

J > 14 for σ < 450,

J > 16 for 450 < σ < 520,

J > 20 for 520 σ < 660,

J > 27 for 660 < σ [MPa]

In the table, the data by red color is by H.Naka and A.Terashima at KEK, which will be published somewhere.

Blue one is by K.Tsuchiya at KEK.

NbTi is too brittle at cryogenic temperature.
Nb/SUS joint will be okay if the copper is little bit thicker.

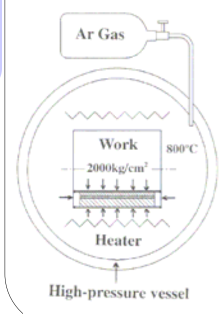
Nb/Cu/SUS : Cu 0.8mm → 1mm

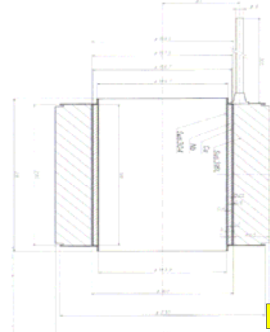
Red: H.Naka and A.Terashima, Blue: K.Tsuchiya, Black K.Saito — **Mechanical Properties** — K.Saito

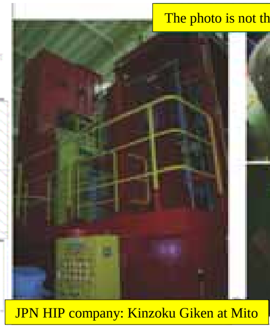
Materials		0.2% Yield Strength [MPa] 300K	77K	4.2K	Tensile [MPa] 300K	77K	4.2K	Charpy Impact Test J [J] 300K	77K	4.2K
Nb		34.3~71.0 / [illegible]	[illegible]	421.7±47.7 / [illegible]	132.4~154.1 / [illegible]	[illegible]	930.0±48.0 / [illegible]			
Ti	1st Grade	204.3±4.2	348.3±3.5	408.3±13.8	287.7±0.8	713.7±4.2	971.7±9.0	201.8±4.0	211.8±10.2	191.8±12.7
Ti	2nd Grade Tsuchiya	371.7±7.8 / [illegible]	698.0±4.6 / [illegible]	891.3±16.8 / [illegible]	443.7±7.1 / [illegible]	882.7±3.1 / [illegible]	1093±3.3 / [illegible]	101.0±8.1 / [illegible]	12.0±2.3 / [illegible]	27.8±4.3 / [illegible]
Ti								118.8±4.0	88.3±72.8	
NbTi		[illegible]	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SUS 316L				817.0±2.3			1481.0±5.0			
Ti(2nd)/Ti(2nd) TIG welding		274.7±21.3	443.3±22.0	717.7±17.8	413.3±2.1	822.0±2.0	1041.7±3.1	50.6±9	18.4±2.0	34.8±1.8
Ti(2nd)/Ti(2nd) EBW		334.0±1.7 / [illegible]	373.3±1.2 / [illegible]	640.3±9.0 / [illegible]	447.7±0.6 / [illegible]	839.7±2.1 / [illegible]	1088.0±3.5 / [illegible]	38.0±1.3 / [illegible]	35.7±0 / [illegible]	32.8±1.3 / [illegible]
Nb/Ti(2nd) EBW		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	61.6±4.4 / [illegible]	18.2±1.0 / [illegible]	10.7±7.0 / [illegible]
Nb/Cu/SUS 316L HIP		[illegible]	[illegible]	278.4±8.4 / [illegible]	[illegible]	[illegible]	884.4±28.9 / [illegible]	79.0±20.3 / [illegible]	19.0±3.2 / [illegible]	[illegible]
Nb/Cu/High Mn steel								127.0±21.8	14.6±3.3	
Nb/Ti HIP				302			183.0±45.1	1.78±0.11	1.71±0.00	
Ti/SUS 316L HIP Tsuchiya (several conditions)				302			473.4±44.3			
					391~480	588~742		3.2~10.1	1.1~4.3	
Tsuchiya (STF)			744±33.3					10.4±2.1	6.2±0.1	
Ti/Nb/SUS 316L Explosive Bonding Tsuchiya				338.4±43.2			327.8±31.3			
								23.3±1.4	20.0±1.3	
Ti/SUS 316L Friction & Compression			778.3±33.2					2.0	1.7	

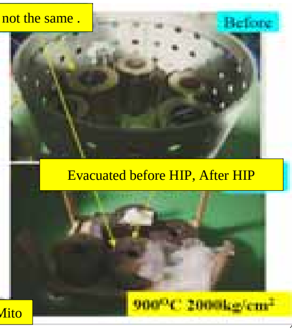
Requested values @ J at 4.2K for JPN regulation: J> 14 for σ< 450, J> 16 for 450<σ<520, J> 20 for 520<σ<660, J> 27 for 660<σ [MPa]

How to make the SUS/Nb joint: HIP (Hot Isostatic Pressing)

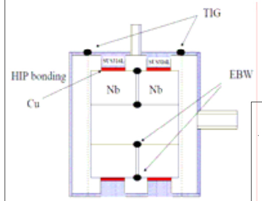




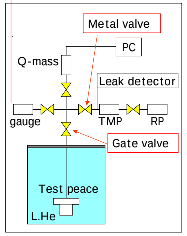




Leak Test at 2K

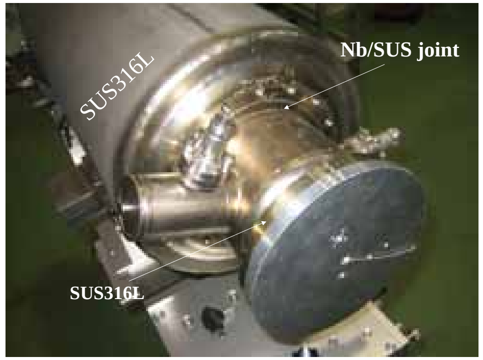


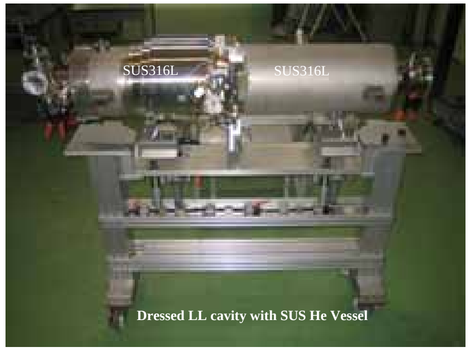
2K leak test system (Ganapati's method)



Welding on the END groups

Successfully tested the Nb/SUS Joint at STF0.5





Summary

- The Nb/SUS joint has been successfully tested at STF0.5. It is leak tight at He-II, which is a great step for the this technology.
- The material property of the Nb/SUS joint which sandwiches thin copper material could satisfy the Japanese high pressure regulation request.
- This joint technology opens to use stainless steel material for the He-vessel, which will guarantee the safety more and reduce the cavity dressing cost.