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Diffusion bonding of tungsten / EUROFER97 using vanadium interlayer

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Activity 1:	Fabrication Process Development
Task:	Development of diffusion bonded tungsten / EUROFER97 joints
WP:	WP10-MAT-WWALLOY-01-09/KIT/BS
Reporting Period:	February 2010 - June 2010
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Diffusion bonding of tungsten to EUROFER97

→ Large differences in the coefficient of thermal expansion (CTE) between tungsten and steel

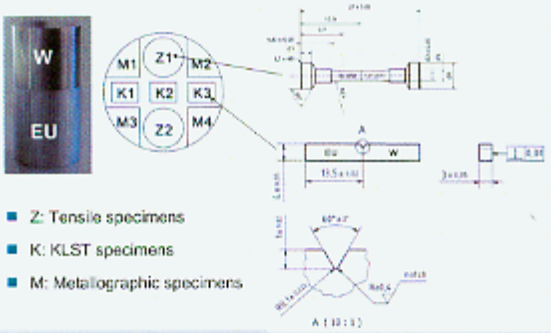
CTE of tungsten at 20 °C: 4.5 x 10^{-6} K^{-1}

CTE of steel at 20 °C: 12.0 x 10^{-6} K^{-1}

Diffusion bonding process:

- Uniaxial diffusion bonding
- Surface roughness of tungsten and EUROFER97, R_z < 1 µm
- Bonding at 1050 °C
- Bonding duration up to 9 h
- Bonding pressure is calculated using the creep parameter of EUROFER97 for a secondary creep, ε_s of about 8 %

Specimens after diffusion bonding

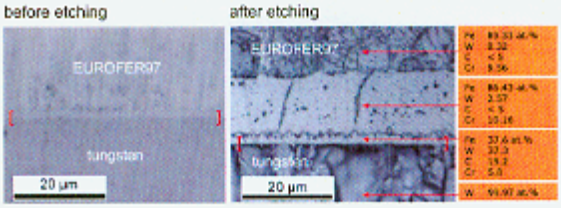


- Z: Tensile specimens
- K: KLST specimens
- M: Metallographic specimens

Microstructure at bonding seam of diffusion bonded specimen - without post bonding heat treatment

Bonding temperature at 1050 °C

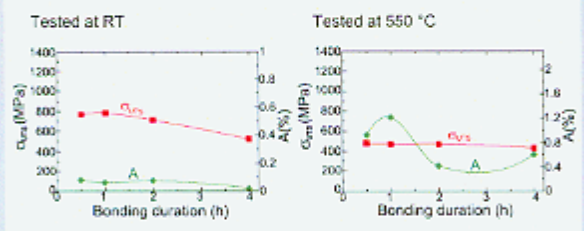
Bonding duration: 4 h



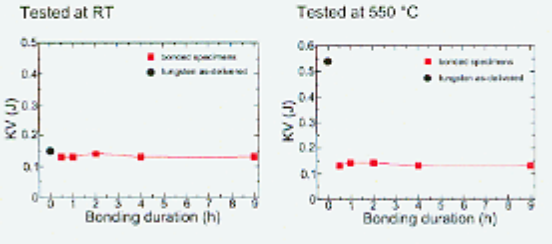
→ Sound joining

→ Intermetallic phases at the interface

Tensile tests on diffusion bonded specimens - without post bonding heat treatment



Charpy impact tests on diffusion bonded specimens - without post bonding heat treatment



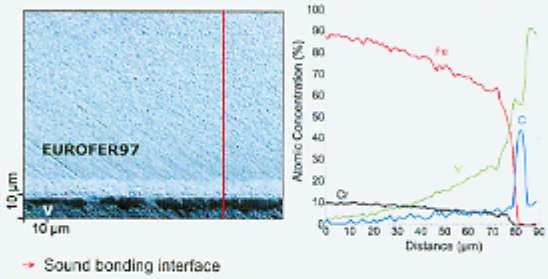
Diffusion bonding of tungsten to EUROFER97 using 1 mm thick vanadium interlayer

→ Coefficient of thermal expansion of vanadium at 20 °C: 8.5 x 10^{-6} K^{-1}

Diffusion bonding process:

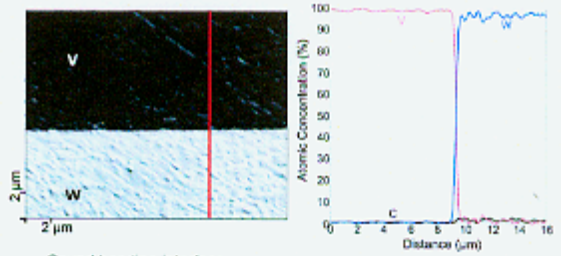
- Uniaxial diffusion bonding
- Surface roughness of vanadium plate, R_z: 711 – 1282 nm
- Bonding at 1050 °C and 1 h
- Bonding pressure of 19 MPa
  calculated using the creep parameter of EUROFER97
  for a secondary creep, ε_s of about 8 %
- Post bonding annealing at 760 °C and 90 min

Interface between EUROFER97 and vanadium interlayer



→ Sound bonding interface
→ Layers consist of intermetallic phases and vanadium carbide

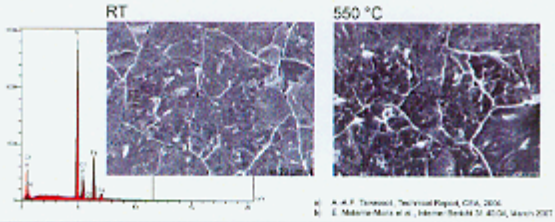
Interface between vanadium and tungsten interlayer



→ Sound bonding interface
→ No layer with intermetallic phases at the interface

Mechanical Properties and fracture surfaces

	RT			550 °C		
	joint	W	EUROFER	joint	W	EUROFER
σ_{UTS} (MPa)	207	1280	516 a)	172	430	335 a)
KV (J)	0.14	0.15	9.63 b)	0.17	0.61	



a) A. A. F. Tavassoli, Technical Report, CEA, 2004.
b) E. Materna-Morris et al., Internal Report IV 40.04, March 2007

Summary & Outlook

Performed Work (February 2010 - June 2010)

- *Diffusion bonding of W to EUROFER97 using V as interlayer at 1050 °C*
- *Investigation of the mechanical properties of the bonded specimens by tensile tests, and Charpy impact test at RT and 550 °C.*
- *Investigation of the microstructure of the bonded specimens at the bonding seam by AES*
- *Fracture analysis at the broken tensile specimens by EDX*

Work planned for the next period

- *Continuation of the diffusion bonding experiments and their characterization using V as interlayer at various bonding temperatures lower than 1050 °C*
- *Varying the bonding duration at the optimized bonding temperature.*

Work planned for WP 2011

- *Diffusion bonding of tungsten / EUROFER97 using Nb as interlayer*