METALLOTHERMIC SHS REACTIONS INVOLVING NIOBIUM OXIDE

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CHEMICAL SCHEMES OF SHS

FOR CAST ALLOY Nb-Si(Hf, Ti, Al)

Preparation of Nb:

$$3Nb_2O_5 + 10Al \rightarrow 6Nb + 5Al_2O_3, \ T_c = 2750K$$

Preparation of cast alloy:

$$Nb_2O_5/2Al/Si/4Hf/Ti/Al \rightarrow m_1Nb\text{-}Si(Hf, Ti, Al) + m_2Al_2O_3$$

EXPERIMENTAL

Reagents:

powders of Nb2O5, Cr2O3, TiO2; Al, Hf, Si

granuless $HfAl_3$: d: 0-40, 100-160, 160-300 мкм

Initial mixtures

- Nb2O5/Al/Si/Hf/Ti

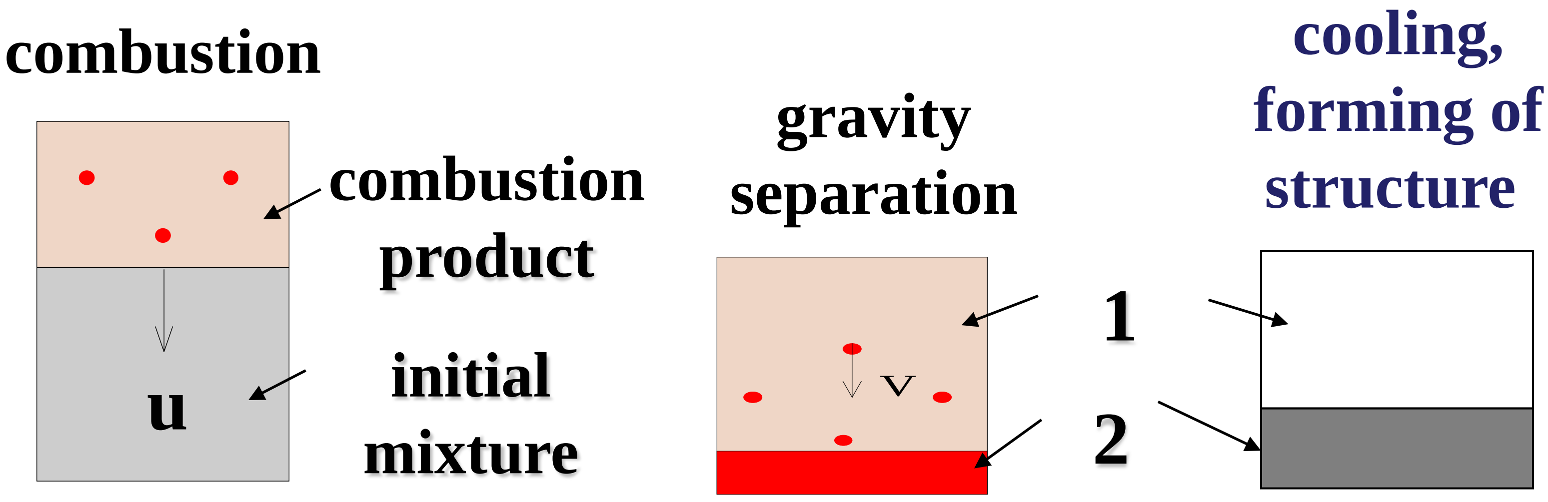
- Nb2O5/Al/Si/$HfAl_3$/Ti

CENTRIFUGAL SHS INSTALATION

Overload – 50-500 g

Mass of initial from 0,5 to 1,5 kg.

MAIN STAGES IN SHS OF Nb-Si(Hf, Ti, Al) ALLOY

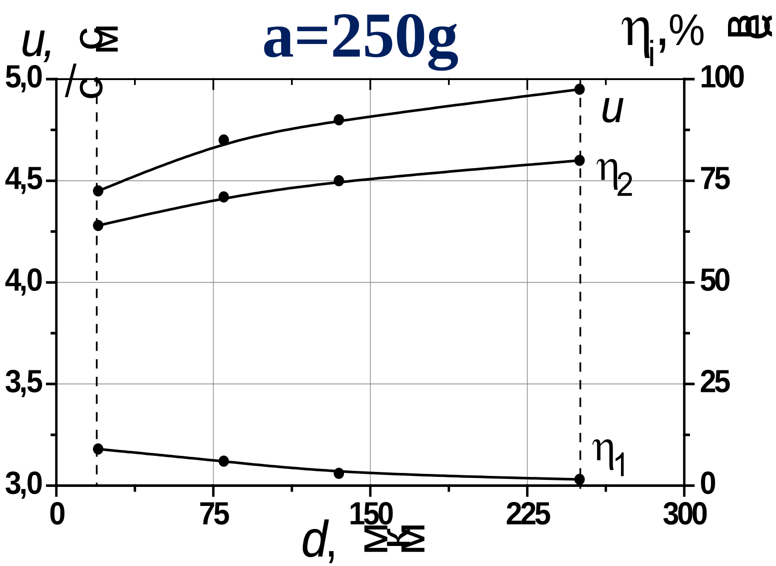


(1) –oxide phase, (2) – alloy

Characteristic times

- burning time: $t_1 = H / u$
- gravity separation time: $t_2 \sim h/v$, $v = (\rho_2 - \rho_1) d_m^2 g / 18\mu$
- cooling time: $t_3 \sim D^2 / a$

INFLUENCE OF $HFAl_3$ GRAIN SIZE ON SHS PARAMETERS



u-combustion velocitiy

η_1-fullness of mixture sputtering

η_2-completeness of output alloy in ingot

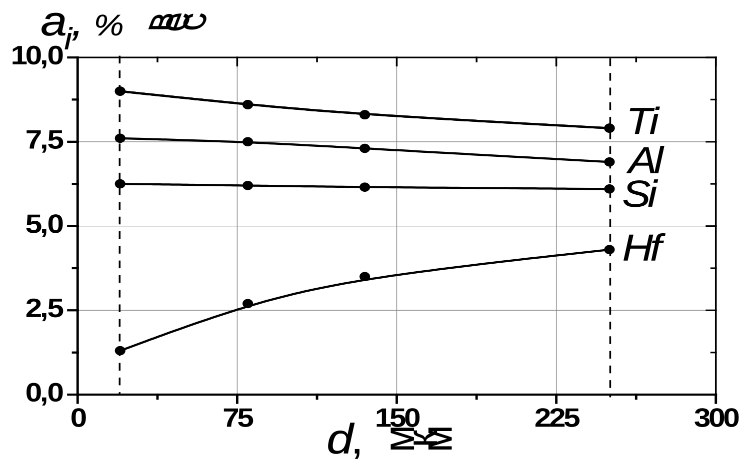
Two layered cast SHS product

Nb-Si(Hf, Ti, Al) alloy

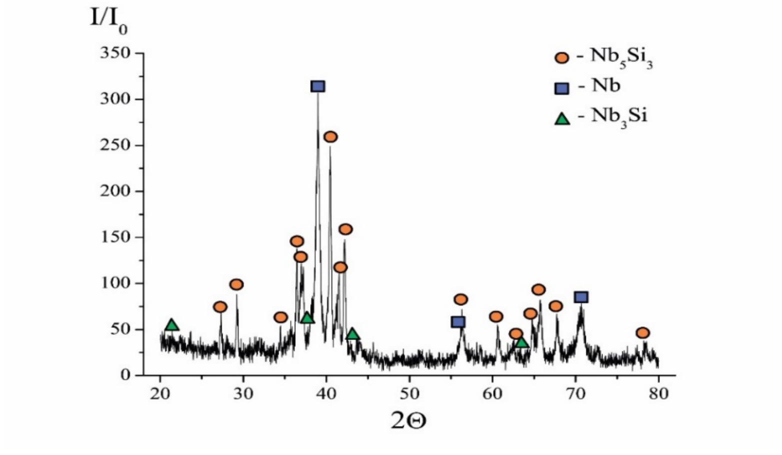
Oxide product

INFLUENCE OF $HFAl_3$ GRAIN SIZE ON CHEMICLE COMPOSITION Nb-Si(Hf, Ti, Al) ALLOY

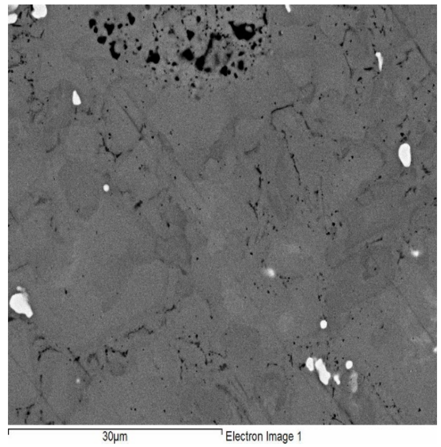
Nb = 71 - 72%, вес.



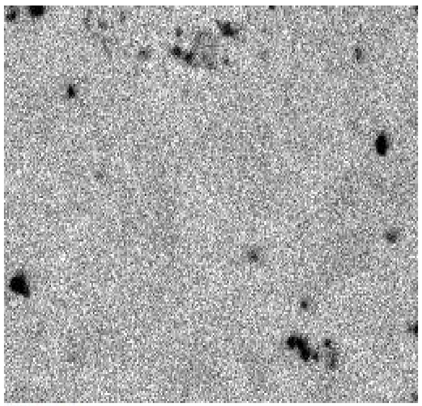
Phase composition of bottom layer of combustion product



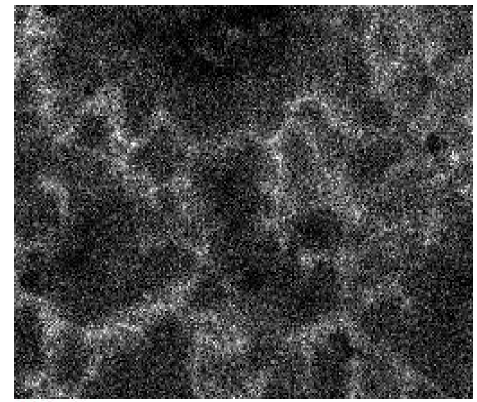
The map of elements distribution in the Nb-Si(Hf, Ti, Al) alloy



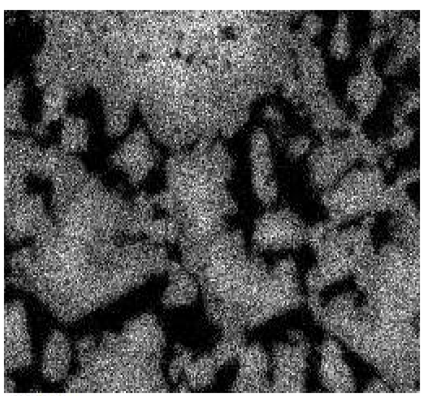
microsection



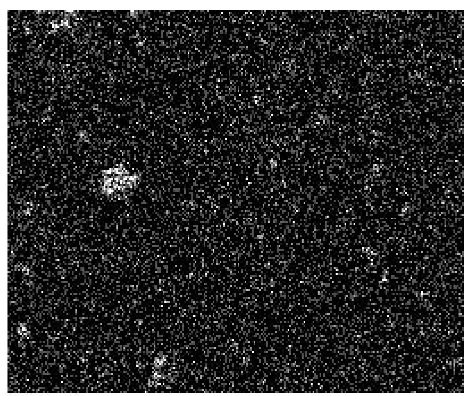
Nb La1



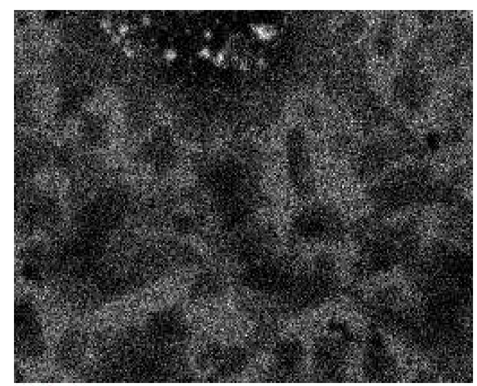
Ti Ka1



Si Ka1

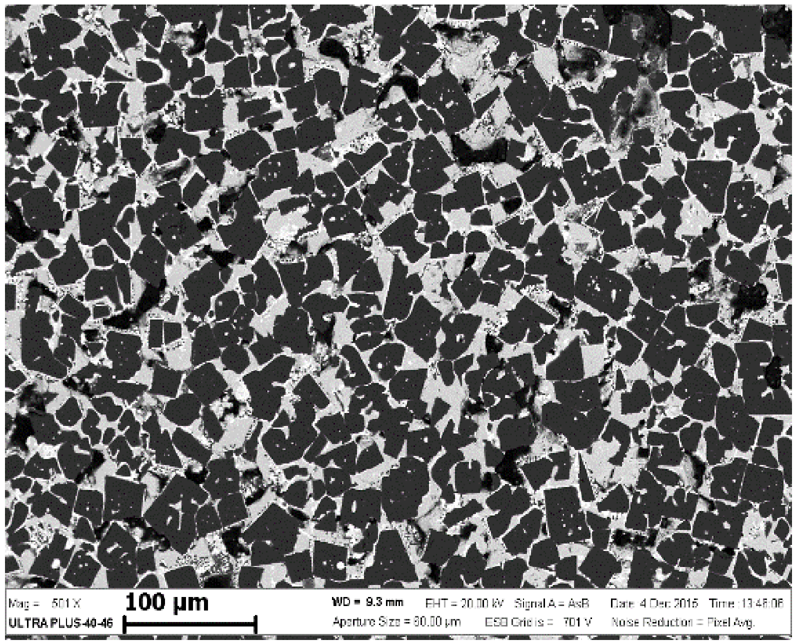


Hf La1



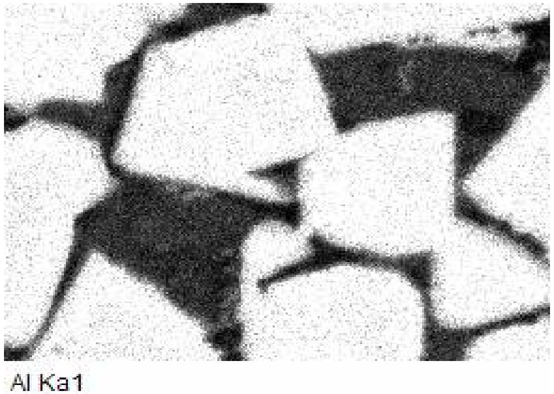
Al Ka1

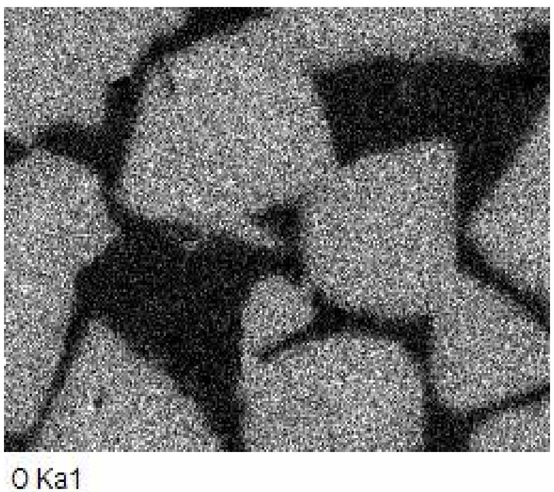
COMPOSITION AND STRUCTURE OF OXIDE COMBUSTION PRODUCT (LAYER UPPER LAYER)

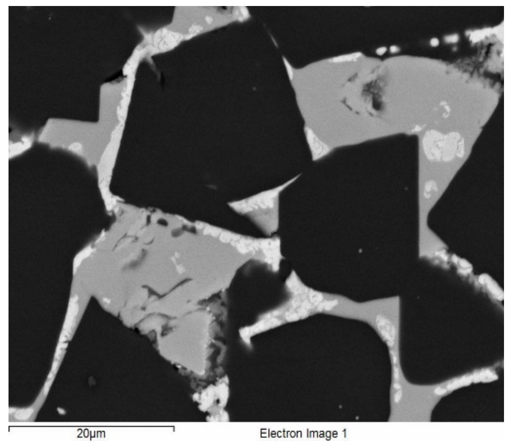


O	Al	Si	Ti	Nb	Hf
48.0	30.3	0.5	6.3	0.9	13.1

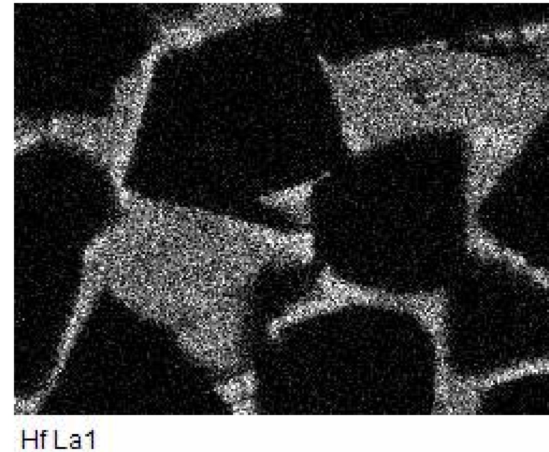
MICROSTRUCTURE AND ELEMETS DISTRIBUTION IN OXIDE LAYER

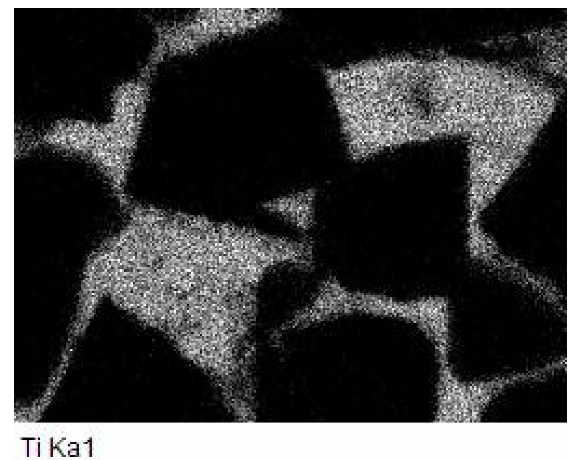




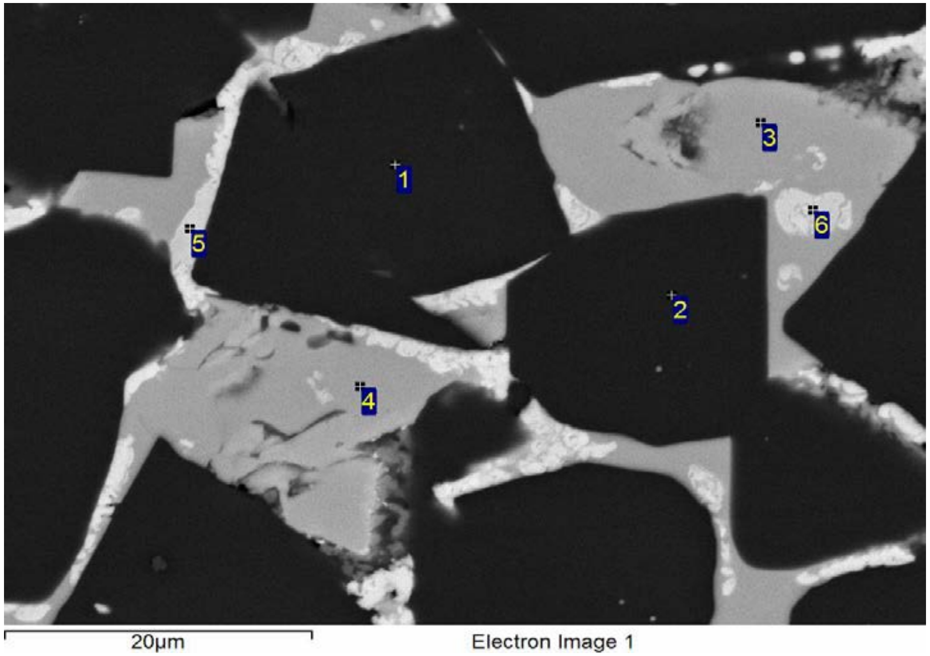


microsection





MICROSTRUCTURE AND CHEMICAL COMPOSITION OF STRUCTURAL UNITS IN OXIDE LAYER



№	O	Al	Ti	Hf
1	54.0	44.4	1.0	0.4
2	53.9	45.0	1.0	0.2
3	33.5	10.7	20.3	33.5
4	33.7	10.4	20.8	32.4
5	28.6	5.0	16.3	48.2
6	27.3	4.5	16.7	49.5

CTADYES OF CHEMICLE CONVERSION IN COMBUSTION VAWE

Nb2O5/2Al/Si/4HfAl$_3$/Ti →

1) Nb2O5 +Al/HfAl$_3$/Ti →Nb + m(Al$_2$O$_3$/HfO$_2$/TiO$_2$)

2) Nb +Ti*/Al*/Si→Nb/ Hf* /Ti*/Al*/Si

CONCLUSION

- The results demonstrate that centrifugal SHS can be used to fabricate cast niobium silicide based composite materials.
- After combustion, centrifugal forces separate a two-phase products melt on two layer; the top (slag) layer is oxides and the bottom layer is “metallic.”
- The metallic bottom layer has a composite structure, consists of the base elements (Nb, Si, Hf and Ti), and contains three phases: a Nb based phase, Nb5Si3 and Nb3Si.
- The slag layer has a two-phase structure: (1) solid solution based on Al_2O_3 and (2) solid solution based on Hf and Ti oxides.