# SHS-PRODUCED TiAl CAST ALLOYS FOR ADDITIVE MANUFACTURING TECHNOLOGIES

V.I. Yukhvid, D.E. Andreev, V N. Sanin, D.M. Ikornikov,
E.A. Levashov, Zh.A. Sentyurina, A.A. Zaitsev,
Yu.S. Pogozhev

Institute of Structural Macrokinetics and Materials Science RAS
Chernogolovka
National University of Science and Technology MISiS
Moscow

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# BASE STAGE OF STADY

**1. Synthesis of semi-product cast ingots by centrifugal SHS**

**2. Vacuum induction remelting of semi-product into massive electrodes for sputtering**

**3. Preparation of spherical granules by centrifugal sputtering**

# CHEMICAL SCHEME FOR OBTAINING TiAl ALLOY WITH Nb-Cr ALLOYING AGENTS

**$TiO_2/Nb_2O_5/Cr_2O_3/CAO_2/Al/Ca \rightarrow$ Ti-Al-Nb-Cr +$Al_2O_3$-CaO**

- base mixture: $3TiO_2 + 7Al \rightarrow 3TiAl + 2Al_2O_3$, Tc = 1500K
- alloying addtions: $Nb_2O_5/Al$, $Cr_2O_3/Al$
- energy addition : $CaO_2/Al/Ca$, $T_c$ =3 800K

## CHARACTERISTICS OF COMBUCTION PRODUCTS

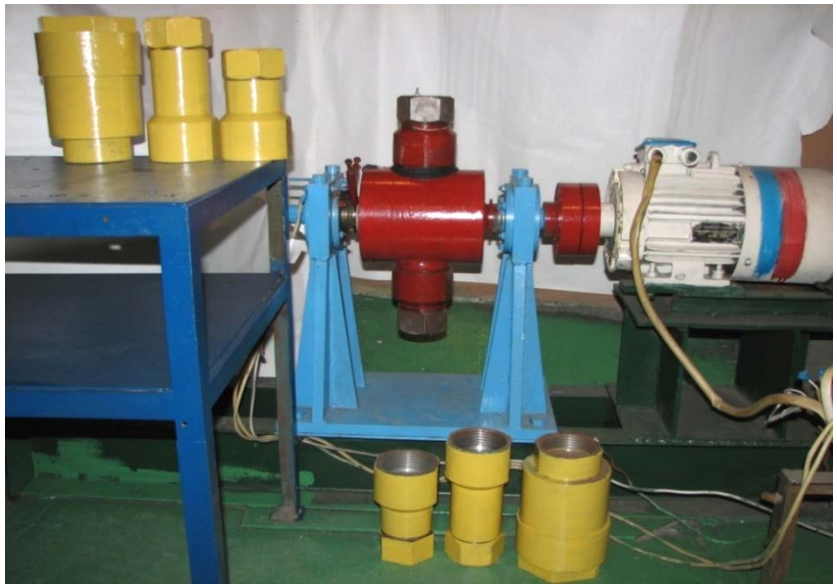
**melting point**:

- Ti-Al-Nb-Cr ~ 1800 K
- $Al_2O_3$-CaO ~ 2000 K

**specific weight**:

- Ti-Al-Nb-Cr ~ 4 г/см$^3$
- $Al_2O_3$-CaO ~ 3 г/см$^3$

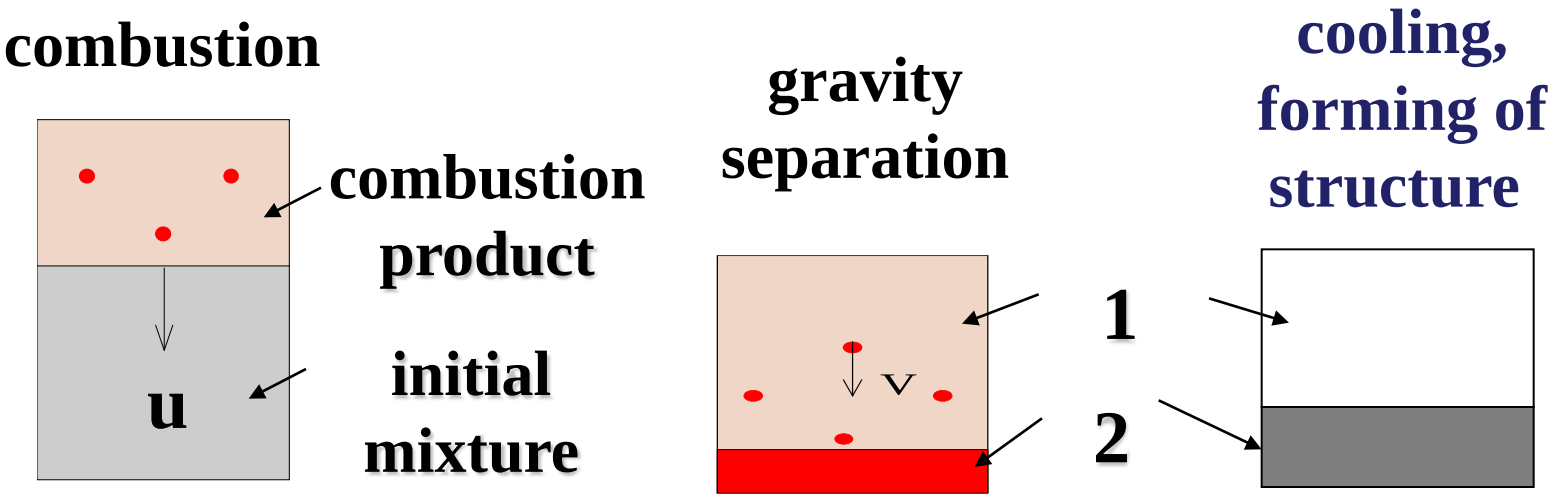
# CENTRIFUGAL SHS INSTALATION



**Overload – 50-500 g**

**Mass of  initial mixtures from 0,5 to 3,0 kg**.

# MAIN STAGES IN SHS OF TIAl-Nb-Cr ALLOY

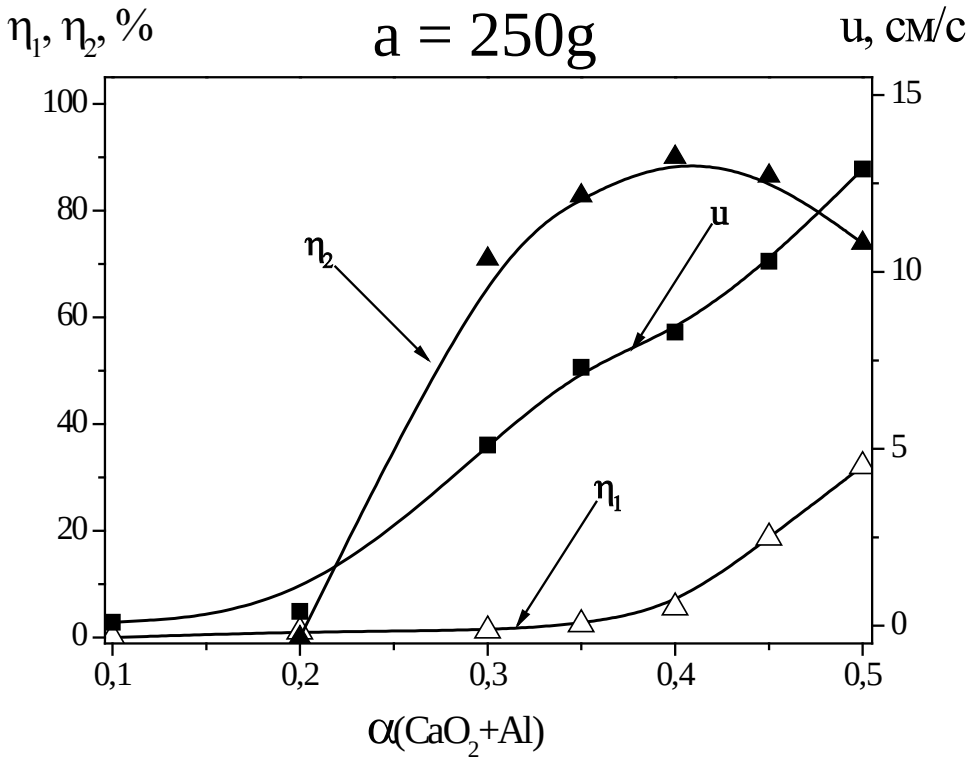



**(1) –oxide phase, (2) – alloy**

## COMBUSTION PRODUCT WITH GOOD SEPARATION

# EFFECT OF ENERGETIC ADDITIONS ON CENTRIFUGAL SHS REGULARITIES

initial mixture-TiO2/Nb2O5/Cr2O3/Al+ α (CaO2/Al/Ca)




α- part of energetic addition in the initial mixture

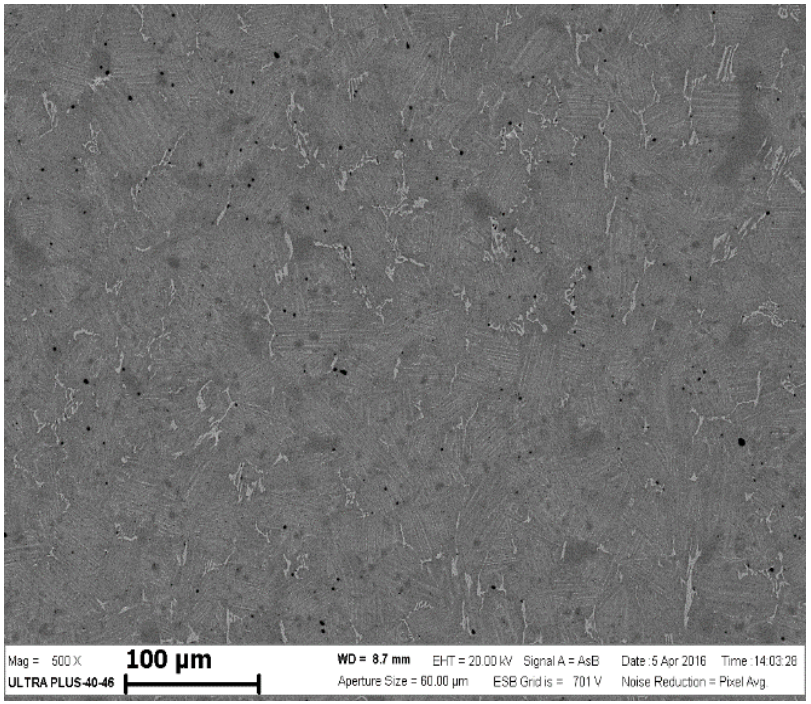
u – combustion velocity

$\eta_1$–sputtering of mixture during combustion

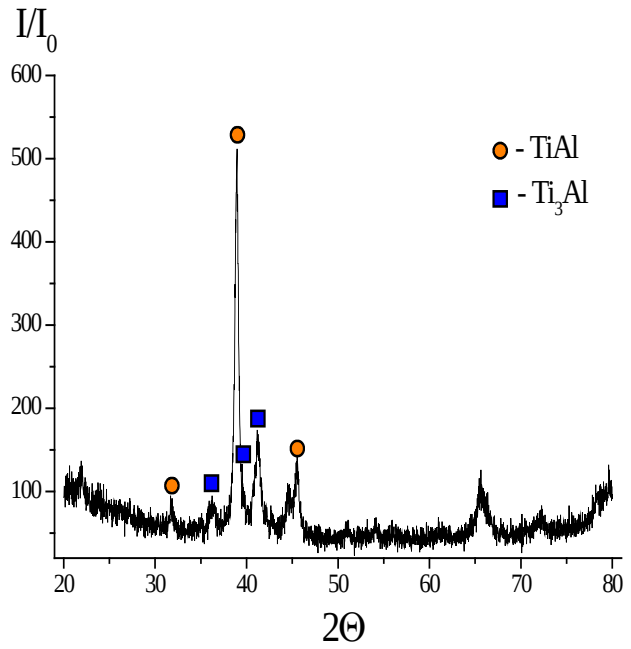
$\eta_2$ -yield of target materialin the ingot

# STRUCTURE AND COMPOSITION OF THE TiAl-Nb-Cr ALLOY

## microstructure



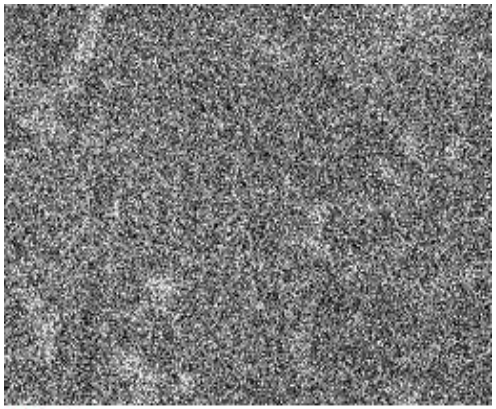

## phase composition



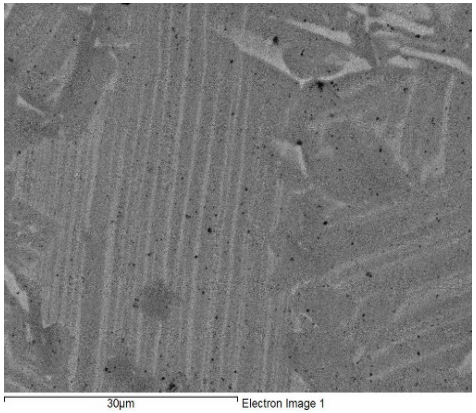

## chemical composition

| Ti | Al | Nb | Cr |
|---|---|---|---|
| 59,2 | 31,7 | 5,4 | 2,8 |

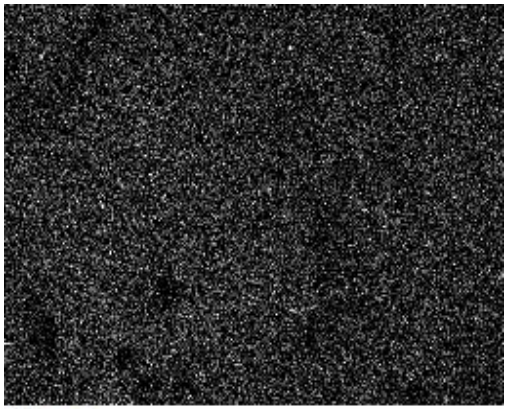
# COMPOSITION OF STRUCTURAL UNITS OF TIAl-Nb-Cr ALLOY



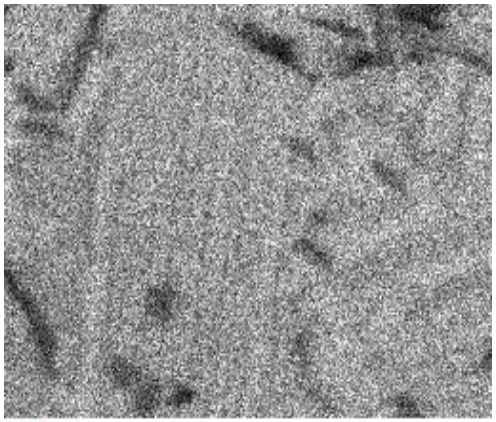
Ti Ka1




**alloy microstructure**



Nb La1



Al Ka1

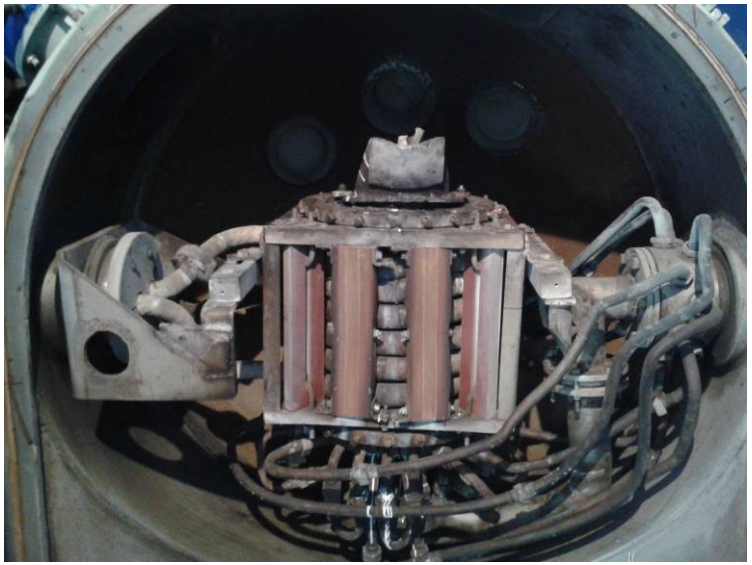
Cr Ka1

# BATCH OF TiAl ALLOY WITH Nb-Cr ALLOYING AGENTS

# Vacuum induction remelting of SHS ingots

T=1600-1650°C

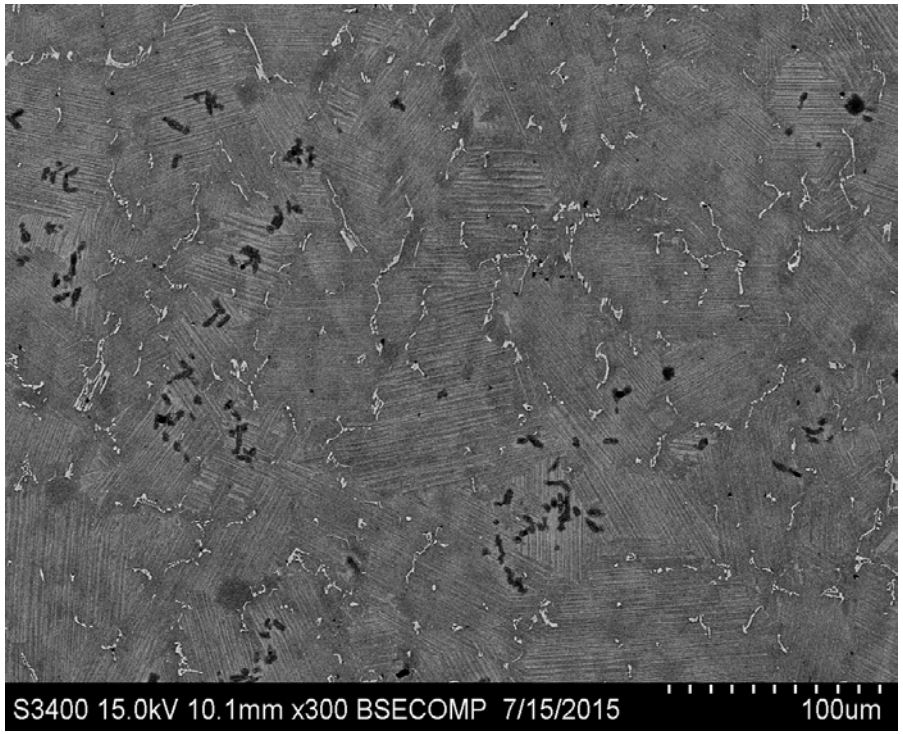
(a)



(б)

**Vacuum induction remelting furness (a) with copper mold (б)**

# COMPOSITION AND STRUCTURE OF ELECTRODES

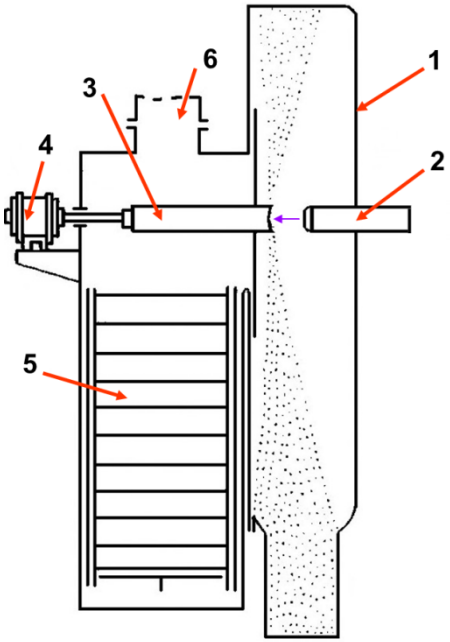



## Chemical composition

| SHS ingots | | | | Electrode | | | |
|---|---|---|---|---|---|---|---|
| Ti | Al | Nb | Cr | Ti | Al | Nb | Cr |
| 65,0 | 27,3 | 4,3 | 3,4 | 61,3 | 30,6 | 4,9 | 3,2 |

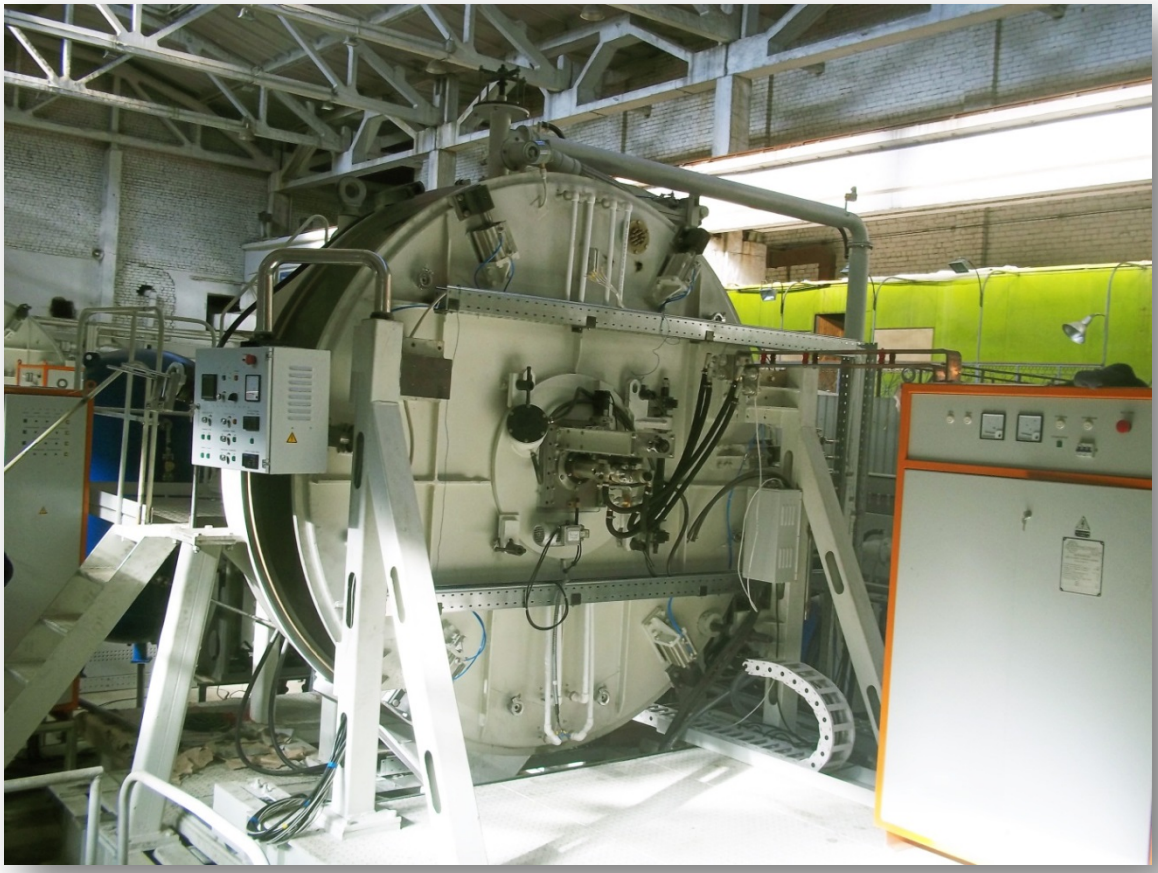
# PREPARATION OF SPHERICAL GRANULES BY CENTRIFUGAL PLASMA SPUTTERING OF ELECTRODES.

## Scheem of installation



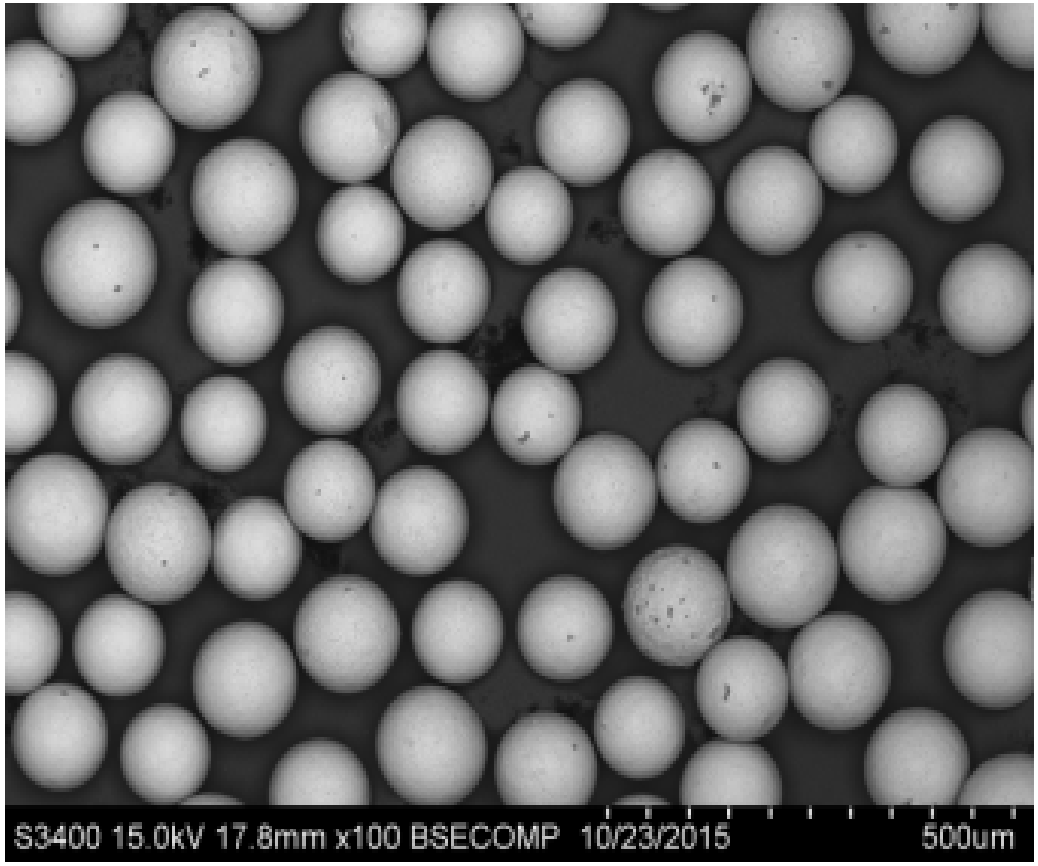

**1 – working camera**
**2 – plasmatron**
**3 – electrod**

## Installation

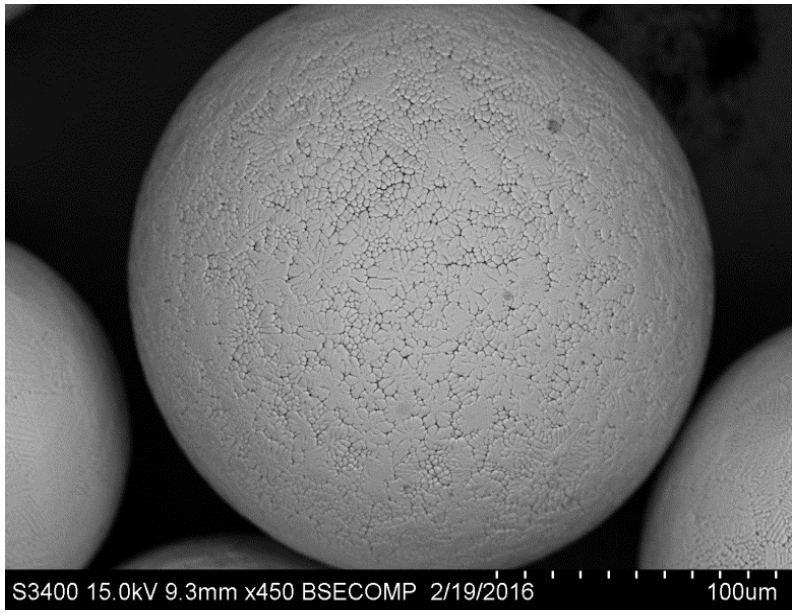


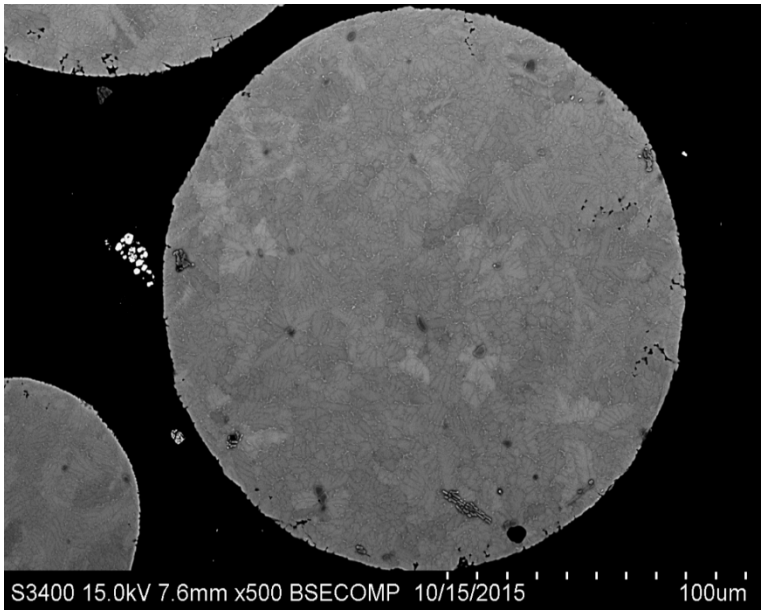
# SPHERICAL GRANULES OF TiAl-Nb-Cr

## d=100-125 мкм



# VIEW AND CHEMICAL COMPOSITION OF TiAl-Nb-Cr GRANULES




## CHEMICAL COMPOSITION

| electrode | | | | granule | | | |
|---|---|---|---|---|---|---|---|
| Ti | Al | Nb | Cr | Ti | Al | Nb | Cr |
| 61,3 | 30,6 | 4,9 | 3,2 | 61,8 | 30,1 | 4,8 | 3,3 |

# Conclusions

1. Centrifugal SHS of ingots of TiAl alloys under centrifugal forces was performed.

2. Optimization of vacuum induction remelting of TiAl- based SHS alloys and crystallization conditions were carried out.

3.Method of spherical granules preparation of TiAl based alloys by centrifugal plasma sputtering was created. .