TiC nanopowder plasma-chemical synthesis with titanium tetrachloride raw material in the DC plasma-arc reactor

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The possibility of TiC nanopowder plasma-chemical synthesis in the DC plasma-arc reactor is shown. The dependence of the molar ratio C/Ti in the raw material in the range 0.7 – 2.1 and carbon concentration in the TiC product is investigated. Carbon concentration in the TiC nanopowder grows with increase of molar ratio C/Ti in the raw materials. TiC nanopowder with stoichiometric composition was produced at molar ratio C/Ti = 1.4. It was determined that molar ratio C/Ti in raw material more over 1.5 leads to free carbon formation in the TiC nanopowder product. Chlorine concentration decrease in the TiC nanopowder product with molar ratio C/Ti increase in the raw materials is shown.

1. Introduction

Powder materials are claimed of many industry areas. Productions of wear- and corrosion-resistant hard alloys, deposition of coatings are some of them. Nanosized powders allow improve final product properties. Plasma chemical DC-arc processes are allocated with high efficiency; these processes have potential to regulate produced powders characteristics in the wide range. The TiC nanopowder synthesis in the DC plasma-arc reactor is presented.

2. Experimental setup

DC plasma-arc reactor is experimental setup on the base of DC electro-arc thermal plasma generator with power rating 25 kW. The hydrocarbon and chloride mixture are feeded with piston dispenser to vaporizer. Resulting vapour is feeded with transport gas to plasma jet through mixing chamber. Condensed reaction product deposited on the reactor water cooled walls and filter. Contained in exhaust gas chlorine was trapped with alkaline solution scrubber. Experiment parameters of TiC nanopowder production in thermal plasma flow are presented in the table 1.

Table 2. Plasma process parameters ranges

№	Parameter	Range
1	Plasmatron useful power	4.8 – 9.3 kW
2	Plasma forming gas	H_2 + Ar
3	Total plasma forming gases consumption	1.4 – 2.5 n.m^3/h
4	Plasma jet useful enthalpy	1. 6 – 5.9 kWh/n.m^3
5	$TiCl_4$ consumption	0.2 kg/h
6	CH_4 consumption	0.02 – 0.2 n.m^3/h
7	Molar ratio C/Ti	0.7 – 2.2

3. Results and discussion

It is experimentally established that TiC nanopowders are formed at interaction of $TiCl_4$ + CH_4 vapor mixture with hydrogen-argon plasma jet. Produced TiC nanopowder have a single phase and cubic NaCl type crystal latice. It consists of nanosized cubic shape particles with 10-80 nm size and aggregates on its base (fig.1).

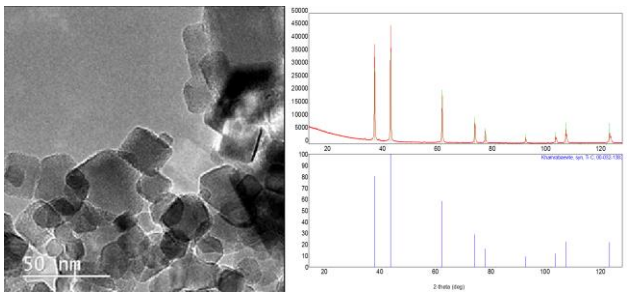

Figure 1. X-ray and SEM results for TiC nanopowders

Output of TiC depended on molar ratio C/Ti. Increase of molar ratio C/Ti from 0.7 to 2.1 leads to increase of TiC output from 60% to 90%. Carbon concentration in the TiC nanopowder increases with molar ratio C/Ti increase. Stoichiometric carbon concentration in the product is reached when C/Ti=1.4. Significant quantity of carbon in the process is in the gaseous phase as a part of methane and its pyrolysis products. Molar ratio C/Ti strong influences on chlorine concentration in the product. Inrease of C/Ti from 0.7 to 0.9 leads to decrease chlorine concentration from 1.6 to 0.4.

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