Abstract

THE EFFECTS OF MWCNTs ON IRON–COPPER NANOCOMPOSITES THERMAL-STRUCTURAL PROPERTIES

Humans are by nature greedy, expansionist and competitive, such qualities are essentialingredient for both building advanced civilization and heated conflicts alike, which pushes the wheel of innovations and research even further to obtain advantageous and enhanced lightweight high strength materials to fulfil the ever-increasingdemand for materials.

The urge for such advanced materials leads to the development of new technologies that dealt with miniaturizing materials toward atomic-scale which gives a rise to a new branch of technologies and science alike, hence the name, nanotechnologies.

Nanocomposites provestheir reliability and effectiveness of use under stress and load, also under the harsh condition of heat and pressure in a vast range of fields and applications from the aerial and aerospace industry

The discovery of multiwalled carbon nanotubes, which possess a broad range of uniquephysical, mechanical, and electronic properties, such properties have created an enormous amount of excitement in research laboratories across the world.Carbon nanotubes has brought a promising future into thedevelopment of metal matrix nanocompositesmaterials which is of great importance in present-day materials technology. The inclusion of carbon nanotubes into metal matrix nanocomposites systems like Al, Ni, Co and Fe, has been the focus of many researches aiming to produce CNT-reinforced metal matrix nanocomposites with enhancedphysicomechanical features for a broad range of functional and structural applications

The subject aimed at in the presented thesis is the effect of incorporating different concentrations of multiwall carbon nanotubes into iron-copper — Fe–Cu with a ratio of 4:1; MWCNTs of 0.5, 1.0 and 2.0 vol.%—nanocomposites—made via mechanical milling of different times of 20, 60 and 120 minutes— on the thermal and structural properties.

For the evaluation and characterisations, multiple instruments were used such as the Jupiter STA 449 F3NETZSCH for measuring heat flow and weight change (thermogravimetric), as for the relative linear expansion ($\Delta L/L_0$)andcoefficient of linear thermal expansion (CTE)the NETZSCH 402C dilatometer were used, all temperature dependences measurements were conducted from ambient temperature up to 800 °C with a heating rate of 10 °C/min. On the other hand, the structural changes evaluation carried out using the automated Philips X Pert Pro diffractometer in the monitoring range of [20–80°] with step scan of 0.026°. Raman spectroscopy carried out using a Raman Bruker Senterra spectrometer instrument, with a green laser (wavelength λ= 532 nm) from an argon ion.The infrared absorption was done using the Jasco FT/IR-6300 spectrometer.

Several temperature ranges were distinguished for the Fe–Cu–X%MWCNTs nanocomposite by the $\Delta L/L_0$ (T) and CTE temperature dependences. Effect of CNTs on the $\Delta L/L_0$ and CTE temperature dependences are different for different temperature ranges, and the magnitude of the effect depends on the CNTs content.

The heat flow and thermogravimetry show thermal stability and higher calorific capacity for the samples with longer milling time and containing a higher concentration of CNTs.

As for the coefficient of thermal expansion, improved CTE of the Fe–Cu-1% MWCNs milled for 120 minutes.

The provided x-ray diffraction patterns show a grain refinement for the 120 minutes milling time, also a homogenous distribution of CNTs (the absence of CNTs clusters appearing as carbon graphite)

Raman spectroscopy, on the other hand, assessed the CNTs morphology integrity and damage state due to the milling time, it reveals a higher defect density with longer milling time, with an exception for the 60 minutes it shows a lower defect density which indicates the healing and the recovery of CNTs.

Infrared spectroscopy aid at showing the presence of functional groups in the samples and the establishment of multiple bonding types.

Keywords: Iron, Copper, Nanotubes, Carbon, Thermodynamic, ball milling.