Electrical resistivity of $Sn_{95.5}Ag_{3.8}Cu_{0.7}$ alloys, modified by nickel admixtures

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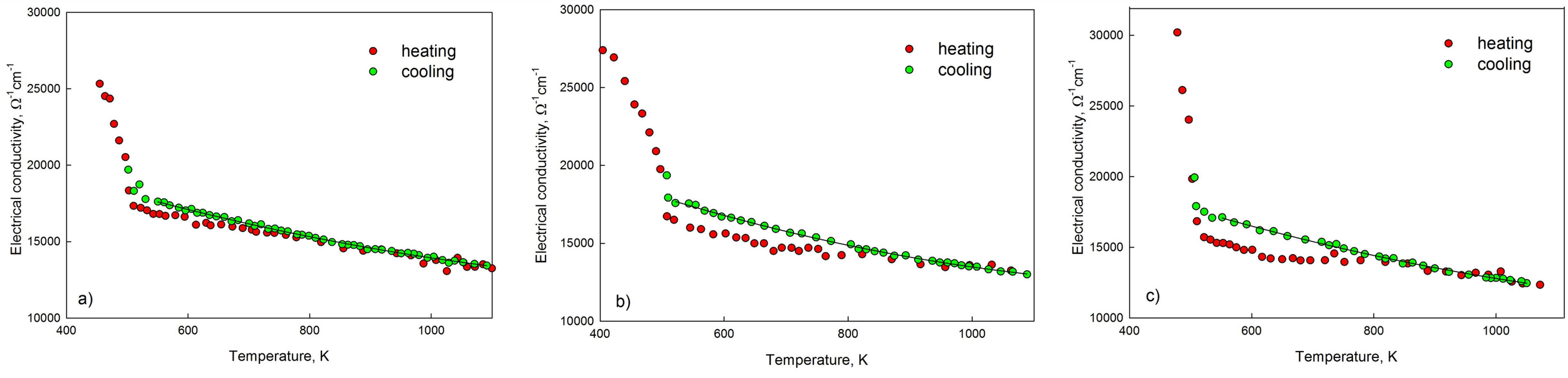
Introduction

Improved mechanical properties and a reinforced microstructure of solder joints using nanocomposite Sn-Ag-Cu (SAC) alloys compared to those without nanoinclusions, revealed new possibilities for the development of currently used commercial lead-free solders. The main profit of the nanosized additions is related to a suppression of the extensive growth of the Cu_6Sn_5 intermetallic compound at the solder/Cu interface towards the solder side. This is achieved due to the spreading of nanoparticles over the IMC's surface, thereby suppressing the growth of Cu_6Sn_5 at the interface as well as in the bulk solder.

Experimental Details

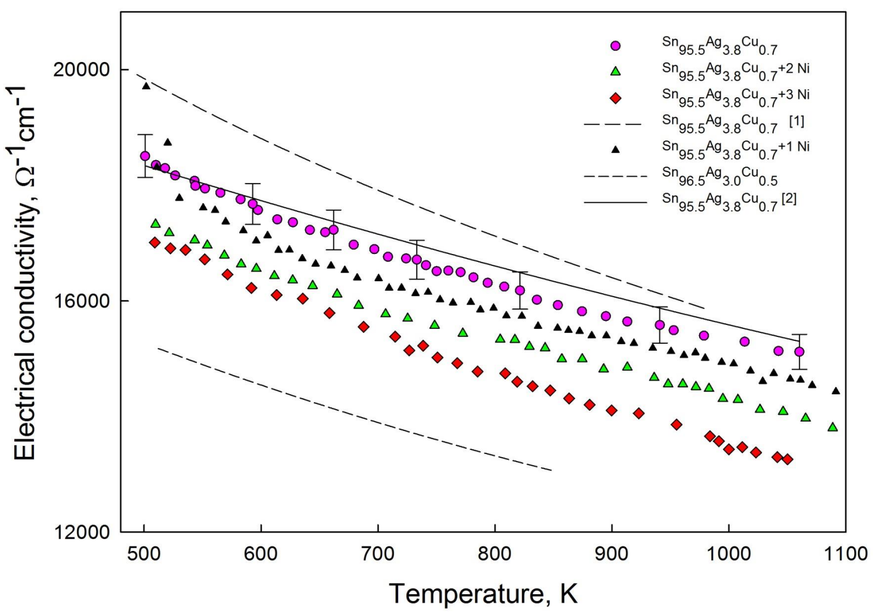
XRD studies were carried out by means of DRON-3 diffractometer (Co-K_α –radiation, graphite monochromator, installed in diffracted beam).
The electrical conductivity measurements were carried out by the 4-point method in an argon atmosphere [1].
Morphology of the samples was examined using REMMA-102-02 Scanning Electron Microscope-Analyzer (JCS SELMI, Sumy, Ukraine)

Results

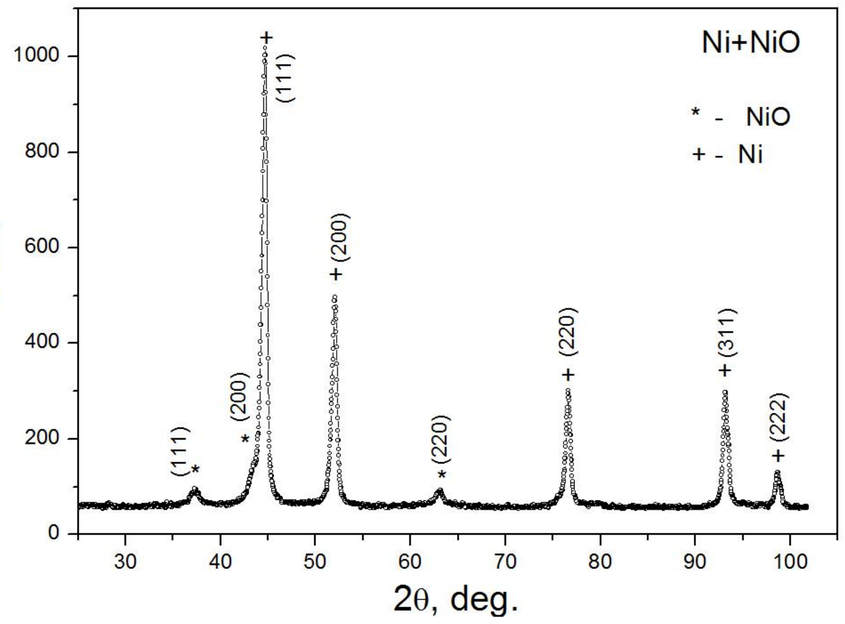


Electrical conductivity vs. temperature for $Sn_{95.5}Ag_{3.8}Cu_{0.7}$ liquid alloys with nanosized admixtures of 1 wt.% Ni (a), 2 wt.% Ni (b), 3 wt.% Ni (c)

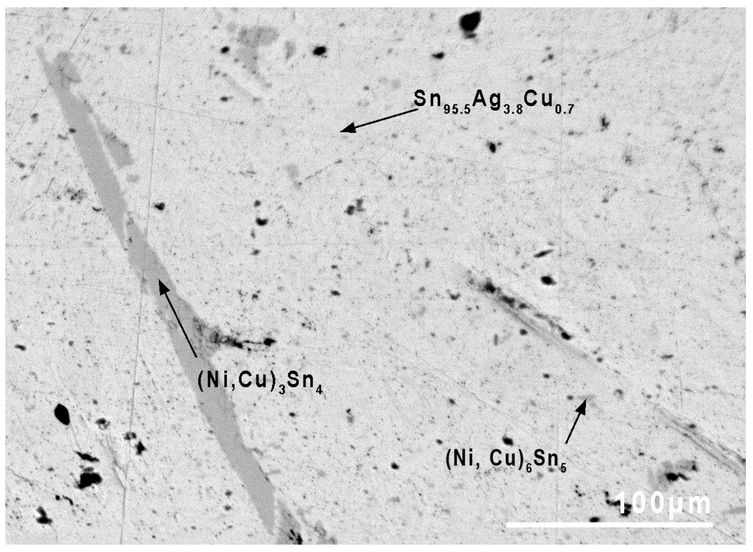
XRD and Microstructural analysis



Electrical conductivity vs. temperature for $Sn_{95.5}Ag_{3.8}Cu_{0.7}$ liquid alloys with nanosized Ni admixtures compared to literature data



X-ray diffraction patterns of Ni nanoparticles



SEM micrographs of $Sn_{95.5}Ag_{3.8}Cu_{0.7}$ + nanoNi

Conclusions

- **The electrical conductivity of nanocomposite $Sn_{95.5}Ag_{3.8}Cu_{0.7}$ (SAC387) alloys without and with different weight percentages of Ni nanoparticles (up to 3 wt.%) was determined. A hysteresis between the heating and cooling curves of the electrical conductivity over a wide temperature range above the melting point is explained by dissolution of Ni nanoparticles in the SAC387 matrix during heating.**

- **Cooling of the homogeneous melts from 1100 K is accompanied by a smooth increase of the electrical conductivity. Higher absolute electrical conductivity values of liquid SAC387 + 1 wt.% Ni as compared to the conductivity of liquid SAC305 + 2 and 3 wt.% Ni is due to the fact that the Ni atoms form additional centers of electron scattering, and an increase of the Ni content leads to a decrease of the electrical conductivity.**

- **The microstructure analysis of the samples in the solid state show a fine distribution of intermetallic compounds in the Sn-based matrix. The Ni atoms substitute the Cu atoms in the Cu_6Sn_5 compound forming $(Cu,Ni)_6Sn_5$ crystals.**

1. S. Mhiaoui. Ph. D. Thesis. Department of Physics. TU Chemnitz, Chemnitz. – 2007. – 165 p. https://katalog.bibliothek.tu-chemnitz.de/Record/0-1353806235.
2. Yu. Plevachuk, V. Sklyarchuk, A. Yakymovych, O. Tkach. Visnyk of the Lviv University. Series Physics. 53, 64 (2017); https://physics.lnu.edu.ua/research/ourpublisher.

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