Sixth Asian School-Conference on Physics and Technology of Nanostructured Materials
Vladivostok, Russia, 25 – 29 April, 2022

Laboratory of MAX Magnetic Materials

ELECTRON SPECTROSCOPY FOR IN-SITU ANALYSIS OF MAX-PHASES

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Electron spectroscopy methods allow performing in-situ analysis of the elemental composition of MAX-phase thin films. Auger electron spectroscopy makes it possible to determine the chemical bonds formed during the synthesis. This work describes the results of using Auger electron spectroscopy for in-situ analysis of Mn_2GeC and Cr_2GeC.

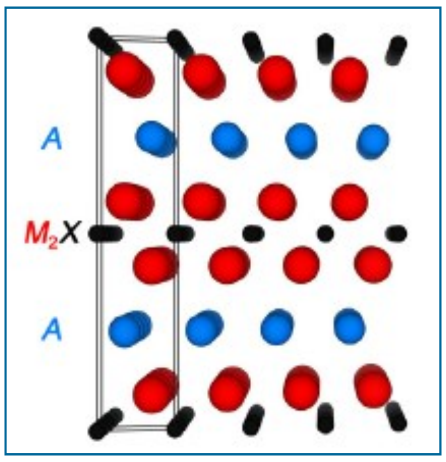

Fig. 1. A schematic illustrating the general crystal structure of the M_2AX phase [2]

Introduction

MAX-phases ($M_{n+1}AX_n$, where n = 1, 2, 3) are nanolayered, hexagonal transition metal carbides and nitrides. M is a transition metal, A is an element of the main subgroup of the periodic system, X is carbon or nitrogen [1].

MAX materials exhibit many useful properties such as high strength, high thermal and electrical conductivity, corrosion resistance and high temperature stability. These valuable properties of MAX-phases make them promising materials for creating details that can be used in extreme conditions. For example, it can be applied to the manufacture of electrical contacts, heating elements, protective coatings.

The Auger electron spectroscopy method makes it possible to perform in-situ elemental analysis of MAX-phases thin films to determine the formed chemical bonds. This paper describes the application of Auger electron spectroscopy in the synthesis of MAX-phases based on chromium (Cr), manganese (Mn), germanium (Ge) and carbon (C), which are widespread at the present time [1–3].

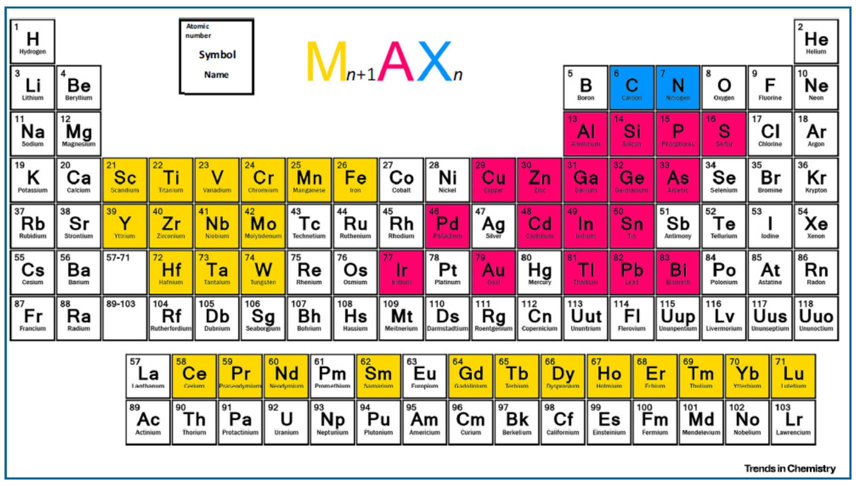

Fig. 2. Periodic table with all elements incorporated in various MAX-phases [1]

Fig. 3. Experimental vacuum system for the MAX-materials synthesis

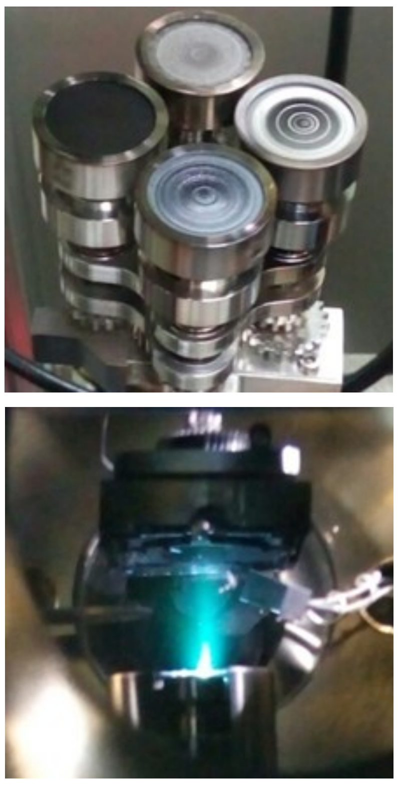

Fig. 4. Images of targets for PLD and a plume ejected from a target during pulsed laser deposition

Experiment

The Mn_2GeC and Cr_2GeC structures were synthesized by pulsed laser deposition (PLD) technology at high-vacuum chamber pressure $P \leq 2.8 \cdot 10^{-8}$ Torr. The Auger electron spectra were measured using a low energy diffraction and Auger electron analysis system (SPECS) with a retarding field energy analyzer. The primary electron energy was 3000 eV.

Results and discussions

The Auger spectra of the Mn_2GeC structure contains peaks which positions correspond to the energy of Auger transitions in germanium, carbon and manganese atoms [4]. Figure 5 shows Auger electron spectra after deposition of the Mn_2GeC structure on Al_2O_3 substrate.

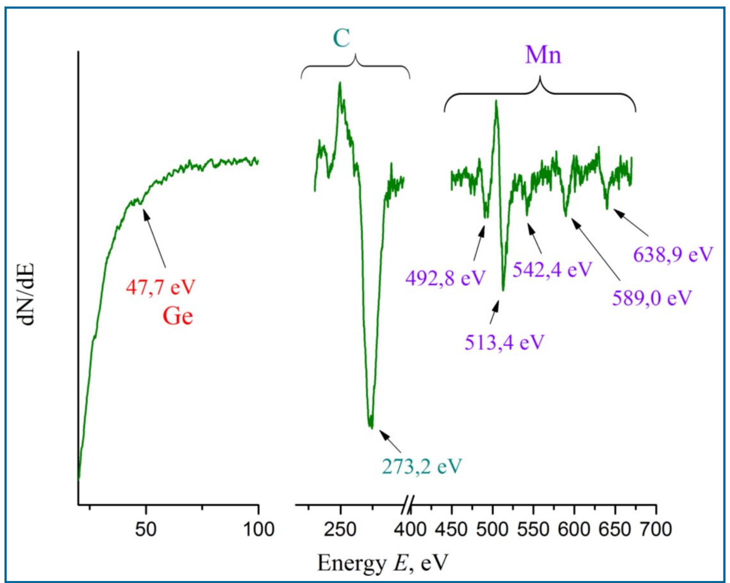

Fig. 5. Auger electron spectra after deposition of the Mn_2GeC structure on Al_2O_3 substrate (after smoothing)

The shape of the carbon Auger peak is typical to graphite rather than manganese carbide. The intensity of the manganese Auger peaks is specific to the peaks in the composition of the Mn_5Ge_3 spectra, which is described in [5]. These results showed the existence of different from Mn_2GeC phase in the composition of the synthesized thin film.

In the Auger spectra of Cr_2GeC structure we identified peaks that are characteristic to chromium, germanium and carbon atoms.

The carbon peaks have a shape that is specific to carbide, which may indicate the presence of chromium carbide Cr_2C. Figure 6 shows Auger electron spectra after deposition of the Cr_2GeC structure on Al_2O_3 substrate.

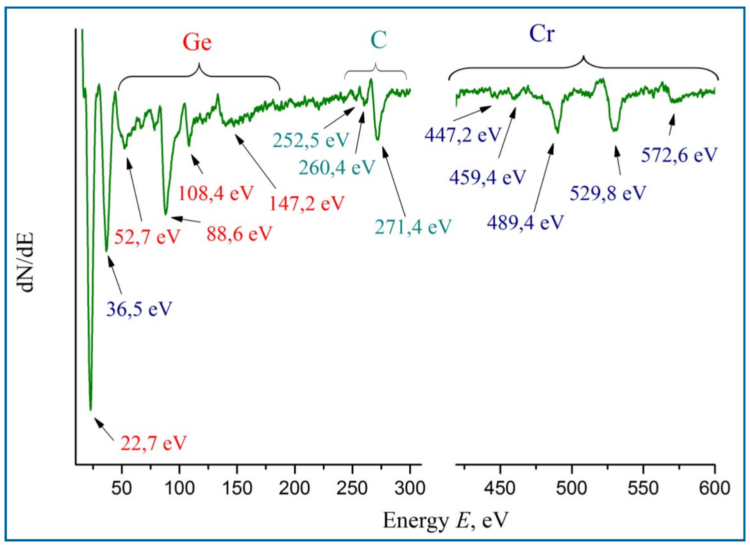

Fig. 6. Auger electron spectra after deposition of the Cr_2GeC structure on Al_2O_3 substrate (after smoothing)

Conclusions

It was found that the application of Auger electron spectroscopy makes it possible to determine the elemental composition of thin films and the presence of transition metal carbides in thin polycrystalline or epitaxial films. Auger electron spectroscopy is an additional highly sensitive in-situ method for the identification of MAX-phases in the study of the initial processes of their formation.

Acknowledgements

The research was supported by the government of the Russian Federation (agreement No. 075-15-2019-1886) and the Russian Science Foundation (grant #21-12-00226, http://rscf.ru/project/21-12-00226/).

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