Exploring the equilibrium phase relations in the U-Au-Te ternary system

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Introduction

The study of phase diagrams is a vital source of information for the identification, understanding and the establishment of strategies for the preparation and single crystal growth of solid compounds. Binary systems are mainly explored, but a great number of ternary ones is still not studied. In this work, we present very preliminary studies on the phase relations in the U-Au-Te ternary system.

Experimental

Samples were usually prepared by reacting the elements under vacuum inside sealed quartz ampoules. In some cases, binary compounds were first made by arc melting and used on the samples preparation. The materials were characterized by powder X-ray diffraction and scanning electron microscopy, complemented by energy-dispersive X-ray spectroscopy.

Results and Discussion

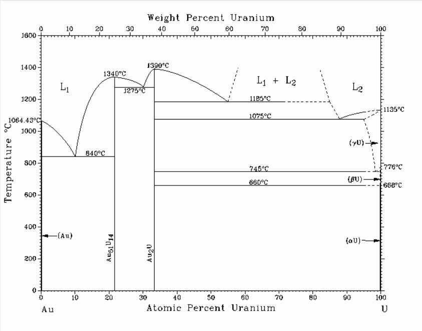

Fig. 1. Au-U binary phase diagram [1].

The U-Au system has two binary phases, UAu_2 and $U_{14}Au_{51}$, that are stable from room temperature up to congruent melting at 1340ºC and 1390ºC, respectively.

In the Au-Te system only a binary phase exists, $AuTe_2$, which melts congruently at 464ºC.

Fig. 2. Arc-melting of U_xAu_z samples.

U-Te has nine binary phases, UTe, U_3Te_4, U_2Te_3, U_3Te_5, U_7Te_{12}, UTe_2, U_2Te_5, UTe_3 and UTe_5. The first one melts congruently at 1740ºC, with 7 others being described as formed peritectically, and U_7Te_{12} by chemical vapor transport reactions.

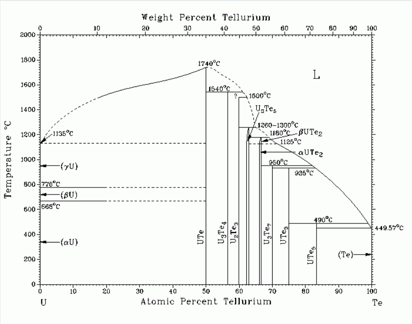

Fig. 3. U-Te binary phase diagram [1].

The high vapor pressure of Te, together with the great stability of many UTe_x compounds, put some challenges on the ternary preparation of ternary samples in equilibrium. However, the use of closed systems and of binary compounds as starting materials can surpass these problems.

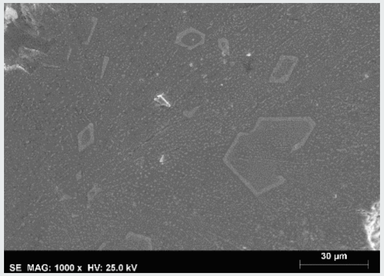

Fig. 4. SE image showing the microstructure observed in the 20Au:60Te:20U material, where Au crystal can be seen.

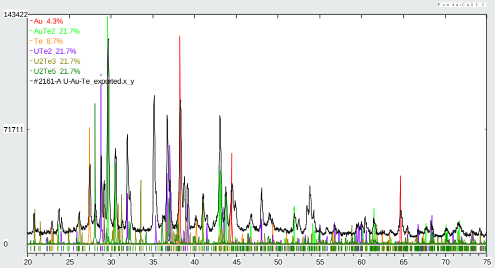

Fig. 5. Powder XRD of the 20Au:60Te:20U material showing a large number of phases, pointing to a far from equilibrium sample.

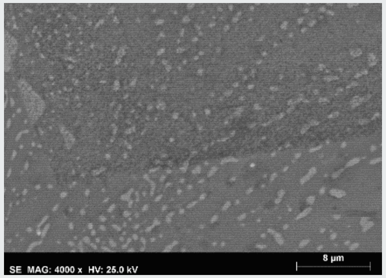

Fig. 6. SE image showing the microstructure observed in the 20Au:60Te:20U material, with binary and ternary eutectics.

Up to now, no ternary compounds were identified, but a solubility range seems to exist in $AuTe_2$. Well shaped Au crystals are seen in the microstructures. Au is at equilibrium with $AuTe_2$, which is also in equilibrium with Te and UTe_3. Several binary and ternary eutectics can be found in this system.

Conclusions

Previously established binary phase relations were confirmed, new phase relations were identified and, albeit the large number of binary compounds, no stable ternary phases were discovered at 700ºC. However, further studies are still needed to discard the possibility of ternary compounds existence.

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References: [1] T.B. Massalski et al., Binary Alloy Phase Diagrams, 2nd Edition, ASM International (1990), ISBN: 978-0-87170-403-0.