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CRYSTALLIZATION OF AMORPHOUS Ni-Zr

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ABSTRACT
Ni-Zr amorphous alloys (metallic glasses) in the form of ribbon can be prepared in a wide range of concentration which strongly influences their physical properties. Many properties of the metallic glasses differ considerably from those of their crystalline counterparts. In contrast to their crystalline counterparts the resistivities of amorphous alloys are very high. Such high resistivities can be explained by the extra scattering on the random atomic arrangement. Crystallization is the final stage on annealing of metallic glasses. This process is irreversible and is accompanied by abrupt change in electrical resistivity. We have investigated temperature dependance of electrical resistance for different concentrations and for different heating rates.By measuring the electrical resistance the various stages of the crystallization process can be identified .
Keywords: metallic glasses, electrical resistance, phase transition, crystallization

1. INTRODUCTION
The formation of metallic glasses requires quenching rates up to 10^6Ks^{-1}. The as-quenched structures are highly disordered and metastable with respect to the equilibrium crystalline phases. Moreover, the as-quenched structures are also metastable with respect to the lower energy, more dense glass that would result hipothetically on slower cooling [1]. When metallic glasses are annealed two types of structural rearrangement can occur. At low temperatures, there are changes in local order yet the materials still remain glassy. At higher temperatures and longer times crystallization occurs. Crystallization process can be investigated thermally (i.e.differential scanning calorimetry) and by monitoring the change in other physical properties such as electrical resistivity, saturation of magnetization, etc. [2].

2. EXPERIMENTAL RESULTS
Master alloy were prepared in argon arc furnace. Amorphous ribbons of Ni_xZr_{1-x} were formed by quenching a melt on a rapidly rotating cooper drum (melt-spinning method). We investigated the process of crystallization by monitoring the changes in electrical resistance and the reported results are for x=28 and x=38.
The electrical resistance was measured under dc conditions and the experimental setup is shown and described in Fig.1.The experimental data were recorded by use of TEST POINT software. Heating rates were controlled by Process controller ESM-4450. The obtained amorphous ribbons were about 35µm thick.The ribbons of 1x20mm were heated with four wire pressure contacts in vacuum from 300K to 700K.

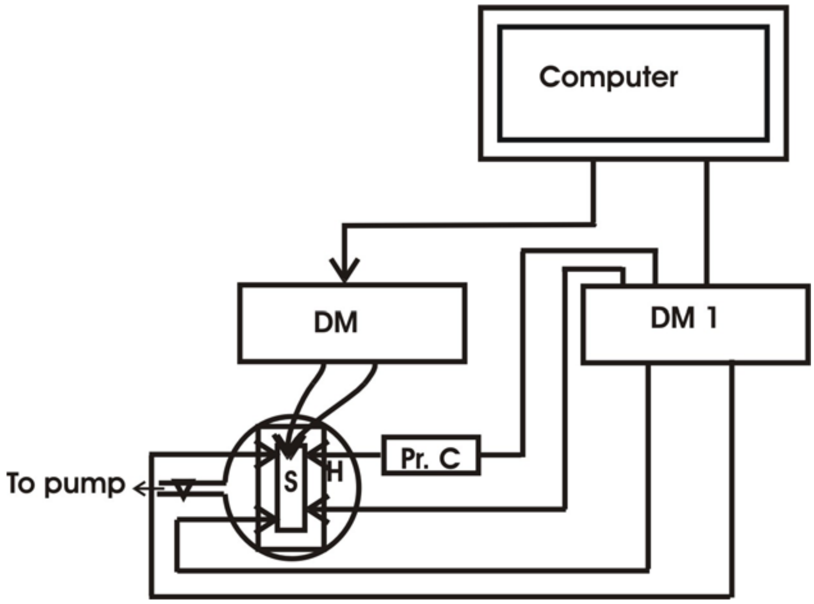

Figure1. Experimental setup for resistance measurements: DM- Keithley multimeter 2002; DM1- Keithley multimeter 2000 with installed Scan card (200 Scan card); Pr.C-process controller ESM-4450 for heating control, S-sample,H- heater.

Crystallization reduces the resistance but transition from amorphous to crystalline state is complex because it depends on various factors. Among others, it depends on the heating rate and is shown for two different Ni-Zr composition and at different heating rates in Fig.2, Fig.3 and Fig. 4.

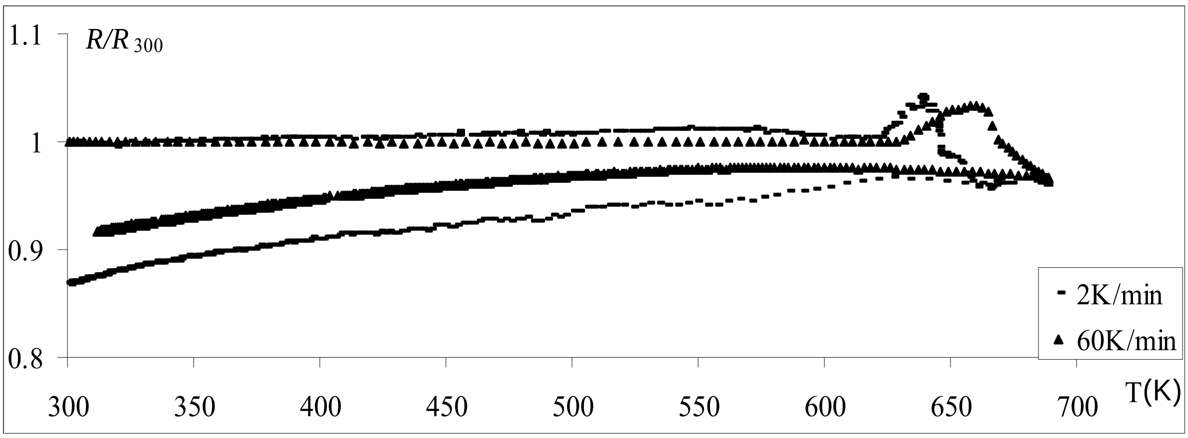

Figure 2. Temperature dependence of normalised resistance for samples with concentration $Ni_{38}Z_{62}$ for different heating rates. Lower parts of curves represent the cooling process.

As it can be seen from all presented figures the changes in electrical resistance of amorphous samples are very small before the crystallization started. When crystallization occured resistance exhibited an abrupt falling. It has to be pointed out that an excess in values that precedes the fall of the resistance was observed in all reported cases. Throughout the cooling process the resistance was decreased as in ordinary metals and this is due to the domination of the crystalline phase in the amorphous matrix. The structural investigations which correspond to such behaviour of resistance are not subject of this paper.

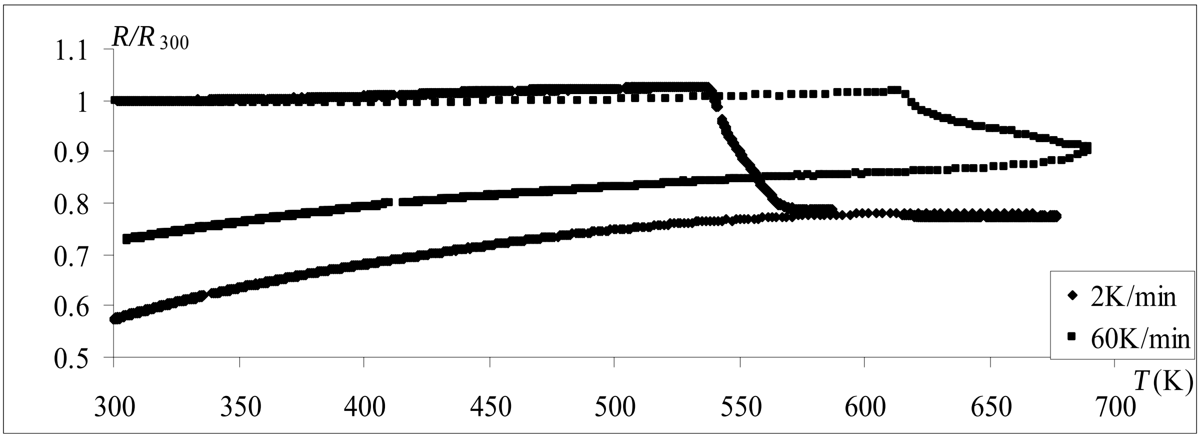

Figure 3.Temperature dependence of normalised resistance for samples with concentration $Ni_{28}Zr_{72}$ for different heating rates. Lower parts of curves represent the cooling process.

Crystallization temperature was increased with increasing rate of heating and also decreased with increasing zirconium content in the alloy (Fig.2.- 4.). The samples were investigated in the same temperature range and we always interrupted the heating process at about the same temperature value. Therefore the sample which crystallized at a higher temperature exhibits a significant smaller reduction of resistance than the sample with a lower crystallization temperature as it is shown in Fig.4.

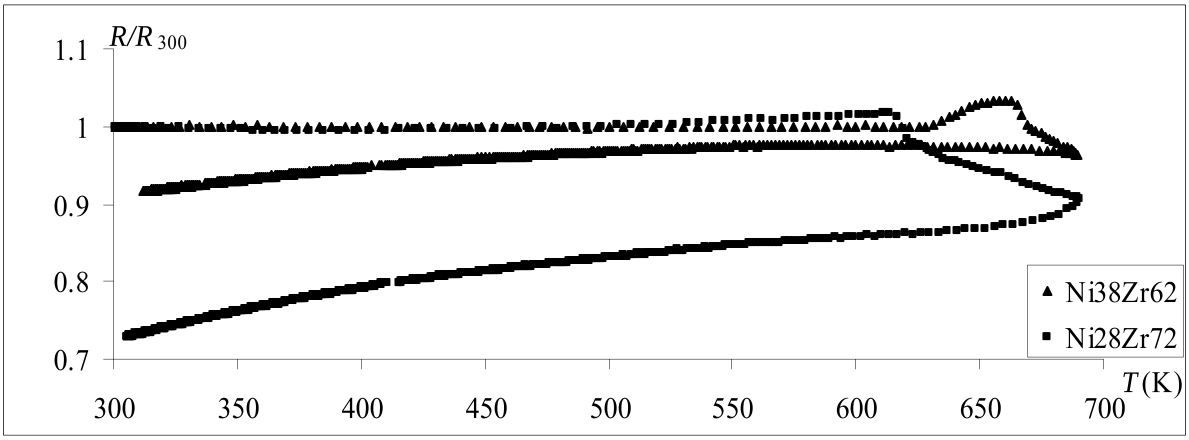

Figure 4. Temperature dependence of normalized resistances for heating rate 60K/min. Lower parts of curves represent the cooling process

3. CONCLUSIONS

The obtained results can be summarised to following conclusions:

1. The values of electrical resistance were changed at the crystallization temperature and a significant abrupt reduction in its values can be measured.
2. The noticed rise in resistance values before their fall to smaller amounts can be due to the onset crystallization.
3. It is possible to controll the devitrication process and growth of the crystall phase by annealing for sufficient time at corresponding temperatures.

4. ACKNOWLEDGMENTS

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5. REFERENCES

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