Formation of Laser Induced Periodic Surface Structure on Amorphous Metallic Alloys

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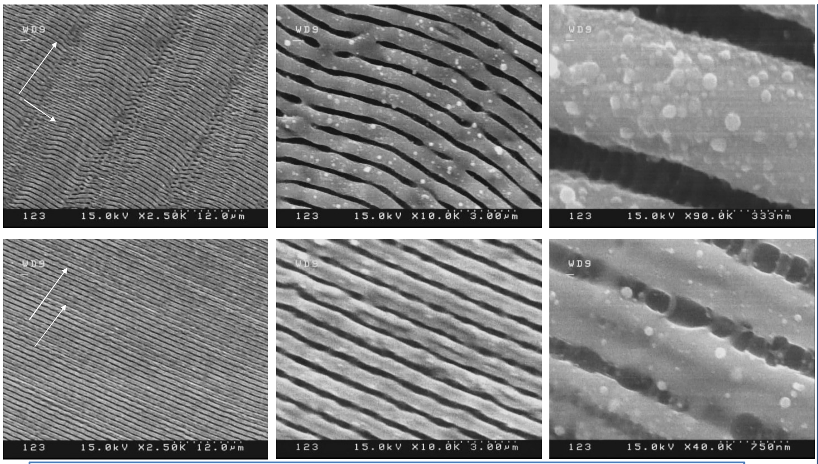
Introduction, Aim and Methods

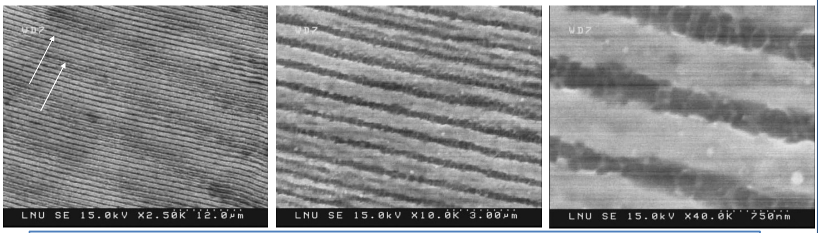
Amorphous metallic alloys (AMA) are interesting for research and manufacturing due to unique properties caused by their disordered metastable structure, such as high strength and elasticity, good corrosion resistance, excellent soft magnetic properties. Using laser irradiation it is possible to controllably change the structure and hence the properties of the alloy [1, 2]. A femtosecond pulsed laser allows forming the laser-induced periodic surface structure (LIPSS) on the material surface that can significantly change the properties of the material, such as optical, tribological, wettability [3, 4]. Therefore, the LIPSS formation on AMA is of great interest. Combining properties caused by amorphous structure and properties caused by LIPSS seems to be very perspective for practical usage.

Amorphous metal alloys with chemical compositions Fe73.5Nb3Cu1Si15.5B7 (Fe-based) and Co73Fe1Mn3Mo1Si13B9 (Co-based) were manufactured in the form of the ribbon by rapid cooling from the melt using the melt-spinning technique. The femtosecond pulse laser (wavelength - 1030 nm) was used for AMA surface irradiation. The alloy surface changes were studied using the SEM method, and the alloy structure was investigated by back-scattered X-Ray diffraction (Cu-Kα irradiation).

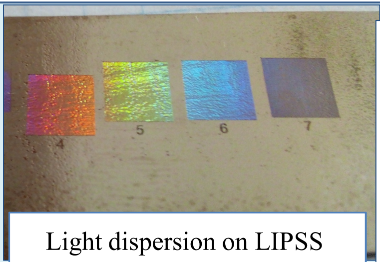
Results



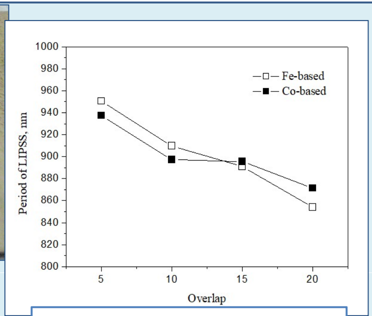
LIPSS structure obtained on $Fe_{73.5}Nb_3Cu_1Si_{15.5}B_7$ at perpendicular (top) and parallel (bottom) orientation of scanning vector to the laser polarization



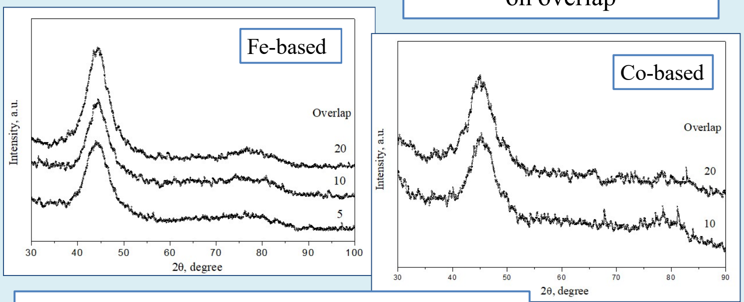
LIPSS structure obtained on $Co_{73}Fe_1Mn_3Mo_1Si_{13}B_9$ at parallel orientation of scanning vector to the laser polarization



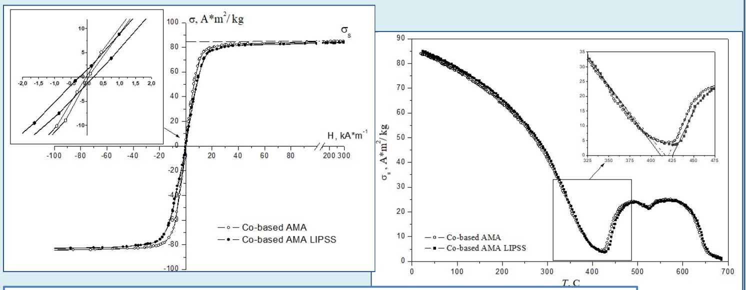
Light dispersion on LIPSS formed on Co-based AMA (5x5 mm square areas of LIPSS)



LIPSS period dependence on overlap



X-Ray diffraction patterns of irradiated ribbons



Hysteresis and thermo-magnetic curves for Co-based alloy

Conclusion

The highly regular LIPSS was obtained on the amorphous $Fe_{73.5}Nb_3Cu_1Si_{15.5}B_7$ and $Co_{73}Fe_1Mn_3Mo_1Si_{13}B_9$ ribbons using femtosecond pulse laser irradiation with wavelength 1030 nm. The period of LIPSS was observed to be 850 - 950 nm for Fe-based and 870 – 940 nm for Co-based AMA depending on overlap. The formation of LIPSS did not cause the devitrification of the amorphous structure of the ribbon. This allows the opportunity to structure the ribbon surface without changing its inner structure using femtosecond pulse laser irradiation.

References

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