ROBL-CRG	**Experiment title:** Structural analysis of Mn implanted Ge by X-ray diffraction	**Experiment number**: 20-02-672
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Report:

The observation of room temperature ferromagnetism in Mn doped Ge has attracted a great deal of attention recently. One explanation for the ferromagnetism is that transition metal (TM) ions are diluted within the host matrix and ferromagnetically aligned via an indirect magnetic coupling. However, the doped TM atoms can also form secondary-phase clusters, which produce the observed magnetism. In order to totally understand the origin of the ferromagnetism, it is extremely necessary to correlate the measured magnetic properties with material characterizations, e.g. x-ray diffraction, which are powerful in detecting secondary phase or precipitates. The implantation process modifies only the near surface region, i.e. a very small volume. Therefore, x-ray diffraction requires a high intense and low-divergent beam. In our previous research on Fe, Ni and Co implanted ZnO, synchrotron x-ray diffraction as provided at ROBL already demonstrates its unique capability to probe the TM metal nanocrystals, their orientation and thermal stability [1]. In the ongoing investigation, we have implanted Mn into Ge single crystals with different Mn fluences. We will measure the magnetic and electronic properties. Combining with XRD, we can shed lights on the understanding of dilution, precipitation of Mn in Ge. Additionally, the microstructural evolution in Ge, and Er implanted SiO_2 layer and its impact on the electroluminescence properties are investigated as a function of different fabrication conditions.

Results

Fig. 1 shows the diffractograms for Ge(001) implanted with $1x10^{15}$, $1x10^{16}$ and $5x10^{16}$ cm^{-2} Mn ions (100 keV) at 570 K as well as a virgin Ge wafer. At the lowest fluence of Mn, there is no

secondary phase formed. While at larger fluence, the phase of Mn_5Ge_3 formed. Basically Mn_5Ge_3 shows two kinds of orientation Mn_5Ge_3 (111) (002)//Ge(001). Mn5Ge3 is ferromagnetic.

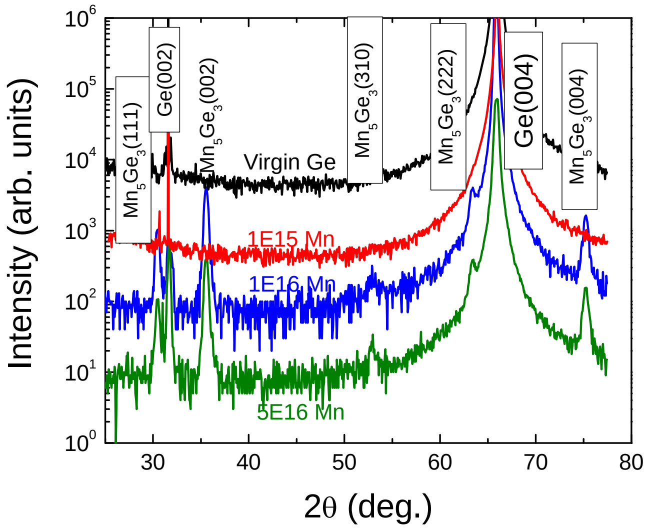

Fig. 1. XRD patterns of Mn implanted Ge.

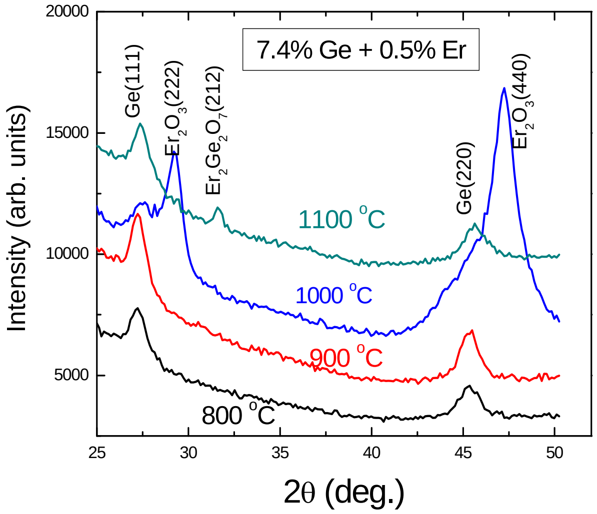

Fig. 2. XRD patterns with increasing annealing temperature for 7.4 % Ge and 0.5 % Er.

During this beam time, we also investigated the microstructural evolution in a system like SiO_2:Ge-NC:Er under different fabrication conditions and correlate these results with the inverse energy transfer from Er^{3+} to the GeODCs. Fig. 2 shows the phase transformation of Ge and Er inside amorphous SiO_2 annealed at different temperature for 30 seconds by rapid thermal annealing. With increasing annealing temperature, the microstructure will pass though a state of crystalline Er_2O_3 followed by the formation of an exotic $Er_2Ge_2O_7$ phase, and the maximum yield of the Ge-related electroluminescence, EL, is achieved prior to the formation of the Er_2O_3 nanocrystallites. This result was just published as a rapid communication at Phys. Rev. B.

References

[1] K. Potzger, Shengqiang Zhou, et al., Appl. Phys. Lett. **88**, 052508 (2006).
[2] A. Kanjilal, L. Rebohle, N. K. Baddela, S. Zhou, et al., Phys. Rev. B 79, 161302 (2009).