One- and two-step post-growth annealing investigation of (Cd,Mn)Te crystals for developing room-temperature nuclear detectors

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(Cd,Mn)Te is a promising candidate for radiation detector application because of its suitably large band-gap providing high resistivity, a high average atomic number ensuring effective interactions between incident radiation and detector's material, and favorable electron-transport properties guaranteeing high charge collection efficiency [1–3]. These features assure high energy resolution and good detector performance at room temperature. Nonetheless, (Cd,Mn)Te single crystals with high quality are still difficult to obtain. The as-grown (Cd,Mn)Te crystals usually contain a high density of structural defects, such as tellurium inclusions or cadmium vacancies, which adversely influence the device operation.

Post growth annealing is a potentially hopeful method of improving the properties of (Cd,Mn)Te crystals. It has been demonstrated that annealing (Cd,Mn)Te samples in cadmium atmosphere at uniform temperature reduces the cadmium vacancies amount, and annealing in the same atmosphere in temperature gradient lowers the quantity of tellurium inclusions [4]. But there is not much consistent information about two-step annealing which comprises processes in both cadmium and tellurium atmospheres. We suppose a multi-step annealing can successfully improve optical properties of the crystal. Because we have big technological possibilities, we tested different types of annealings and studied their influence on crystal properties.

In our work we performed one-step and two-step annealing processes of un-doped (Cd,Mn)Te specimens. We investigated crystals grown from stoichiometric solution and crystals grown in excess of cadmium or tellurium, as well. During the experiments we used different annealing atmospheres, and checked how the sequence of two-step annealing (e.g. first annealing in Cd, then in Te vapors or first in Te, then in Cd atmosphere) affects samples' characteristics. We compared crystal properties before and after diverse annealings. That issue will be discussed basing on the infra-red microscopic observations in the transmission mode, the transmittance studies and the photoluminescence in the temperature function measurements in order to analyze the origin source of particular peaks.

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[1] A. Burger, K. Chattopadhyay, H. Chen, J.O. Ndap, X. Ma, S. Trivedi, S. W. Kutcher, R. Chen, R.D. Rosemeier, *J. Cryst. Growth* **198/199**, 872 (1999).
[2] A. Mycielski, A. Burger, M. Sowinska, M. Groza, A. Szadkowski, P. Wojnar, B. Witkowska, W. Kaliszek, P. Siffert, *Phys. Stat. Sol. (c)* **2**, 1578 (2005).
[3] A. Mycielski, L. Kowalczyk, R.R. Gałązka, R. Sobolewski, D. Wang, A. Burger, M. Sowińska, M. Groza, P. Siffert, A. Szadkowski, B. Witkowska, W. Kaliszek, *J. All. Comp.* **423**, 163 (2006).
[4] D. Kochanowska, A. Mycielski, M. Witkowska-Baran, A. Szadkowski, B. Witkowska, W. Kaliszek, Y. Cui, R.B. James, *IEEE Nucl. Sci. Symp. Conf. Rec.* **R12-1**, 202 (2008).